Social, health and lifestyle predictors of sleep during pregnancy

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Submitted in accordance with the requirements for the degree of

Doctor of Philosophy

The University of

Leeds School of

Medicine

November 2016

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Publications

Posters presented in conferences

1. Al Afif N, Scott EM, Law GR, Ellison GTH. 2015. How does pregnancy influence sleeping patterns? An analysis of contemporary and nationally representative data from the Understanding Society cohort. Faculty Postgraduate Symposium, November, Leeds Institute of Genetics, Health and Therapeutics.
2. Al Afif N, Scott EM, Law GR, Ellison GTH. 2014. The development of a generic search strategy for sleep-related research based on contemporary systematic reviews. Faculty Postgraduate Symposium, March, Leeds Institute of Genetics, Health and Therapeutics.
3. Alafif N, Law GR, Ellison GTH. 2013, The development of a generic search strategy for sleep related research based on contemporary systematic reviews. British Sleep Society 25th Anniversary Scientific Meeting, 10 October, Edinburgh.

Published abstracts presented in conferences

1. Al Afif N, Law GR, Scott EM, Al Naji A, Ellison GTH. 2013. The sensitivity of sleep-related research filters based on the search terms used by contemporary systematic reviews. Society for the Study of Human Biology Proffered Papers Meeting, October, Oxford Brookes University. [Accessed 11 November 2016] Available from: http://www.sshb.org/wp- content/uploads/2012/12/SSHB-Proffered-Papers-Meeting-programme-and-abstract- book-2013.pdf.
2. Alafif N. Law GR, Ellison GTH. 2016. Identifying the sleep patterns in pregnancy in Understanding Society (USoc), UK Household Longitudinal Survey: pregnant-non-pregnant Wave 1 & 4. 9th Saudi Students Conference, September, Birmingham University. [Accessed 11 November 2016] Available from: http://uksacb.org/ssc9/conference/paper-presentation-sessions/51-presentation-sessions/341-s2-8-diabetes-and-nutrition.
3. Al Afif N, Alghamdi, A.A. Tan, E. Ciantar, E. Scott EM, Law GR, Ellison GTH. 2015. Body weight, BMI and gestational weight gain are predictors of short sleep duration amongst pregnant women at risk of gestational diabetes. Proceedings of the Nutrition Society, December 2015, 75 [Accessed 11 November 2016] Available from: https://www.cambridge.org/core/journals/proceedings-of-the-nutrition-society/article/body-weight-bmi-and-gestational-weight-gain-are-predictors-of-short- sleep-duration-amongst-pregnant-women-at-risk-of-gestational-diabetes/7F3DC02D7D56E402FD08A1B0B8E6A243.
4. Al Afif N, Alghamdi A, Law GR, Scott EM and Ellison GTH. 2016. Worse or just different? Self- reported sleep characteristics of pregnant and non-pregnant women in the UK Household Longitudinal Study. Society for Social Medicine 60th Annual Scientific Meeting, September, York. Journal of Epidemiology & Community Health [Accessed 11 November 2016]: doi:10.1136/jech-2016-208064.219.

Acknowledgment

First and foremost, I thank Allah, the Most Beneficent, the Most Merciful, for giving me the ability to progress successfully with my academic achievements. I would like to dedicate this thesis to the late King Abdullah bin Abdulaziz Al Saud, since it was as a result of his determination to ensure that the women in Saudi society were educated for the good of future generations that I had the privilege to pursue doctoral studies. I dedicate my efforts and achievements, and the hardships I endured being far from home to his precious memory.

There are many who surrounded me during my studies with love and support and they deserve to be thanked here. I start by thanking my dear parents for their emotional support throughout my doctoral studies and for their heartfelt prayers which have constantly sustained me. I also wish to express my thanks: to my dearest sister, Nouf, because her kind-heartedness knows no bounds; to my best friends, Noha and Naseem, because their encouragement helped me to persevere whenever there were obstacles to overcome, and to my dear neighbours, Reemea and Fowzia, who became like my second family here in the UK. Thank you all so much!

I would also like to express my gratitude to my supervisor Dr George Ellison, for his support and constructive criticism which has taught me so much and has helped me to become a better researcher. My appreciation is also extended to the rest of the Research Team, my co-supervisors Dr Graham Law and Dr Eleanor Scott and Dr Peter Tennant for their support and guidance throughout my PhD journey. I would also like to thank my dear fellow postgraduates, Rasha, Amal, Alia and Lina, who were so very supportive, and added greatly to my research experience.

Last but not least, I want to say a very special thank you to all my beloved children, Mohammed, Sarah and Dana, for their patience. It was so very hard not being close to them throughout my PhD project, but our dream has finally come true. Your mother is now Dr Nora Alafif.

My hope is that this research will serve to benefit humanity, by contributing to the improvement of health and to ensuring a better future for all.

Abstract

The aim of this thesis was to strengthen understanding of self-reported sleep in pregnancy by drawing together evidence from: previously published research.These analyses indicate that: several pre- existing/pre-pregnant sociodemographic and health characteristics contribute to the less favourable sleep commonly reported by pregnant women (as compared to non-pregnant women with the same age-range as those who were pregnant: 16-49yrs); de novo analyses of existing and novel datasets; and the lived experience of pregnant women themselves. This mixed- methods approach found that: a lack of standardisation and potential flaws in the design of previous studies do not yet permit a formal meta-analysis to be performed; and previous findings remain vulnerable to error and publication bias.

The three de novo quantitative analyses of self-reported sleep conducted for this thesis sought to address many of the flaws in previous research.; and that variation in these and (un)related lifestyle and behavioural factors during pregnancy also contribute to variation in self-reported sleep amongst pregnant women. However, the last of these analyses provides evidence that variation in a commonly experienced phenomenon (glucose intolerance and, at its extreme, gestational diabetes) is associated with less favourable sleep in what appears to be a dose-response relationship.

Analysis of posts to web-based forums by women with first-hand experience of sleep in pregnancy confirm that pregnancy-specific somatic changes were experienced/understood to be the principal causes of less favourable sleep; although the advice offered to others facing similar problems tended to focus on behavioural and situational factors as suitable avenues for intervention.

On the basis of this evidence, it is clear that none of the self-administered sleep instruments/items available, and used, to-date are capable of comprehensively assessing the sleep of pregnant women. Future research must develop/use a dedicated sleep instrument to improve our understanding of the range, prevalence and likely determinants of the less favourable sleep more commonly reported by pregnant women.

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List of Abbreviations

AASM	American Academy of Sleep Medicine's
AHI	Apnoea Hypopnea Index
ASDA	American Sleep Disorders Association
BMI	Body Mass Index
CI	Confidence interval
DAG	Directed acyclic graph
DM	Diabetes mellitus
GDM	Gestational diabetes mellitus
HIV	Human Immunodeficiency Virus
ICSD	International Classification of Sleep Disorders: Diagnostic and Coding Manual
KQs	Key questions
NICE	National Institute for Clinical Excellence
NREM	Non-Rapid Eye Movement
OGT	Oral glucose tolerance
OGTT	Oral glucose tolerance test
OR	Odds ratio
RRR	Relative risk ratio
OSA	Obstructive sleep apnea
PASD	Pregnancy-Associated Sleep Disorder
PSQI	Pittsburgh Sleep Quality Index
REM	Rapid Eye Movement
RLS	Restless legs syndrome
SF12	12-Item Health Survey
UKHLS	UK Household Longitudinal Study
WASO	Wake up after sleep onset

Glossary of Terminology related to sleep or pregnancy[1]

Anthropometric: Refers to the measurement of the human individual and typically includes height, weight, and BMI.

Central sleep apnoea: A sleep-related disorder in which the effort to breath is diminished or absent, typically for 10 to 30 seconds, either intermittently or in cycles. It is usually associated with a reduction in blood oxygen saturation.

Dyssomnia: A sleep disorder that involves abnormal and unnatural movements, behaviours, emotions, perceptions, and dreams that occur while falling asleep, sleeping, between sleep stages, or during arousal from sleep.

Eclampsia: The occurrence of convulsions that is precipitated by pregnancy-induced hypertension and is not attributable to other causes.

Gestation: The state of being pregnant; the period from conception to birth when a woman carries a developing foetus in her uterus.

Gravidity: The number of times a woman has been pregnant, regardless of whether the pregnancies were interrupted (e.g. by abortion, or foetal death) or resulted in a live birth.

Hypersomnia: A sleep disorder characterized by excessive sleepiness, extended sleep time in a 24-hour cycle, and the inability to achieve the feeling of refreshment that usually comes from sleep.

Insomnia: A term relating to trouble falling asleep or staying asleep throughout the night. This may come and go (episodic insomnia), last up to three weeks (short-term insomnia), or be long-lasting (chronic insomnia).

Maternal: Pertaining to the mother in pregnancy and childbirth.

Multiparous: Having given birth two or more times.

Narcolepsy: A neurological disorder caused by the brain's inability to regulate sleep-wake cycles normally. The main features of narcolepsy are excessive daytime sleepiness and cataplexy. The disease is also often associated with sudden sleep attacks, insomnia, dream-like hallucinations, and a condition called sleep paralysis.

[1] Glossary derived from: WebMD, Wikipedia

Nocturia: Excessive urination during the night. During sleep time, the body produces less urine and this is more concentrated, meaning that most people do not need to wake up during the night to urinate and can sleep uninterrupted for six to eight hours. This condition is also known as nocturnal polyuria.

Non-Rapid Eye Movements (NREM): The process of NREM consists of 4 stages:
Stage 1: During the initial stage of sleep, the eyes are closed and one can be wakened without difficulty. However, if aroused from this stage, a person may feel as if they have not slept, and many experience the feeling of falling during this stage of sleep.
Stage 2: This is a period of light sleep in which brain waves show spontaneous periods of muscle tone mixed with periods of muscle relaxation. The heart rate slows and the body temperature decreases. At this point, the body prepares to enter deep sleep. If aroused from sleep during this stage, an individual may report not having slept at all.
Stages 3 and 4: These are deep sleep stages, with the latter being more intense than the former. These stages are identified as slow-wave, or delta, sleep. If aroused from sleep during these stages, a person may feel disoriented for a few minutes.

Nulliparous: A woman who has never given birth.

Obstetric: The medical specialty dealing with the care of all women's reproductive tracts and their children during pregnancy (prenatal period).

Odds ratio (OR): provides a measure of association between an exposure and an outcome. The OR represents the odds that an outcome will occur given a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure.

Parasomnia: A category of insomnia defined as a positive response to either of two questions: "Do you experience difficulty sleeping?" or "Do you have difficulty falling or staying asleep?

Parity: The number of children borne by one woman.

Perinatal: Occurring during the period around birth (five months before and one month after).

Periodic leg movements: Repetitive leg movements occurring during sleep, characterized by rapid partial flexion of the foot at the ankle, extension of the big toe,

and partial flexion of the knee and hip.

Preeclampsia: A hypertensive disorder of pregnancy consisting of hypertension plus proteinuria, non-dependent generalized oedema, or both.

Prenatal/Antenatal: Prior to childbirth, occurring before the birth.

Primiparous: Relating to a woman who has given birth only once.

Rapid Eye Movement (REM): REM takes place 90 minutes after sleep onset after which point, the first 10-minute period of REM takes places. Following this, each recurring REM stage lengthens, and the final one may last up to an hour. During this initial stage of sleep, brainwave patterns are similar to those recorded during wakefulness. The main change in REM for people without sleep disorders is an increase in heart rate, more erratic respiration and eyes moving rapidly in different directions. As a consequence of the heightened brain activity in REM, intense dreaming occurs.

Relative risk ratio (RRRs): RRRs are the ratio of two relative risks comparing to the base line (Hocine et al., 2007)[2]. They provide estimates of the risk of developing the outcome in the participants who are exposed the exposure's category of interest as compared to the risk in participants who are exposed to the exposure's referent category, assuming all other individual characteristics are held constant. RRRs are obtained by exponentiating the multinomial regression model coefficients generated in multinomial regression analyses (a form of logistic regression analysis in which the outcome or dependent variable is polytomous; i.e. is a categorical variable with more than two categories). For example, where (in the present thesis) the exposure variable of interest is parity (a binary variable with categories: 'nulliparous' and 'multiparous' – with nulliparous as the referent category) and the outcome variable of interest is self-reported sleep quality (a polytomous variable with categories: 'Good', 'Fairly Good', 'Fairly Bad' and 'Bad' – with 'Good' as the referent category), the three RRR estimates provided for the association between 'multiparous' and 'Fairly Good', 'Fairly Bad' and 'Bad' sleep quality (respectively) would indicate the extent to which the relative risk

[2] Hocine MN, Tubert-Bitter P, Moreau T, Chavance M, Varon E, Guillemot D. 2007. Relative-risk ratio was a useful measure of differential association in cohort and case-series studies. *Journal of clinical epidemiology*. **4:** 361-5.

associated with multiparity was higher (or lower) than that for nulliparity when comparing the association between parity and sleep quality amongst those with 'Fairly Good' vs. 'Good', 'Fairly Bad' vs. 'Good' and 'Bad' vs. 'Good' quality sleep.

Restless legs syndrome: A disagreeable, deep creeping or crawling sensation in the calves that occurs during sitting or in a recumbent position.

Singleton: A child born singly, rather than one of a multiple birth.

Sleep apnoea: A sleep disorder characterized by abnormal pauses in breathing or instances of abnormally low breathing, during sleep. Each pause in breathing, called an apnoea, can last from a few seconds to minutes, and may occur 5 to 30 times or more an hour.

Sleep inertia: A physiological state characterised by a decline in motor dexterity and a subjective feeling of grogginess immediately following an abrupt awakening. This impaired alertness may interfere with the ability to perform mental or physical tasks.

Sleep onset: The onset of sleep under normal situation in normal adult is through NREM sleep.

Socio-demographic: A branch of study (and categories produced thereby) combining sociology and demography; of, pertaining to, or characterized by a combination of sociological (related to sociology) and demographic (related to populations) characteristics.

Symphysis pubis dysfunction: Pregnancy-related pelvic pain is common and thought to affect one in five women during their pregnancy. It describes the pain that originates from the joints in the pelvis. This pain can be felt over the lower back, hips, groin and down the inside or back of the legs. The term pelvic girdle pain is also used to describe the pain experienced in the front and back of the pelvis.

Chapter 1

Introduction

1.1 Background to the research

Sleep is a vital biological function that promotes physical and emotional wellbeing. According to Carskadon and Dement (1994:16):

"Sleep is a reversible behavioural state of perceptual disengagement from, and unresponsiveness to, the environment. Sleep plays a crucial role in allowing the brain to work properly, enhancing learning ability and remembering information. Without enough sleep, malfunctions occur in many vital areas of the body starting from impaired memory and thought processes to more serious conditions such as depression, decreased immune response, fatigue increased pain perception, and ultimately in chronic health outcomes."

A growing body of evidence has found relationships between long- and short-term sleep loss and: cardiovascular disease; an increased risk of stroke (Ayas et al., 2003); increased blood pressure and an increased risk of developing diabetes due to impaired sugar metabolism during poor sleep (Spiegel et al.,2009). Furthermore, the risk of obesity is increased due to the disruption of the hormone leptin which regulates carbohydrate metabolism. Since low levels of leptin cause the body to crave carbohydrates, regardless of the amount of calories consumed, obesity becomes more likely (Van Cauter and Plat, 2000).

During sleep, the body alternates between two types of sleep: Non-Rapid Eye Movement (NREM) sleep and Rapid Eye Movement (REM) sleep.[1] Typically, people begin the sleep cycle with a period of NREM sleep followed by a very short period of REM sleep. Thereafter a series of sleep cycles begins with NREM stages 1, 2, 3 and 4 (see below) and progresses to REM. This cycle is replicated at various times throughout the night, on average between 4-5 times, the duration for each ranging from around 60 to 90 minutes. Dreams generally occur in the REM stage of sleep (see Figure 1.1). (Angelica's World. How to Sleep Well in, 25.8.2011).

[1]A glossary of terms and abbreviations has been provided at the beginning of this thesis

The four stages of NREM can be summarised as follows:

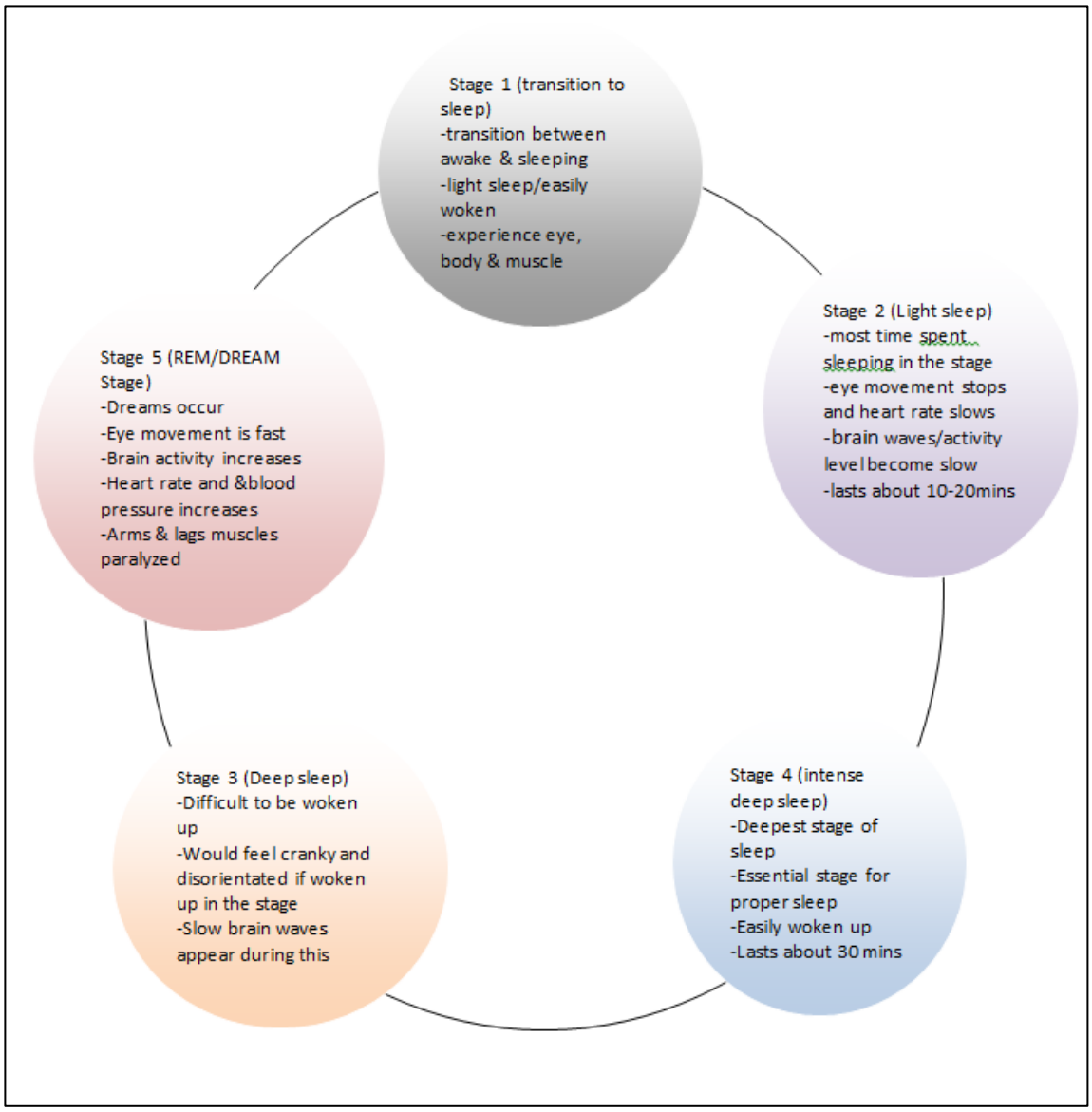
Stage 1: During this stage the eyes are closed and individuals can be awakened with little difficulty. However, if aroused during this stage, a person may feel as if they have not slept at all, while many get the feeling of falling during this stage of sleep (hence the expression 'falling asleep').

Stage 2: This is a period of light sleep in which brain waves reveal there are spontaneous periods of muscle tone mixed with periods of muscle relaxation. The heart rate slows and body temperature decreases. At this point, the body starts to enter deep sleep. However, if aroused from sleep during this stage, many may report not being asleep at all.

Stages 3 and 4: These final two stages comprise deep sleep, Stage 4 simply being more intense/pronounced than Stage 3. These stages are identified as slow-wave, or delta, brain waves. If aroused from sleep during these stages, a person may feel disoriented and extremely irritable for a few minutes.

In contrast to NREM sleep, REM sleep takes place 90 minutes after the onset of sleep (immediately after which the first 10 minute or so period of REM takes places). Following this initial period of REM sleep, each recurring period of REM lengthens, the final one lasting up to 60 minutes. During REM, brainwave patterns are similar to those recorded during wakefulness. However, the principal differences in REM observed amongst people who have sleep disorders are: an increase in heart rate; more erratic respiration; and eyes moving rapidly in different directions (hence the name of this sleep stage). As a consequence of the heightened brain activity occurring during REM sleep, this is the stage within which intense dreaming usually occurs (WebMD 1.3. 2013).

Figure 1.1 Sleep cycle derived from (Angelica's World. How to Sleep Well in, 25.8.2011).



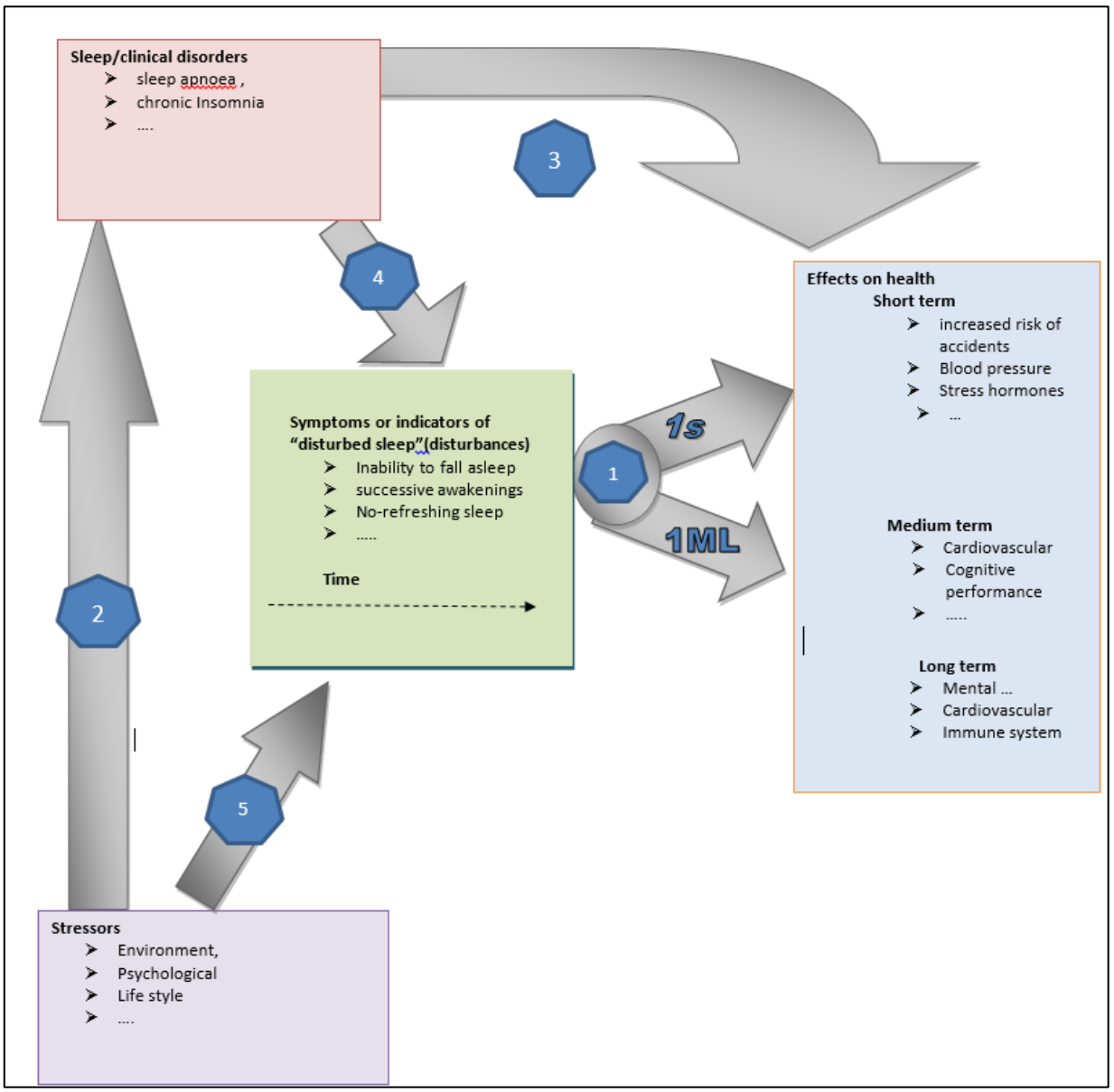
1.1.1 Sleep as a global issue

In 2004, WHO brought together n=21 epidemiologists and experts on sleep medicine to review the effects of disturbed sleep on health. They concluded that there were a range of potential pathological consequences resulting from sleep disturbance, including short-term, medium-term and long-term (see Figure 1.2) (WHO technical meeting on sleep and health, 22.1.2004). Interest in the potential role that sleep might play in the health of industrialised and industrialising countries has led to a renewed interest in research into the aetiology, diagnosis and prognosis of sleep- related problems that

has spread from sleep-specific journals into the mainstream medical and epidemiological literature (WHO, 2004).

Indeed, Ovid-SP Medline searches using the term “sleep” reveal a marked increase in the number of publications found in the sleep research field: 1970-1980 n=3,152 articles; 1980-1990 n=5,623 articles; 1990- 2000 n=9,742 articles; 2000-2010 n=18,920 articles.

Figure 1.2 Scope of the 2004 WHO Sleep Experts Meeting in Bonn derived from (WHO technical meeting on sleep and health, 22.1.2004).



1.1.2 Sleep Associations

To improve awareness of the importance of sleep, a number of associations and foundations have been established to: communicate with the general public and with patients affected by/presenting with sleep problems; develop clinical standards within the emerging professions associated with sleep medicine; engage in educational activities and support for trainees; and coordinate increasing funds for sleep research. A selection of these organisations are described in further detail in Table 1.1

Table 1.1 A summary of the main aims and activities of sleep-related organisations currently operating within and between different countries, with a particular focus on those that are UK-based.

No	Name	Country	Description	Website
1	**The National Sleep Awareness Roundtable**	UK	A national coalition of governmental, professional, voluntary and other organizations whose mission is: 1. To raise awareness of sleep. 2. To Increase the understanding of sleep. 3. To reduce the public health and safety impact of sleep deprivation and sleep disorders by improving communication and collaboration among local, state and federal agencies; professional organizations and the public.	www.NSART.org
2	**Edinburgh Sleep Centre**	UK	The leading centre in the provision of diagnostic and treatment services for people with sleep disorders and related medical and psychological disorders. It provides assessment and treatment of all types of sleep disorders from those which are breathing-related such as Obstructive Sleep Apnoea to insomnia, narcolepsy, and sleep disturbed by psychiatric and medical conditions.	www.edinburghsleepcentre.com/sleep_disord

3	**London Sleep Centre**	UK	The Centre provides services within an integrated model of health care, utilising state-of-the-art scientific technology and expertise in the diagnosis of sleep problems. This is combined with a comprehensive medical, psychological, social and holistic treatment package that is individually tailored for every patient.	http://www.londonsleepcentre.com/
4	**The Irish Sleep Apnoea Trust (ISAT)**	Ireland	ISAT was established in May 2000 following an initial exploratory meeting of patients with obstructive sleep apnoea syndrome at St. Vincent's University Hospital, Dublin. ISAT's aims are: • To increase public and professional understanding of the significance of the diagnosis and the correct treatment of Sleep Apnoea in terms of good health, safety and the economy. • To reduce the incidence of health and safety problems related to insufficient sleep. • To research and collate information on the dangers to sufferers of sleep apnoea and disseminate this information to the public, patients, healthcare professionals, the appropriate public authorities and employers through active advocacy,	http://www.isat.ie/about/about.html

5	**American Academy of Sleep Medicine (AASM)**	USA	Headquartered in Darien, IL, the AASM is the only professional society dedicated exclusively to the medical sub-speciality of sleep medicine. As the leading voice in the sleep field, the AASM sets standards and promotes excellence in health care, education and research. Established in 1975 as the Association of Sleep Disorders Centre, the AASM has a combined membership of nearly 12,000 accredited member sleep centres and individual members, including physicians, scientists and other healthcare professionals.	http://www.aasmnet.org/learningcenter/home.aspx
6	**Sleep Research Society (SRS)**	USA	SRS educates and researches sleep and sleep disorders for scientific investigators. It serves its members and the field of sleep research through training and education, and by providing forums for collaboration and exchange of ideas. The SRS facilitates its goals through its annual sleep meeting. Additionally, the SRS advocates on behalf of its members to increase federally-funded sleep research through grass-roots lobbying and communications efforts.	http://www. sleepresearchsociety.org
7	**National Centre on Sleep Disorders**	USA	NCSDR was established in 1993 to address a serious public health concern. It seeks to fulfil its goal of improving the health of Americans by serving four key functions: research, training, technology transfer, and coordination. NCSDR coordinates the Federal Government's efforts on sleep disorders and works closely with other public, private and non-profit groups	http://www.n hlbi.nih.gov/a bout/ncsdr/ab

8	**Stanford University Centre of Excellence for the Diagnosis and**	USA	The Centre of Excellence in the field of sleep medicine takes a multi-disciplinary approach with preeminent, highly trained sleep professionals using high-tech equipment in state-of-the- art facilities to diagnose and treat sleep disorders. The Centre also conducts cutting edge research in narcolepsy, circadian rhythms and human sleep.	http://psychiatry.stanford.edu/coe/
9	**Canadian Sleep Society**	Canada	A professional association of clinicians, scientists and technologists that was formed in June 1986 to further the advancement and understanding of sleep and its disorders through scientific study and public awareness. The Society has the following objectives: • To promote and support the growth and quality of sleep disorder medicine in Canada. • To increase the profile and support for sleep research in Canada. • To increase public awareness of the importance of sleep research and sleep disorder medicine, and Canada's contribution to this area. • To engage in educational activities and facilitate support for trainees	http://www.canadiansleepsociety.ca/tours/
10	**The European Sleep and Research Society**	Europe	This international scientific non-profit organization promotes all aspects of sleep research and sleep medicine. These include the publication of the *Journal of Sleep Research;* the organization of scientific meetings; the promotion of training and education; the dissemination of information, and the establishment of fellowships and awards. The Society's aims are: • to promote research on sleep and related areas • to improve the care for patients with sleep disorders and	http://www.esrs.eu/esrs/about-us.html

11	**Australasian Sleep Association (ASA)**	Australia New Zealand	ASA is the peak scientific body in Australia & New Zealand representing clinicians, scientists and researchers in the broad area of sleep. Established as a company limited by guarantee in 2009, ASA is run by a Board of Directors, consisting of elected members of the Association. ASA's goals are to: • Promote Education and Training in sleep health & sleep science within its membership and the other health related professions • Foster Research in sleep health and sleep science • Establish Clinical Standards within the profession and industry.	http://www.sleep.org.au/about/australasian-sleep-association
12	**Asian Sleep Research Society (ASRS)**	India	The Founding Committee of ASRS was formed in New Delhi, India, on 10 September 1992, followed by the formation of ASRS on June 16 1994 in Tokyo, Japan. This international scientific organization aims to promote all aspects of sleep research by organizing scientific meetings, promoting training and education, disseminating information and establishing fellowships and awards.	http://www.asrsonline.org/
13	**National Sleep Foundation (NSF)**	USA	Promoting healthy sleep for all, the NSF works in partnership with leaders in the fields of sleep science and medicine to raise awareness of the importance of sleep, treatment for sleep problems and the consequences of sleep loss. It goals are to ensure that: • Sleep is used as a vital sign of health by medical professionals and the public; • The biological sleep/wake process is common knowledge; • Workplaces, schools, homes and transportation infrastructures are designed to be sleep-friendly; • Sleep science is rapidly incorporated into products and services.	https://sleepfoundation.org/about-us

			The NSF is governed by a Board of Directors. NSF committees, councils, task forces and consensus panels each have unique responsibilities areas that address specific NSF goals.	
14	**British Sleep Society (BSS)**	UK	BSS is a professional organisation for medical, scientific and healthcare workers dealing with sleeping disorders. It is a registered British charity and its ultimate aim is to improve public health by promoting education and research into sleep and its disorders	https://www.sleepsociety.org.uk/about/

1.1.3 Sleep disturbances specific to pregnancy

Published research has shown that sleep disturbances are twice as commonly reported amongst women compared to men (Brugge et al., 1989). Anxiety and depression are both associated with sleep disorders, and are likely to be both causes of less favourable sleep and the consequence of this. Importantly, both of these psychological conditions are more frequent in women. Changes in perceived sleep quality occur during the menstrual cycle in pre-menopausal women, as well as during pregnancy (Brunner et al., 1994); and it is a commonly held belief that anxiety and depression are associated with cyclical changes in hormone levels (Lee et al., 1990; Karacan et al., 1968). Indeed, a substantial number of reviews on the topic of sleep in pregnancy suggest that there is considerable consensus regarding the risk that pregnancy poses for an increase in both the severity and frequency of sleep disturbances (Sahota et al., 2003) and of associated psychological conditions (Hall et al., 2009).

However, during pregnancy, hormonal, physiological and anatomical changes are thought to influence sleep; as are any psychological consequences thereof together with anxieties related to pregnancy itself and impending motherhood. Many of these changes appear to vary by gestational age, suggesting that stage-specific phenomena, such as morning sickness during the early stages of pregnancy; and the growth in size of the baby during the final stages, directly contribute to less favourable sleep. Changes in hormonal secretion during pregnancy are particularly pronounced when the placenta stimulates the production of (and itself produces) an increased concentration of circulating steroid hormones including: progesterone; oestrogen; prolactin; and oxytocin (Little et al., 1974). Of these, progesterone in particular has been implicated in the modification of the so-called 'sleep architecture', and is widely credited with the excessive daytime sleepiness that many women describe shortly after conception (Attarian and Viola-Saltzman, 2006). There is also evidence to suggest that oestrogen reduces REM sleep, while prolactin has been shown to elevate REM. Likewise, the secretion of oxytocin increases at night in pregnancy concurrent with the onset of uterine contractions. All three of these hormones have therefore been implicated in the changing sleep patterns commonly observed/reported during pregnancy (Bourjeily

2009; Santiago et al., 2001).

Other manifestations of physiological changes that are thought to influence sleep in pregnancy include the respiratory system, which appears to be modified during pregnancy as a result of both mechanical and biochemical mechanisms. In particular, changes in the airway mucosa occur (involving hypaeremia, hypersecretion, and mucosal oedema), particularly during the third trimester of

pregnancy, and these may predispose pregnant women to snoring and/or upper-airway obstructive events, including 'pregnancy-associated obstructive sleep apnoea' (Santiago et al., 2001).

Commonly reported sleep disturbances in pregnancy include: insomnia; sleepiness; snoring and sleep apnoea; limb twitching/jerking; and late night/early morning waking (Mindell and Jacobson 2000; Pien and Schwab 2004; Sahota et al., 2003; Santiago et al., 2001). Moreover, an increased frequency of nightmares during pregnancy has also been reported as a factor associated with more frequent awakenings during the night (Lee and Dejoseph 2007). Interestingly, in pregnancy, two common sleep disorders – 'restless leg syndrome' (RLS) and 'periodic limb movements in sleep' (PLMS) – often occur together; and can lead to difficulties with sleep onset and frequent night time awakenings (Lee et al., 2001). These appear to be related to lowered iron (anaemia) and folic acid levels during pregnancy, and in some women they subside following treatment with iron or folic acid supplements (Mindell and Jacobson 2000). Indeed, subsequent studies have highlighted the importance of maintaining normal serum ferritin and serum folate levels during pregnancy in order to reduce restless legs complaints and improve access to more consolidated sleep during pregnancy (Lee et al., 2001).

1.1.4 Sleeping disturbances in pregnancy associated with gestational age

As described earlier, much of the evidence felt to demonstrate a direct effect of pregnancy on sleep comes from studies showing variation in the extent and frequency of less favourable sleep at different stages of pregnancy. For example, over forty years ago, Schweiger (1972) examined n=100 pregnant women in a prenatal clinic in the UK using retrospective self-reports of sleep and found that 68% of these women reported poor sleep. This commenced in the first trimester for 14% of these women, in the

second trimmest for 20% and in the final (third) trimester for the remaining two thirds 66%. Poor sleep during the first trimester was attributed to nausea and vomiting, and nocturia. During the second trimester, embryo development and heartburn added to mothers' complaints; while in the third trimester, pregnant women reported additional sleeping difficulties due to back pain, shortness of breath, leg cramps, itching and difficulty finding a comfortable sleeping position (Bassett et al., 1998; Lee and Dejoseph 2007).

1.1.5 Pregnancy Associated Sleep Disorder

In response to the growing evidence of a high prevalence of less favourable sleep during pregnancy, the American Academy of Sleep Medicine (AASM) included *Pregnancy-Associated Sleep Disorder* [PASD] as a 'proposed disorder' in both the first and second (revised) editions of the *International Classification of Sleep Disorders: Diagnostic and Coding Manual* (ICSM; see Diagnostic and Coding Manual [ICSD], 2001). PASD has a minimum diagnostic criterion of: 'mild sleepiness' or 'mild insomnia' with an initial onset occurring post-conception, which is then present during pregnancy.

1.1.6 Sleep disturbances in Gestational Diabetes Mellitus (GDM)

Sleep disturbance has been linked to abnormal glucose metabolism and an elevated risk of diabetes (Reutrakul and Cauter, 2014). Sleeping disturbances have also been shown to be associated with glucose intolerance in pregnancy (Facco et al., 2010). Moreover, pregnant women who develop GDM, a form of glucose intolerance exceeding a clinically-defined threshold, are at increased risk of a wide range of poor pregnancy outcomes including: pre-eclampsia; delivery by caesarean section; macrosomia; foetal birth injury; as well as foetal hypoglycaemia and hyperbilirubinemia. Common risk factors for GDM or sub-clinical levels of impaired glucose tolerance during pregnancy include: older maternal age; obesity/high body mass index (BMI); multigravidity and multiparity; and a family history of diabetes (Metzger et al., 2008). Importantly, the risk of GDM appears highest amongst overweight women who also have sleep disorders (Qiu et al., 2010).#

1.2 Originality of the research undertaking for the present thesis

1.2.1 Shortage of studies in GDM

An OvidSP Medline search conducted from 2012 to 2013 as part of the planning for the present study found that of n=41,127 studies on sleep only n=2,078 (fewer than 5% of these studies) had examined sleep in pregnancy, and only n=5 studies had examined sleep amongst pregnant women diagnosed with GDM. Therefore, there is a need to extend current research into sleep disorders amongst pregnant women, including those at risk of GDM or those who go on to develop this, to assess the risks/consequences associated with less favourable sleep. Moreover, previous research has paid scant attention to potential predictors of sleep in pregnant women (with or without GDM). Existing research suggests that sociodemographic and health characteristics are the principal factors affecting sleep in pregnancy – though the factors examined to-date are limited to characteristics such as age, employment and obesity (see Facco et al., 2010b;Qiu et al., 2010). Considering the global rise in the number of older pregnant women, and in those who continue to work during pregnancy, and given the increasing prevalence of obesity, it seems timely to explore these predictors in greater detail (Santiago 2001).

Moreover, there is currently a lack of UK-based research in this area despite a reported increase in the number of sleeping disturbances within the UK. This has drawn recent attention from the popular press, with the *Daily Mirror* reporting that "nearly a third of the population in the UK are suffering from insomnia which is affecting their health" (NHS 27.1.2011). Although sleep is commonly cited as a 'problem' or a 'risk' to ill-health, current approaches to improving sleep largely focus on pharmacological therapies despite there being a number of alternative sleep interventions available. These are particularly important for pregnant women who are often discouraged/unable to take sleep medication as a result of both known and unknown effects thereof on their unborn child. Such non-pharmacological interventions might include: improving sleep hygiene, by establishing regular sleep-wake hours, limiting naps and avoiding stimulants

such as caffeine; practising relaxation techniques; minimizing intrusive bedroom noises; limiting fluid intake after 6 pm to reduce nocturnal urinary frequency; and managing low back pain by using massage, localised heat and supportive pillows. Stimulus-control techniques such as going to bed only when sleepy, using bed only for sleep and sexual intimacy, and getting out of bed in the event of prolonged awakenings also warrant consideration (Santiago et al., 2001).

1.3 Thesis Aims

There is growing recognition of the likely/apparent importance of sleep to health. In addition, the prevalence of sleep and sleep-related disorders is growing. Moreover, the potential role that these disorders may play in pregnancy, particularly amongst women at risk of GDM and the poor pregnancy outcomes that may result has been acknowledged. Therefore, this thesis takes as its primary focus the sleep of pregnant women. Its overarching aim is to better understand what is known about this relatively under-researched topic – particularly within the UK context, using a combination of secondary (i.e. review-based) and primary data based on quantitative and qualitative studies. It also aims to establish the current state of research/knowledge in this area; the role which social and biological factors might play on sleep, both before and during pregnancy; and the extent to which pregnancy-specific factors (such as glucose intolerance and, at its extreme, GDM) might be associated with less favourable sleep. Finally, the thesis aims to draw together these reviews and analyses to generate recommendations for future research in this area, to address any shortcomings in previous studies, in the data available for analysis (including that available for analysis by the present thesis), and in the 'framing' of sleep in pregnancy. Currently, the tendency is to view this as an unavoidable 'problem' for pregnant women, in a similar way that other ostensibly naturally occurring pregnancy phenomena are susceptible to social surveillance and medicalisation. While the present thesis does not specifically examine each of the hormonal, physiological and anatomical changes that occur at different stages of pregnancy, it aims to assess their potential relationship with sleep by assessing the relationship between sleep and gestational age at sleep assessment, body mass index at sleep assessment, and (in the clinical sample of women at risk of GDM) 'glucose intolerance' in late pregnancy. Each of these variables therefore act as

proxies for the hormonal, physiological and anatomical changes which: vary by gestational age; are associated with BMI; and include changes in glucose tolerance as pregnancy progresses.

To this end, the present thesis will address six discrete Key Questions:

KQ1: What might be learnt from previously published studies about: the sleep of pregnant women; and the methodological challenges that such studies entail (including the potential for publication bias)?

KQ2: Are disparities in self-reported sleep between pregnant and non-pregnant women associated with *pre-existing* differences in sociodemographic and health characteristics?

KQ3(i): What contributions might variation in exercise, diet and other lifestyle behaviours *during* pregnancy make to variation in sleep *amongst* pregnant women?

KQ3(ii): To what extent might the relationship between lifestyle and sleep *during* pregnancy be influenced by the hormonal, physiological and anatomical changes that occur at *different stages* of pregnancy?

KQ4: Might variation in any of the hormonal, physiological and/or anatomical changes that accompany pregnancy be associated with variation in self-reported sleep amongst pregnant women?

KQ5: How might the lived experiences of sleep amongst pregnant women reflect, and further illuminate, what is known from quantitative analyses of variation in self-reported sleep characteristics during pregnancy?

KQ6: Do any of the self-administered sleep instruments that have been used to examine self-reported sleep in pregnancy provide a comprehensive assessment of sleep in pregnancy; and/or a basis upon which clinical assessments of *Pregnancy Associated Sleep Disorder* might be made?

1.4 Hypothesis

As such, the hypotheses addressed by the present thesis are that:

1. Existing research into sleep within pregnancy contains a number of flaws that may have generated misleading estimates of the importance and prevalence of sleep- related problems during pregnancy;
2. Analyses exploring the sleep of pregnant and non-pregnant women, and variation in sleep amongst pregnant women, will demonstrate that the less favourable sleep commonly reported by pregnant women is attenuated following adjustment for differences in sociodemographic and health characteristics (between pregnant and pregnant women, and amongst pregnant women), and that it is associated with a range of lifestyle, behavioural and health-related factors that are characteristic of, yet subject to change, during pregnancy, including those associated with pregnancy-specific factors, such as gestational age at assessment, and the risk/diagnosis of GDM;
3. The perceived sleep of pregnant women reflects prevailing medical and lay views regarding sleep in pregnancy, as primarily determined by the hormonal, physiological and anatomical changes occurring during pregnancy, but it may also reflect what are considered to be/present as 'unique understanding' of sleep- related phenomena by pregnant women; and
4. Current approaches to the measurement of self-reported sleep (using self-administered instruments and custom item sets) are unlikely to address the specific issues understood to be relevant to sleep in pregnancy amongst pregnant women, and require additional design-related work to strengthen the utility of these within the context of sleep in pregnancy, particularly in terms of their potential clinical utility.

Chapter 2

Systematic Review

2.1 Introduction

The rationale behind including a systematic review at the outset of this thesis is to establish what is already known regarding sleep and pregnancy. The study's overall aim of identifying socio-demographic, health predictors of sleep in pregnant women (both those with and without formal diagnoses of gestational diabetes mellitus [GDM]) means that it is also helpful to review the existing literature to acquire a better understanding of the scope of these predictors. In addition, this review details what is currently known about (or at least thought to be) the likely impact of these predictors on sleep in pregnant women. This knowledge can also be used to identify the variables that have been measured in previous studies and to identify those which are likely to be acting as potential confounders so that these can then be adjusted in the studies planned for inclusion in this thesis.

The literature review will also provide a preliminary insight into the way that sleep has thus far been assessed in pregnancy, in terms of duration, disturbance and perceived quality. Furthermore, it will determine the inclusion and exclusion criteria that have been applied to the samples of pregnant women examined thus far. Combining these, together with the findings and recommendations of previous studies, will ensure that the research planned for the present thesis learns from the experience of other researchers and makes an original contribution to knowledge and understanding in this area.

2.2 Aim of the systematic review

This systematic review aims to address the first key questions(KQ) presented in the Introductory Chapter to the thesis, namely:

KQ1: What might be learnt from previously published studies about: the sleep of pregnant women; and the methodological challenges that such studies entail (including the potential for publication bias)?

2.3 Methods

The systematic review planned for inclusion in this study consisted of five stages:

A. Stage One: Select search terms for "sleep" and "pregnancy"

The aim of the initial stage of this review was to conduct a preliminary 'review of reviews' to identify search terms that had proven useful for finding primary studies addressing "sleep" and "pregnancy". This involved:

- Using a systematic approach to identify any systematic reviews focusing on topics relevant to "sleep" and/or "pregnancy" and
- Extracting the search strategies and search terms used by these reviews so that they can be combined for use in conducting the systematic review for the present study.

A.1 Finding search terms using OvidSP-Medline

A.1.1 Reviews addressing "Sleep"

The truncated term <sleep*> was used to search OvidSP-Medline, this term being intended to capture all related words, such as 'sleepless' and 'sleeping'. The search was limited to studies on 'humans', that contained abstracts (to assist in screening for inclusion/exclusion) and had been conducted during the period January to September 2012. The search applied either Medline's dedicated 'review' filter function which is designed to optimise the sensitivity of the search so that only *bona fide* review articles are retrieved) or included the additional search terms <systematic review> OR <meta-analysis>.

Of the original n=263 articles found (see Figure 2.1), n=20 were not available at Leeds University Library and needed to be obtained via inter-library loan or by contacting their author(s). A further n=4 foreign-language articles required translation from

Italian (n=2), Danish (n=1) and Dutch (n=1). Once again, GoogleTranslate® was used for this process. Of these, n=260 were positively identified as reviews that contained details of the search terms (and databases) used; and n=83 of these were found to be related to pregnancy (see Table2.1).

Figure 2-1. Flowchart summarising the steps taken to identify and screen (for inclusion) articles reporting systematic reviews of studies exploring sleep and sleep-related characteristics, for which systematic search terms were reported.

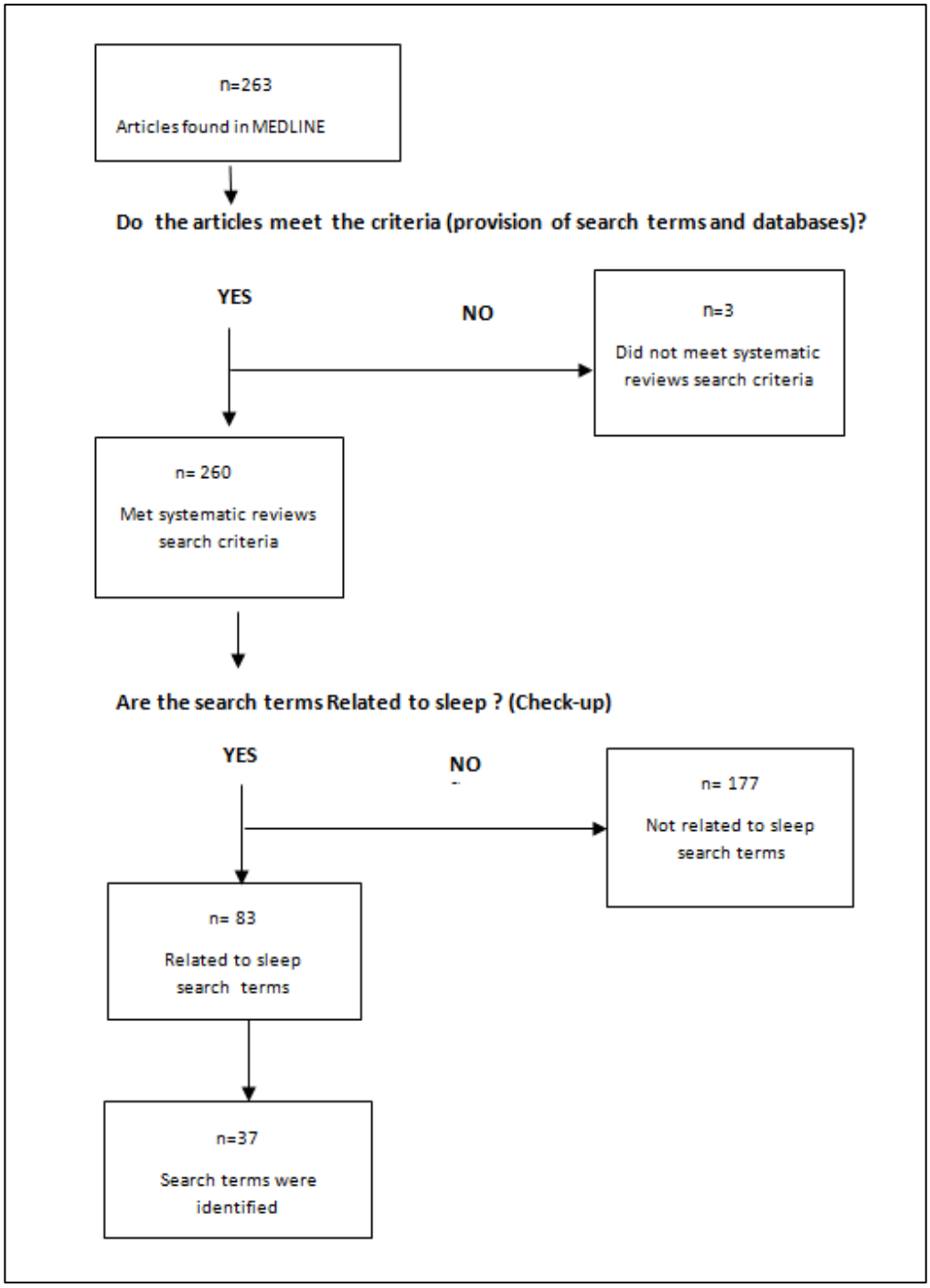


Table 2-1 Search terms for "sleep"

NO.	Search Terms	Frequency
1.	Central sleep apnoea treatment	2
2.	Central sleep apnoea	2
3.	Sleep apnoea	5
4.	Apnoea	2
5.	Obstructive sleep apnoea	3
6.	Sleep-related breathing disorders	2
7.	Insomnia	5
8.	Sleep	14
9.	Sleep time	2
10.	Sleep duration	2
11.	Sleep hours	1
12.	Time in bed	1
13.	Sleep quantity	1
14.	Sleep quality	1
15.	Sleep disorder	4
16.	Sleep disorders	4
17.	Sleep disordered	1
18.	Time spent asleep	1
19.	Time spent sleeping	1
20.	Time sleeping	1
21.	Time asleep	1
22.	Sleep length	1
23.	Hypopnea syndrome	1
24.	Dyssomnia	1
25.	Parasomnia	2
26.	Hypersomnia	1
27.	Sleep disturbance	1
28.	Sleeplessness	1

29.	Sleepiness	1
30.	Sleep efficiency	1
31.	Sleep latency	1
32.	Sleep problem	2
33.	Sleep disturbance	1
34.	Sleep difficulties	1
35.	Nightmare	1
36.	Sleep terror	1
37.	Sleep deprivation	1

A.1.2 Reviews addressing "pregnancy"

OvidSP-Medline was also used to search for published reviews that had developed/used pregnancy-related search terms, the word 'pregnant' being truncated to <pregnan*> to ensure reviews using a range of related words such as 'pregnancy' and 'pregnant' in their titles, abstracts or key words were included. As before, the search was limited to studies on humans and to those with abstracts available for review, the only difference being that this covered the period January to October 2012. However, on this occasion, Medline's dedicated 'review' filter function designed to optimise the specificity of search results was used to limit the numbers of articles obtained to a manageable number, since initial searches generated n>1,500 articles which would have been impractical to manage. Applying Medline's 'maximise specificity' filter reduced this to a more manageable total of n=359 articles (see Figure 2.2).

Of the n=359 articles found (see Figure 2.2), n=9 were not available at Leeds University Library and needed to be obtained via inter-library loan or by contacting their author(s). Another n=2 foreign-language articles required translation from German and Spanish respectively. GoogleTranslate® translations were deemed to offer sufficient detail to assess the utility of these articles. Following careful examination of the titles and abstracts of these articles, n=54 were positively identified as bona fide reviews reporting the precise search terms and databases they had used; and n=26 of these were found to have a focus on sleep or sleep-related topics (see Table 2.2).

Figure 2-2. Flowchart summarising the steps taken to identify and screen (for inclusion) articles reporting systematic reviews of studies exploring pregnancy and pregnancy- related characteristics, for which systematic search terms were reported.

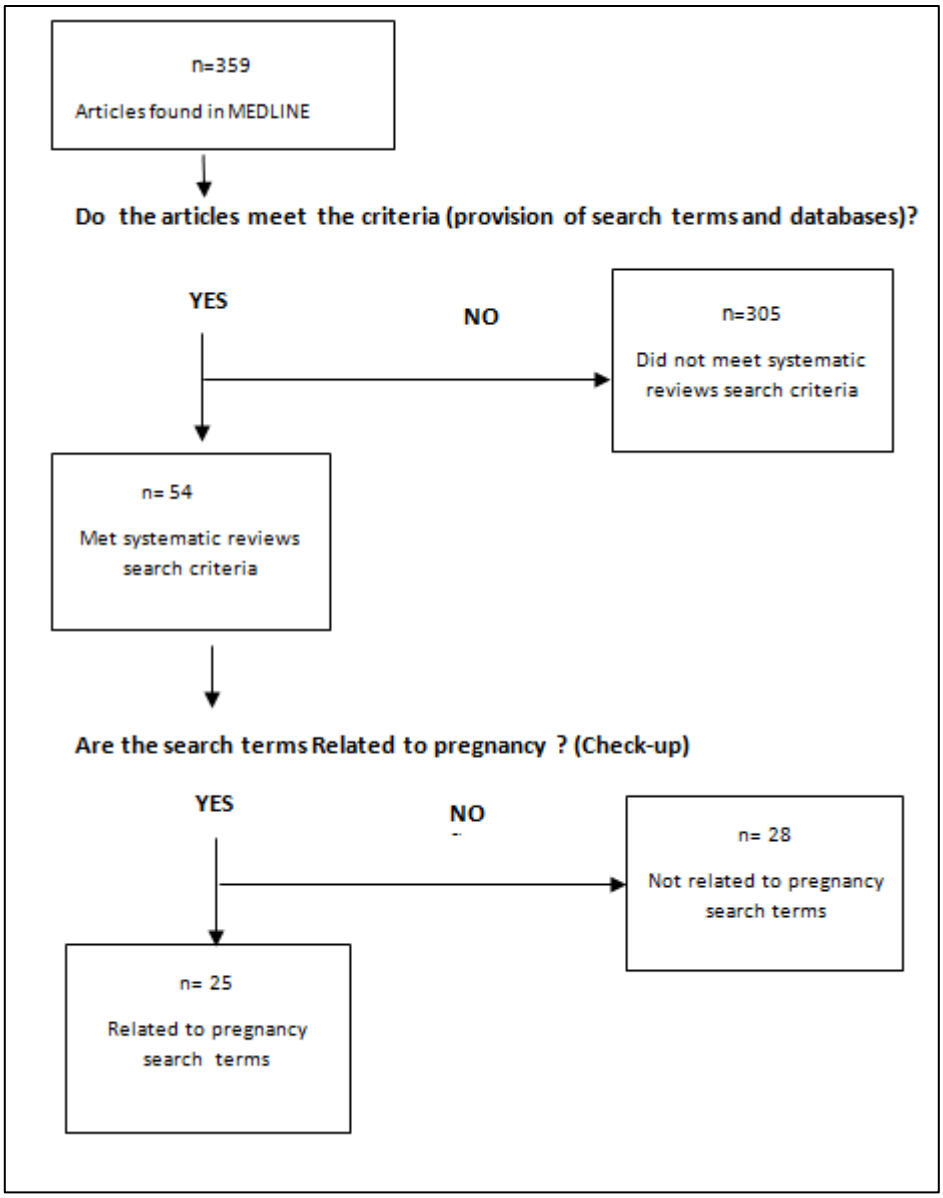


Table 2-2 Search terms identified for "pregnancy"

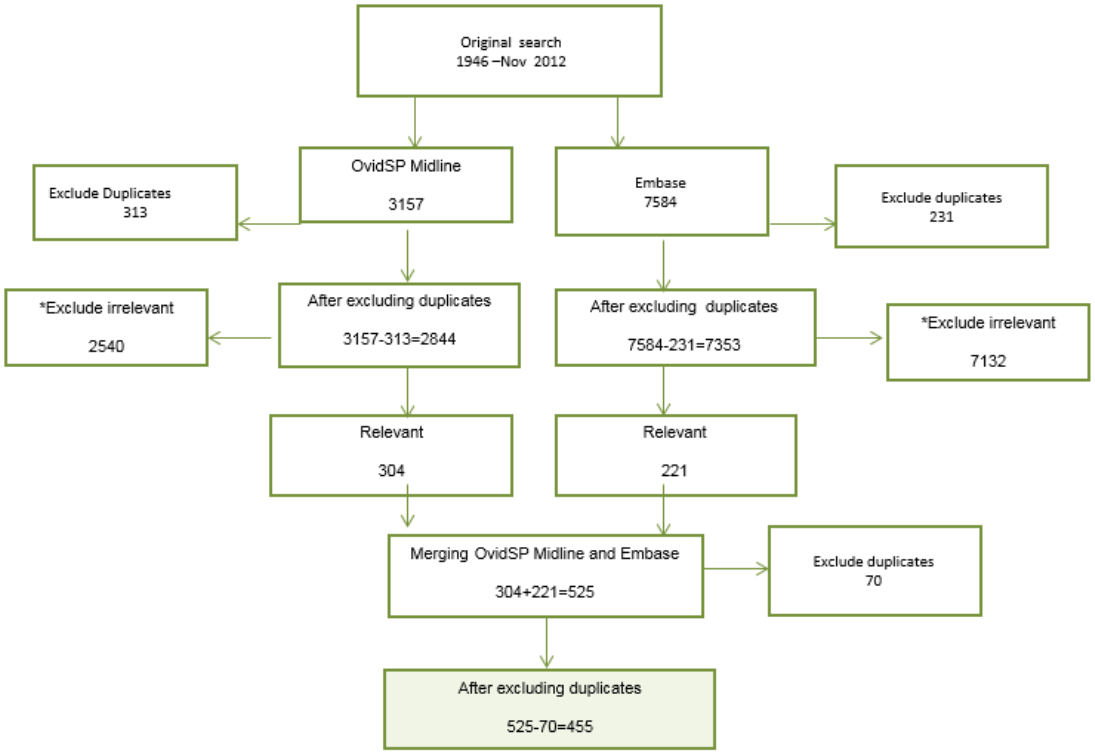
NO.	Search Terms	Frequency
1.	Pregnancy	46
2.	Pregnant	2
3.	Pregnan*	5
4.	Pregnant women	4
5.	Pregnancy complication	17
6.	Pregnancy Trimester	2
7.	Obstetric	8
8.	Obstetric complication	2
9.	Obstetrical	3
10.	Obstetrical complications	1
11.	Maternal	8
12.	Maternal age	2
13.	Maternal complications	1
14.	Pregnancy Outcome	16
15.	Pregnancy in Adolescence	1
16.	Pregnancy Rate	3
17.	Maternity care	1
18.	Prenatal	6
19.	Prenatal care	3
20.	Perinatal	2
21.	Prenatal Diagnosis	6
22.	Antenatal	5
23.	Gestational outcome	1
24.	Gestation	3
25.	Gravid	1

B. Stage Two: Applying harmonised search terms to OvidSP-Medline and Embase

B.1 Original search (1946-November 2012)

The search strategy began by applying the combined search terms for "Sleep" (Table 2.1) and "Pregnancy" (Table 2.2) to both OvidSP-Medline and Embase, to identify any primary empirical quantitative studies containing measurements of sleep on study participants while they were pregnant. This process is illustrated as a separate flowchart (see Figure 2.3) and has also been summarised in Table 2.3.

Figure 2-3. Flowchart summarizing the results of searching (and screening search findings) for primary quantitative observational studoes relevant to sleep assessments conducted during pregnancy. Searches were conducted using the OvidSP-Medline and Embase databases of articles published from 1946-November 2012.



*Conference abstracts and studies on non humans or children

Table 2-3. Search strategy using combined search terms for "Sleep" and "Pregnancy" for original search (1946-November 2012) and updated search (November 2012-July 2015) for OvidSP-Medline and Embase.

Search Dates	Search Engine Used	Total		NO. Of Duplicates Excluded	After Removing Duplicates	Excluded As Irrelevant*	Relevant
1946-Nov 2012	OvidSP-Medline	3,157		313	2,844	2,540	304
	Embase	7,584		231	7,353	7,132	221
	Merging both databases	304+221=525		70	**525-70=455**		
Nov 2012-July 2015	OvidSP-Medline	1,000		155	845	705	140
	Embase	989		310	679	609	70
	Merging both databases	140+70=210		57	**210-57=153**		
Duplicates found after merging results for 1946-Nov 2012 (*n*=455) and Nov 2012-July 2015 (*n*=153) for both databases		455+153=608		156	**608-156=452**		

*Conference Abstracts and studies on Non Humans or Children were excluded.

B.1.1 OvidSP-Medline original search (1946-November 2012*)*

Using a combination of the search terms identified from previous reviews (see Tables 2.1 and 2.2), an OvidSP-Medline search of the database from 1946 through to November 2012 was conducted without applying any time or language limits. However, this search was filtered for studies with abstracts that focused on humans, and a total of 3,157 articles were identified.

B.1.2 Embase original search (1946-November 2012)

Embase was searched using terms identified from previous reviews (see Tables 2.1 and 2.2) without applying any time or language limits so that all articles in the database from 1946 through to November 2012 were included. As previously, the search was filtered for studies with abstracts that focused on humans, and identified a total of 7,584 articles.

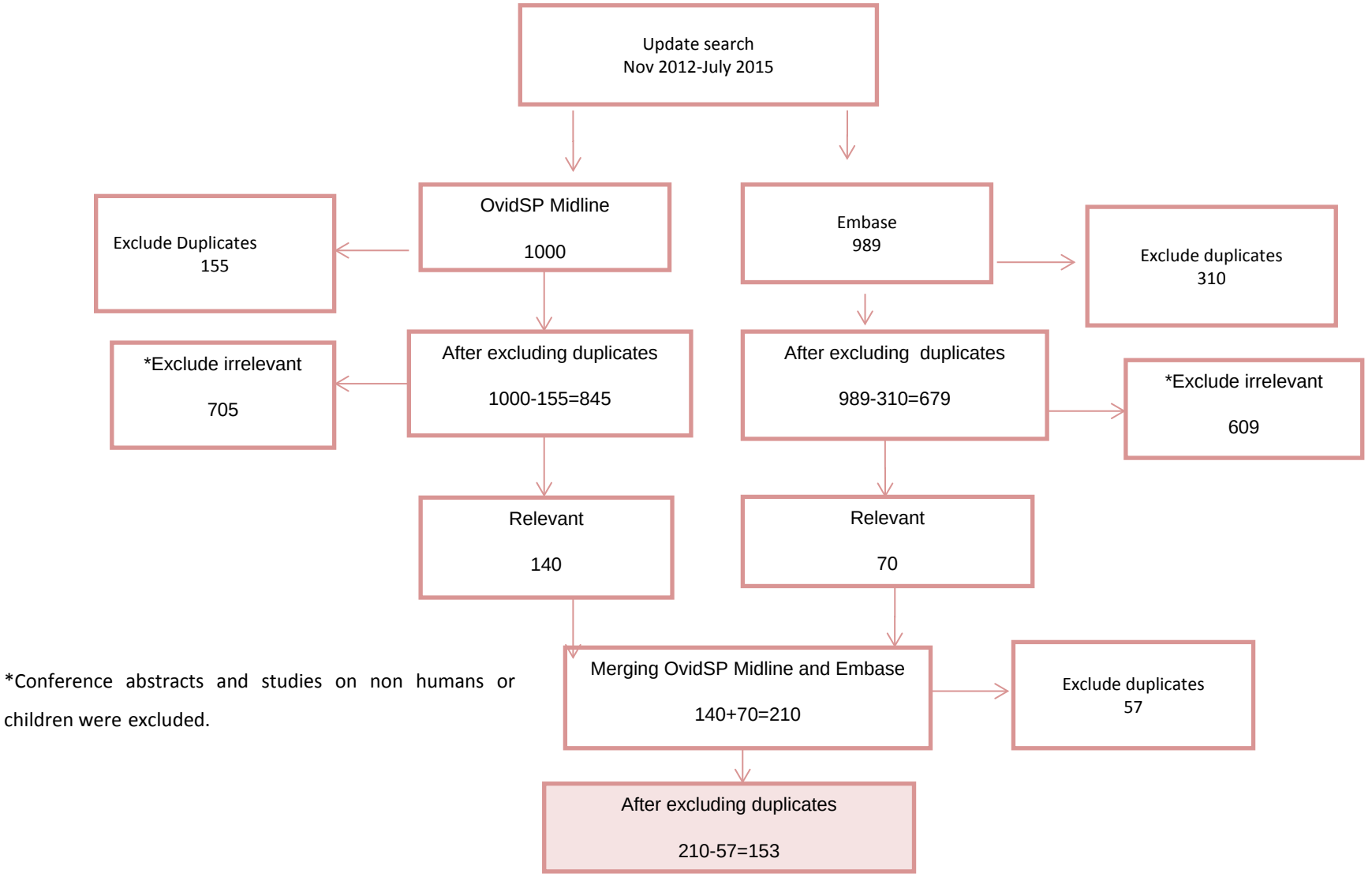
B.1.3 Merging OvidSP results from Medline and Embase searches (1946- November 2012)

After merging the results generated after searching both databases, a total of n=525 articles were found. This total was reduced to n=455 articles after removing duplicates (i.e. those articles occurring in the results of both searches).

B.2 Updated search (November 2012-July 2015)

The combined search terms for "sleep" and "pregnancy" were re-applied to OvidSP-Medline and Embase to update the original search, so that the combined results would then cover the period November 2012-July 2015. This process has been summarised in Figure 2.4.

Figure 2-4. Flowchart summarizing the results of updated searching (and screening search findings) for primary quantitative observational studoes relevant to sleep assessments conducted during pregnancy. Searches were conducted using the OvidSP-Medline and Embase databases of articles published from November 2012-July 2015.



*Conference abstracts and studies on non humans or children were excluded.

B.2.1 OvidSP-Medline updated search (November 2012-July 2015)

The updated OvidSP-Medline search (November 2012-July 2015) was undertaken with no 'language' limits applied, although this search once more used filters to ensure that only articles with abstracts and studies on humans were included. This generated an additional n=1,000 articles for possible inclusion in this Chapter's analyses.

B.2.2 Embase updated search (November 2012-July 2015)

The updated Embase search (November 2012-July 2015) was likewise undertaken with no 'language' limits applied, and with filters to identify only articles with abstracts and studies that were on humans. This generated an additional n=989 articles for possible inclusion in the analyses to be conducted.

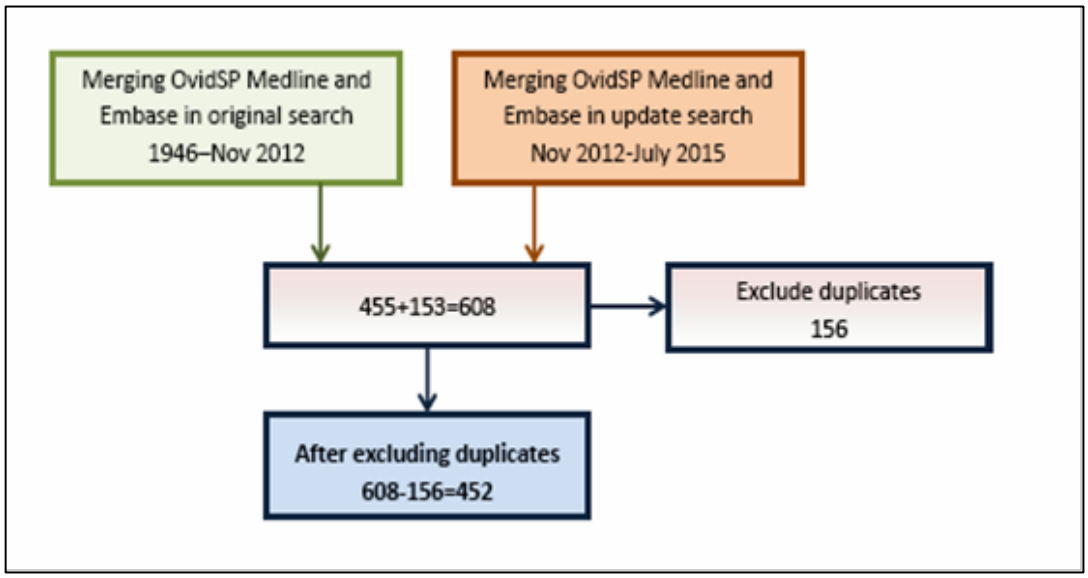
B.2.3 Merged searches for OvidSP-Medline and Embase (November 2012-July 2015)

After merging the results of both searches, and screening these against the inclusion and exclusion criteria, a total of n=210 articles remained, which was reduced to n=153 after the removal of duplicate articles (see Figure 2.4).

B.3 Merging of original and updated searches

When the outcome of the original searches (1946-November 2012) and updated searches (November 2012-July 2015) were merged, this produced a total of n=608 articles, which was reduced to a final number of n=452 articles after excluding duplicates (see Figure 2.5).

Figure 2-5 Flowchart summarizing the results of both the original and updated searching (and screening search findings) for primary quantitative observational studies relevant to sleep assessments conducted during pregnancy. Searches were conducted using the OvidSP-Medline and Embase databases of articles published from 1946-July 2015.



B.4 Creation of the Endnote database

"Archive" databases were then created for the original search outputs (1946-November 2012) for OvidSP-Medline and Embase separately. These search outputs were then merged combining Embase and Medline and any duplicates were removed. These search outputs were then divided into relevant and irrelevant categories, annotating the contents of the Endnote database accordingly. The same process was then repeated for the updated search covering the period November 2012-July 2015.

B.5 Establishing inclusion/exclusion criteria

The inclusion and exclusion criteria adopted in the present study required all included articles to contain measures of sleep conducted on female human participants while they were pregnant. Therefore, in order to assess the utility of these criteria, the titles and abstracts of the first n=200 articles were reviewed manually to identify those which were relevant to sleep in pregnancy (i.e. those which reported sleep measurements *during* pregnancy). This involved independent screening by two researchers (the doctoral candidate herself and her lead supervisor). Any disagreements were resolved by consensus, and used to strengthen the inclusion/criteria employed, meaning that these could then be applied with greater confidence while examining the remaining articles.

This 'screening' of search results involved examining the title of each article, and, where available, the abstract, then classifying these as 'definitely relevant'
(i.e. met all inclusion criteria); 'definitely not relevant' (i.e. failed one or more of the inclusion criteria); or 'relevance unclear' (i.e. where the abstract was not available for review or where this did not contain sufficient information to assess relevance). Articles classified as 'definitely not relevant' were excluded at this stage, while the full-length versions of all the remaining articles (i.e. both 'definitely relevant' and 'relevance unclear') were obtained from the University of Leeds library, through inter-library loan or directly from the authors themselves. A second round of 'screening' was then undertaken, involving the careful examination of each article (paying particular attention to the Methods and Results sections) to establish which of these might be classified as 'definitely relevant', and to identify any self-administered instruments and

any custom item sets used by the authors to assess the self-reported sleep of pregnant participants.(see Table 2.4)

Thus, the formal inclusion criteria used were:

- The article must report data recorded on sleep (i.e. sleep measurement) regardless of whether this involved the use of subjective or objective techniques;
- At least some of the sleep data must have been collected from women during pregnancy, and these data must be presented separately from any data collected before and/or after pregnancy; and
- The article must draw upon a primary empirical research study,

  i.e. not a review of previously published research.

Table 2-4 A summary of the articles considered irrelevant to the focus of the present Chapter's systematic review.

	Classifications	1946-NOV 2012	NOV 2012-JULY 2015	Total
IRRELEVANT	Review, non-empirical study, no sleep measurement	213	62	275
	Languages other than English**	8	9	17
	Sleep in mother and post-partum	135	37	172
	High risk pregnancy (mental disorder, chronic disease)	80	34	114
	Total of irrelevant studies identified	436	142	578
RELEVANT	Low risk pregnancy	8	6	14
	Low risk pregnancy but no exclusion criteria mentioned	8	1	9
	GDM	3	4	7
	Total of relevant studies identified	19	11	30
Total		**455**	**153**	**608**

**There were n=17 articles published in languages other than English: Persian (n=4); Turkish (n=2); Polish (n=2); German (n=2); Czech (n=2); Japanese (n=1); French (n=1); Chinese (n=1); Spanish (n=1); and Russian (n=1).

Additional classification of the reviewed articles sought to disaggregate these into three distinct groups, namely:

1. **Low risk pregnancy** (where the study's sampling exclusion criteria *did not* specifically mention the exclusion of participants experiencing 'high risk' pregnancy, but no such risks were reported).
2. **Low risk pregnancy** (where the study's sampling exclusion criteria specifically mentioned the exclusion of participants experiencing 'high risk' pregnancy).
3. **Pregnancy involving women diagnosed with GDM** (where the study's sampling criteria specifically sought to include women diagnosed with GDM).

C. Stage Three: Tabulate relevant studies

Based on the three samples of study participants outlined above (i.e. those with low risk pregnancy where no such inclusion criteria were specified ; those with low risk pregnancies identified using specific inclusion criteria; and those included on the basis of a clinical diagnosis of GDM), some n=30 studies were ultimately categorised as relevant for inclusion in the systematic review conducted in this chapter. After organising the articles alphabetically by Author Surname and Year, each study was given a unique ID number in the Endnote database, so that if the same author(s) had published another study in the same year, the study title could also be added to avoid confusion. The source of the data used in each study of this kind was carefully examined to ensure these data were not the same and that data supporting relationships between pregnancy and sleep would not be 'counted' more than once in the final syntheses.

First category: Low risk pregnancy with no explicit exclusion criteria (n=9)

[8]Kaneita et al., 2005, [10]Ko et al., 2010, [13]Leung et al., 2005, [14]Lopes et al., 2004, [15]Loprinzi et al., 2012, [19]Ohide et al., 2007, [26]Schorr et al., 1998, [27]Signal et al., 2014, [28]Sugihara et al., 1998. See tables (2.5,2.6)

Second category: Low risk pregnancy with explicit exclusion criteria (n=14)

[2]Cai et al., 2013, [3]Facco et al., 2010 (sleep disturbance in pregnancy),
[5]Haney et al., 2014, [7]Hertz et al., 1992, [9]Karkan et al., 1968, [11]Lara Carrasco et al., 2014, [12]Lee et al., 2000, [16]Loube et al., 1996, [17]Matsuzuki et al., 2011, [20]Okun et al., 2013, [21]Okun et al., 2014, [22]Osaikuwuomwan et al., 2014, [29]Tauman et al., 2011, [30]Wilson et al., 2011. See tables (2.7,2.8)

Third category: Participants included on the basis of a clinical diagnosis of GDM (n=7)

[1]Bisson et al., 2014, [4]Facco et al., 2010, [6]Herring et al., 2014,[18]O'Brien et al., 2012,
[23]Qiu et al, 2010 [24]Reutrakul et al., 2011, [25]Reutrakul et al., 2013. See tables (2.9,2.10).

Comprehensive extractions of data for articles within each of these categories have been presented in three sets of two tables (Tables 2.5 and 2.6, 2.7 and 2.8, and 2.9 and 2.10). The first of each pair of tables includes information on the article's citation: year

of publication; country in which the study took place; study design used; sample size(s) of pregnant participants included the age and mean age range; gestational age(s) at which sleep measurements were recorded; the exposure and outcome variables (as specified); the technique(s) used to assess sleep; and the inclusion/exclusion of measured covariates.The second table in each pair provides information on any statistical analyses undertaken (including any statistical models used, and the reported results as described in these models).

A summary of these characteristics for all n=30 of the studies is provided below:

Year: The earliest study was published in 1968, the most recent in 2014. Only n=1 study was published in 1968, n=4 in the period 1992-1999, and n=5 in 2000-2007; whilst the majority (n=20; 66.7%) were published in 2008-2014.

Country: Most of the studies were conducted in the USA (n=16), with more than one study in Japan (n=3), Canada (n=2), Brazil (n=2), and only n=1 in each of the following seven countries: Hong Kong, China, Taiwan, Australia, New Zealand, Nigeria and Israel. Importantly, none of the previous studies included in the present review had been conducted within the UK.

Study design: Cross-sectional analysis was the most commonly used (n=11) study design, followed by cohort studies (n=10) and case control (n=9).

Sample size: The selected studies were classified by their number of participants as small (5-50 participants); medium (51-150 participants) and large (n≥150 participants). On this basis, n=4 of the studies examined were classified as 'small'; n=6 were classified as 'medium'; and n=20 were classified as 'large'. Altogether, these n=30 studies provided data on a total number of n=62,014 women.

Participants: There were three main participant categories: the majority of studies (n=20; 66.7%) focused solely on pregnant women; a further n=9 involved pregnant and non-pregnant participants; and only n=1 study included both pre-pregnant and pregnant participants.

Mean age range: The lowest mean age of participants included in any one study was 23 years; and the maximum was 33 years.

Gestational age (T1,T2,T3)[1]: Most of the studies (n=14) assessed sleep in all three trimesters of pregnancy; while n=8 studies examined sleep in just two trimesters: T1 and T2 (n=4 studies); T2 and T3 (n=3 studies); T1 and T3 (n=1 study); and n=8 studies had examined pregnant women in only one trimester: T3 (n=6 studies); and T2 (n= 2 studies).

Sleep measurements: The majority of studies used subjective measurement tools (i.e. self-administered sleep instruments=17). The remainder either used objective tools alone (n=4; including polysomnography with/without actigraphy), or a combination of subjective and objective sleep measurement tools (n=9).

Analytical techniques: Only n=14 studies used general linear/logistic regression techniques while the remainder only used descriptive or bivariate analyses.

Covariates: Taken together, the studies reviewed had measured (and/or considered for possible inclusion as exposures or confounders) one or more of the following variables: age; race/ethnicity; height; BMI; neck circumference; waist circumference; educational attainment; employment/occupation; family income/income/financial strain; residency; marital status/relationship status; marital satisfaction; parity and/or garvidity; history of psychiatric/psychological/mental health problems; smoking; alcohol consumption; general lifestyle behaviours/exercise; current mental health/stress/fatigue/anxiety; and gestational age at measurement/assessment. However, only n=17 of the n=30 studies had adjusted for covariates considered potential confounders (or perhaps as competing exposures). (see Appendix 2.1) for list of Abbreviations used in the reviewed studies for tables (2.5-2.10). See table 2.11

[1] T1=First trimester (0-12 weeks), T2=Second trimester (13-27 weeks), T3=Third trimester (>27) http://www.webmd.com/baby/tc/pregnancy-your-first-trimester#1

Table 2.11 Summary of findings of the studies included in the systematic review:

Systematic review studies	**First category:** **Low risk pregnancy with no explicit exclusion criteria (n=9)**	**Second category:** **Low risk pregnancy)with explicit exclusion criteria (n=14)**	**Third category:** **Participants included on the basis of a clinical diagnosis of GDM (n=7)**
Year of study: 1968-1992	-	1	-
1992-1999	2	2	-
2000-2007	4	1	-
2008-2014	3	4	7
Region in which study was based: North America	2	9	7
Australia and New Zealand	1	1	-
Asia	5	3	-
Brazil	1	-	-
Africa	-	1	-
Study design: Cohort	1	5	4
Cross-sectional	7	3	1
Case-control	1	6	2
Sample size: ≥150 participants	7	9	4
51-150 participants	1	2	1
5-50 participants	1	3	2
Participants included: Pregnant only	8	7	5
Pregnant and non-pregnant	1	6	2
Pre-pregnant and pregnant	-	1	-
Mean age range:	Lowest mean age of participants included in any one study was 19 years; and the maximum was 44 years.	Lowest mean age of participants included in any one study was 18 years; and the maximum was 45 years.	Lowest mean age of participants included in any one study was 18 years; and the maximum was 45 years.
Gestational age/trimester(s) at which sleep measured: T1,T2,T3	8	4	
T2,T3	NA	1	2
T1,T3	NA	1	NA

T1,T2	NA	4	1
T2	NA	NA	2
T3	1	3	1
Sleep assessment method used: Subjective measurement tools	7	7	4
Objective tools	1	3	1
Combination of subjective and objective tools	1	4	2
Data analysis used: Descriptive or bivariate analyses and linear/logistic regression	4	3	6
Descriptive or bivariate analyses alone	5	11	1
Adjustment for covariates: Yes	4	5	6
No	5	9	1
Findings reported: Association between pregnancy/ GDM/hyperglycemia and sleep characteristics Sleep duration	7(studies)	10(studies)	6(studies)
Latency	6(studies)	5(studies)	-
Wake up in the night	7(studies)	8(studies)	-
Snoring	4(studies)	3(studies)	6(studies)
Take medication to help sleep	2(studies)	3(studies)	-
Sleep quality	1 (study)	4(studies)	1 (study)
Daytime sleepiness	7(studies)	2(studies)	1 (study)
Dream	1 (study)	1 (study)	-
RLS	1 (study)	1. (study)	-

2.4 Discussion

While the systematic review described in this Chapter offers a firm basis upon which to understand the wealth of information available from previous quantitative studies exploring sleep in pregnancy, it was necessary to apply a consistent approach to evaluate whether (or not) the evidence provided by each study was reliable. This involved developing and applying a critical appraisal tool, comprising a series of questions focussing on the methods used and potential biases in the analyses

undertaken (see Appendix 2.2 Critical Appraisal Checklist).

Critically appraising the included studies highlighted a lack of consistency in a range of areas. These include measurement (not least of sleep itself), study design (with relatively few offering longitudinal evidence from well-powered samples) and analysis (with a limited number of studies attempting multivariable analyses capable of adjusting for potential confounding). Consequently, substantial uncertainty remains regarding the following three key issues:

- What role, if any, pregnancy-related changes in hormonal, physiological and anatomical changes play in the less favourable sleep commonly reported by pregnant women (based on self-administered sleep instruments and custom item sets) or in the changes in sleep recorded objectively (both using polysomnographic recordings to measure the frequency and duration of rapid eye movement (REM) and slow wave sleep (SWS); and using actigraphy to generate data on movement-related sleep/wake-active/rest patterns);
- What role, if any, pre-pregnant lifestyles, behaviour and circumstances might play in any changes in sleep experienced during pregnancy (particularly those known to be relevant to sleep); and
- What role, if any, changes in lifestyle, behaviour and circumstances (particularly those known to be relevant to sleep) that occur during pregnancy (including those that occur as a result of pregnancy, and those that continue to change as pregnancy proceeds) might play in any changes in sleep experienced in pregnancy.

2.5 Key findings

Very few of the previous studies reviewed made any concerted effort to distinguish between these three groups of potential determinants. However, previous studies on pregnant women with medical conditions unique to pregnancy (such as pregnancy-induced hypertension, pre-eclampsia and GDM) do recognise that variation in such phenomena might offer insights into the impact of pregnancy-specific changes (of a hormonal, physiological and anatomical nature) on sleep per se.

Perhaps most importantly, relatively few studies (n=10; 33%) used longitudinal designs

capable of measuring *changes* in sleep. Moreover, none of these used well-designed (theory-driven) multivariable statistical models to establish whether variation in such changes might be explained by pre-existing sociodemographic or health characteristics. Nor did any of them determine whether such variation might be associated with differences in health and wellbeing *during* pregnancy. Associations of this type might indicate a possible role for sleep as either determinant or consequence of such differences; or at least a potential marker of these suitable for consideration as a clinical diagnostic tool. There were two other potential flaws amongst the past studies reviewed. Firstly, most studies failed to separate singleton and multiple pregnancies (for which there may be very different associations with sleep); and second they tended to focus predominantly on a limited range of sleep characteristics.

This review has helped to identify a number of methodological issues that it will be important to address in future prospective studies of sleep in pregnancy. It also highlighted the need to explore these issues in data collected within the United Kingdom, given that none of the reviewed studies had been conducted on data collected there.

Critical appraisal of the studies included consideration of each study's: sample size, study design, sleep measurement used, sleep characteristics measured, and statistical technique used.

Among the 30 studies examined, (Kaneita et al., 2007; and O'Brien et al., 2012) provided data on far larger samples of participants (15,981 - cross-sectional and 1,712 – cohort), respectively. Both studies used multivariate analyses that adjusted for potential confounders and the sleep outcome assessed using a validated self-reported questionnaire. However, while (Kaneita et al. 2007) examined seven separate sleep characteristics (duration; latency; disturbance/awakening; coughing/snoring; medication; quality; and daytime sleepiness); (O'Brien et al. 2012) focussed instead on the association between sleep and glucose intolerance since glucose intolerance was the key outcome of interest, rather than pregnancy per se.

2.6 Tables (2.5 – 2.10)

Table 2.5. Low risk category with no explicit exclusion criteria (study participants and methods).

Table 2.5. Low risk category with no explicit exclusion criteria (study participants and methods).

Author, region, year *Study title*	Study design	Final Sample size	Sample population	Age (yrs) & mean age range	Gestational Age	*Exposure:* Definition of exposure	*Outcome/s*: Definition of outcomes	Sleep assessment method	Inclusion/ exclusion criteria
[8]Kaneita et al., Japan, 2005 *Relation of smoking and drinking to sleep disturbance among* *Japanese pregnant women*	Cross-sectional	15,981 P♀ T1: 1810 T2: 4958 T3: 9213	P♀ from 500 clinical institutions with maternity patients during 1- 14/02/2002.	19-40	T1, T2, T3	*Smoking and drinking behavior during pregnancy:* non- smokers; ex- smokers; new- smokers; smokers; heavy smokers (= ≥20 cigarettes) non-drinkers; ex-drinkers; new-drinkers; drinkers; heavy drinkers (= >40gm of pure	*Sleep:* Subjective insufficient sleep ; difficulty in initiating or maintaining sleep; early-morning awakening; short sleep duration (defined as <7h sleep/ night); excessive daytime sleepiness; RLS	Sleep questionnaire based on PSQI and International RLS Group	Inclusion: ♀ with confirmed pregnancy having attended for second or subsequent consultation at clinical institutions during 1-14/02/2002 Exclusion: Not reported.
[10]Ko et al., Taiwan, 2010 *A comparative study of sleep quality between pregnant and*	Cross-sectional	300 P♀ T1:150 T2:150 NP♀ 300	150 T2 P♀ 150 T3 P♀ recruited from two medical centers in Taiwan	150 P♀ T2 31.19±4.03 (aged 20- 42); 150 P♀ T3	T2, T3	P♀	*Sleep:* Sleep quality: sleep latency; sleep duration; habitual sleep efficiency; sleep disturbances; use of sleeping medication; daytime dysfunction	-PSQI -Edinburgh Postnatal Depression Scale - Perceived Stress Scale.	Inclusion: Aged over 20 in T2, T3 Exclusion: Not reported

Table 2.5. Low risk category with no explicit exclusion criteria (study participants and methods).

Author, region, year *Study title*	Study design	Final Sample size	Sample population	Age (yrs) & mean age range	Gestational Age	*Exposure:* Definition of exposure	*Outcome/s*: Definition of outcomes	Sleep assessment method	Inclusion/ exclusion criteria
non-pregnant Taiwanese women				(aged 21- 43). 300 NP♀ 32.67±3.60 (aged					
[13]Leung et al., Hong Kong, 2005 *Sleep disturbances in Chinese pregnant women*	Prospective cohort	195	Antenatal clinic, Prince of Wales Hospital, Hong Kong	19-43 31.4 ±4.4	T1,T2, T3 Mean GA at recruit-ment= 10.9 wks	P♀	*Sleep:* -Snoring; -daytime sleepiness; -frequent awakenings; -difficulty falling asleep	-Sleep and Health Questionnaire; -ESS; -Poly-somnography	Inclusion: Hong Kong Chinese ♀ attending antenatal clinic at Prince of Wales Hospital in T1 Exclusion: Not reported but results showed no ♀ with history of hyper-tension or pre-eclampsia. Two multi-parous ♀ had history of
[14]Lopes et al., Brazil, 2004 *Sleep disorders in pregnancy*	Cross-sectional	300 T1:100 T2:100T3:100	100 P♀ per trimester. Brazilian outpatients from São Paulo. Interviews held in outpatient clinic waiting room, pre-appointment with doctor	11-40	T1, T2, T3	P♀	*Sleep:* Insomnia: difficulty in falling asleep *Sleep breathing disorders:* Snoring; difficulty in breathing	Clinical interview based on directed questions (see Definition of outcomes)	Inclusion: P♀ aged 11- 40 Exclusion: not reported

Table 2.5. Low risk category with no explicit exclusion criteria (study participants and methods).

Author, region, year *Study title*	Study design	Final Sample size	Sample population	Age (yrs) & mean age range	Gestational Age	*Exposure:* Definition of exposure	*Outcome/s*: Definition of outcomes	Sleep assessment method	Inclusion/ exclusion criteria
							Excessive daytime sleepiness: suddenly falling asleep during activity/in inappropriate places *Mild sleepiness:* falling asleep during day/taking naps *Specific awakenings:* due to baby movement; nightmares/		
[15]Loprinzi et al., USA, 2012 *The relationship between physical activity and sleep among pregnant women*	Cross-sectional	138 P♀ T1:27 T2:66 T3:45	Data from the National Health and Nutrition Examination Survey 2005- 2006	18-43	T1,T2, T3	*P♀ wearing Actigraph accelerometer to measure physical activity:* -Intensity of physical activity/day (moderate; vigorous; moderate-to- vigorous) -Prevalence of meeting physical activity guidelines (at	*Sleep:* 22-item questionnaire: no. of hours sleep/night and time (min) taken to fall asleep; snoring frequency; trouble sleeping; frequency of having trouble falling asleep; frequency of waking up at night and getting back to sleep; frequency of waking up too early in morning and inability to sleep again; frequency of feeling unrested during daytime regardless of hours of sleep obtained; frequency of feeling overly sleepy during daytime; frequency of not getting enough sleep; frequency of taking pills to help sleep; frequency of leg jerks while sleeping; frequency of leg	Functional outcomes of sleep questionnaire	Inclusion: Sufficient Actigraph data; positive pregnancy test based on urine and serum sample; non- breast feeding; self- reported sleeping data. Exclusion: Not reported.

Table 2.5. Low risk category with no explicit exclusion criteria (study participants and methods).

Author, region, year *Study title*	Study design	Final Sample size	Sample population	Age (yrs) & mean age range	Gestational Age	*Exposure:* Definition of exposure	*Outcome/s*: Definition of outcomes	Sleep assessment method	Inclusion/ exclusion criteria
						min vigorous-intensity physical activity; or combination of both	while sleeping; difficulty concentrating due to sleepiness/tiredness; difficulty finishing meal due to sleepiness/tiredness; difficulty getting things done due to being too tired/sleepy		
[19]Ohide et al., Japan, 2007 *Is passive smoking associated with sleep disturbance among pregnant women?*	Cross-sectional	16,396 P♀ (2002) T1:1,145 T2:5,709 T3:9,068 Unknown: 474 19,386 P♀ (2006) T1:1,244 T2:6,793 T3:10,991 Unknown: 350	Clinical institutions specializing in obstetrics and gynecology that participated in nationwide surveys: 260 (in 2002) and 344 (2006)	19-40	T1,T2, T3	*P♀ exposed to smoking:* 1-active smoking status; 2-passive smoking status (whether or not subject was exposed to environ-mental tobacco smoke	*Sleep:* Subjective insufficient sleep ascribed to ♀ answering "insufficient" or "very Insufficient" to relevant item. Difficulty in initiating sleep (DIS); Difficulty maintaining sleep (DMS); Early morning awakening (EMA); Short sleep duration (SSD) = getting <7h sleep/night. Excessive daytime sleepiness (EDS); Snoring loudly or breathing uncomfortably (SB). DIS, DMS, EMA, EDS, and SB ascribed to ♀ answering	2002 survey included 6 sleep- related items; 2006 version added further question: "Do you wake up during nocturnal sleep because of snoring loudly or breathing uncomfortably?" (see Definition of outcomes)	Inclusion: Confirmed pregnancy attendees at second or subsequent consultation at clinical institutions 1-14/02/2002 and 6–18/02/2006. Exclusion: Not reported
[26]Schorr et al., USA, 1998	Prospective cohort	4 P♀ (total of 3 studies T1,T2, T3) 4 NP♀	Low risk P♀ identified in private office-based obstetric practice	15-44 32±4.6	T1,T2, T3	P♀	*Sleep*: sleep latency; unexplained	Polysomnography	Inclusion: Low risk P♀ identified in private office-based obstetric practice.

Table 2.5. Low risk category with no explicit exclusion criteria (study participants and methods).

Author, region, year *Study title*	Study design	Final Sample size	Sample population	Age (yrs) & mean age range	Gestational Age	*Exposure:* Definition of exposure	*Outcome/s*: Definition of outcomes	Sleep assessment method	Inclusion/ exclusion criteria
Sleep patterns in pregnancy: a longitudinal study of poly-somnography recordings during pregnancy							total sleep time		Non-P♀ age-matched; weight; non-smokers; race. Exclusion: No medical or surgical illness; No history of snoring, sleep disorders, medical complications, or
[27]Signal et al., New Zealand, 2014 *Prevalence of abnormal sleep duration and excessive daytime sleepiness in pregnancy and the role of socio-demographic factors: comparing pregnant women with women in the general*	Cross-sectional	358 P♀ (Maori) 717 P♀ (non-Maori) 381 General population (Maori) 577 General population (non-Maori)	P♀ recruited from across NZ using range of methods to recruit equal numbers of P♀ (Maori/non-Maori) **Sample of P♀:** questionnaires and information came from lead maternity carer (midwife or obstetrician), community health group, or research team member **General population sample:** Random sample of adults (2,100 Maori; 1,900 non-Maori) chosen from NZ electoral roll in June 2001	20–46	T3	P♀	*Sleep:* -Short (≤6h); normal (>6h and ≤9h), or long (>9h). -Daytime sleepiness measured by ESS	-Self-reported total sleep time in 24h -ESS scores	Inclusion: Random sample of adults aged 20–59 (2,100 Maori; 1,900 non-Maori) selected as per sample population Exclusion: Not reported.

Table 2.5. Low risk category with no explicit exclusion criteria (study participants and methods).

Author, region, year *Study title*	Study design	Final Sample size	Sample population	Age (yrs) & mean age range	Gestational Age	*Exposure:* Definition of exposure	*Outcome/s*: Definition of outcomes	Sleep assessment method	Inclusion/ exclusion criteria
[28]Sugihara et al., Japan, 1998 *Sleep behavior of pregnant women using sleep log*	Cross-sectional	172 P♀ T1:13 T2:71 T3:88	172 P♀ living in/around Tokyo metropolitan area, voluntary participants in sleep log study (1 wk)	28.6 ± 5.6	T1,T2, T3	P♀	*Sleep:* Subjective time in bed (sTIB); subjective time out of bed (sTOB); subjective time of wakefulness in bed (sTWB); subjective frequency of awakening during night sleep (sFAB); subjective total sleep time (sTST); subjective nap time and timing (sNAP).	1-Sleep log 2-Self-reported questionnaire evaluating sTIB; sTOB; sTWB; sFAB; sTST; and sNAP	Inclusion: P♀ living in/around Tokyo metropolitan area, volunteered for sleep log study (1 wk) Exclusion: not

Table 2.6 Low risk category with no explicit exclusion criteria (data analysis used and results of studies).

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Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/ standard error	OR/ regression coefficient/ (95% CI)	Covariates	Adjusted co- variates	Results
[8]Kaneita et al., Japan 2005	Multiple logistic regression used to estimate association between sleep disorders and smoking status after adjusting for demo- graphic status. ORs and 95% CIs are indicated.	n/a	n/a	n/a	OR for SSD in heavy smokers was highest (OR: 3.19, 95% CI: 2.06–4.94). After adjusting for other factors, association between sleep disturbance and drinking status, OR in drinkers was highest for EMA (OR: 1.46, 95%CI: 1.26–1.76).	Age; education; employment; pregnancy trimester; no. of pregnancies.	Age; final academic background; employment status; pregnancy status (no. of pregnancies; pregnancy trimester).	Current smoking prevalence among surveyed Japanese P ♀ = 9.9%; pre- pregnancy = 25.7%. Prevalence of heavy smoking (20+ cigarettes /day) pre- and post-pregnancy = 1.0%. Drinking prevalence post-confirmation of pregnancy= 11.1%; pre-pregnancy= 45.9%. **'Smoking and drinking' group showed highest prevalence of all 7 sleep disorders;** 'non-smoking and non-drinking' group had lowest prevalence. For all 7 sleep disorders, heavy-smoker group showed higher ORs than other groups. OR for **SSD** in heavy smokers was highest (OR: 3.19, 95% CI: 2.06–4.94). Analysis of association between sleep disturbance and drinking status, after adjusting for other factors, showed OR in drinkers was highest for **EMA** (OR: 1.46, 95%CI: 1.26–1.76). **Quality of sleep** for drinkers was lower than for non-drinkers.

Table 2.6 Low risk category with no explicit exclusion criteria (data analysis used and results of studies).

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/ standard error	OR/ regression coefficient/ (95% CI)	Covariates	Adjusted co-variates	Results
[10]Ko et al., Taiwan, 2010	chi-square test ANCOVA	PSQI scores differed significantly among three groups (χ2=8.69, *df*=2, *p*=.01). Prevalence of poor sleepers (PSQI score>5) was 60.0% for P♀ T2, T3 and 48.0% for NP♀	No differences found among three groups in sleep duration (*F*=.99, *p*=.37); sleep medication (*F*=0.65, *p*=.52); daytime dysfunction (*F*=2.49, *p*=.08), and depression (*F*=2.37, *p*=.09). Significant differences (*p*<.05) in global sleep quality; subjective sleep quality; sleep latency; sleep efficiency; sleep disturbances. T2 group prevalence of antenatal depression (EPDS score>14)	n/a	n/a	Age; no. of children; employment status; education level; socio-economic status; marital satisfaction	Age; no. of children; employment status; marital satisfaction	Both smoking and drinking increased odds of **sleep disturbances (e.g. SIS, DIS, DMS, EMA, SSD, EDS and RLS).** Joint ORs for smoking and drinking roughly corresponded to products of OR for smoking or drinking. **Smoking and drinking are independently associated with increased sleep disturbance during pregnancy,** in addition to other well- known side-effects.

Table 2.6 Low risk category with no explicit exclusion criteria (data analysis used and results of studies).

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/ standard error	OR/ regression coefficient/ (95% CI)	Covariates	Adjusted co-variates	Results
[10]Ko et al., Taiwan, 2010	chi-square test ANCOVA	PSQI scores differed significantly among three groups (χ2=8.69, *df*=2, *p*=.01). Prevalence of poor sleepers (PSQI score>5) was 60.0% for P♀ T2, T3 and 48.0% for NP♀	No differences found among three groups in sleep duration (*F*=.99, *p*=.37); sleep medication (*F*=0.65, *p*=.52); daytime dysfunction (*F*=2.49, *p*=.08), and depression (*F*=2.37, *p*=.09). Significant differences (*p*<.05) in global sleep quality; subjective sleep quality; sleep latency; sleep efficiency; sleep disturbances. T2 group prevalence of antenatal depression (EPDS score>14) =27.3% (41/150), depressed	n/a	n/a	Age; no. of children; employment status; education level; socio-economic status; marital satisfaction	Age; no. of children; employment status; marital satisfaction	Prevalence of poor sleepers (PSQI score>5) = 60.0% for T2, T3 P♀ and 48.0% for NP♀. After controlling for significant covariates, P♀ reported worse **global sleep quality, habitual sleep efficiency, and sleep disturbances than NP♀**. **Poor sleep quality and sleep latency were most prevalent in T3**. High prevalence of antenatal depression (27.3-36.0%) was found in P♀, depressed ♀ had **worse sleep quality** than non- depressed ♀ in all groups; stress affected sleep quality in P♀ but not in NP♀ and depression. For subjective sleep quality and sleep latency, T3 ♀ mean was higher than that of T2 ♀, and T3 ♀ mean was

Table 2.6 Low risk category with no explicit exclusion criteria (data analysis used and results of studies).

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/ standard error	OR/ regression coefficient/ (95% CI)	Covariates	Adjusted co- variates	Results
			T2♀ had worse sleep quality (8.39±3.50) vs. non-depressed ♀ (6.05±3.04; *t*=−4.03, *p*<.00). T3 group prevalence of antenatal depression (EPDS score>13) = 36.0% (54/150), depressed T3♀ had worse sleep quality (8.50±3.46) vs. non-depressed ♀ (6.26±3.46; *t*=−4.03, *p*<.00). NP♀ prevalence of depression (EPDS score>12; Evans et al., 2001) = 29.7% (89/300), depressed ♀ had worse sleep quality (8.01±3.45) vs. non-depressed ♀ (5.03±2.57;*t*=−7.33, *p*<.00).					higher than that of NP♀; means did not differ between T2♀ and NP♀. Mean perceived stress was higher in NP♀ than in T2 and T3 ♀. Stress did not differ significantly between T2 and T3 ♀. T2 and T3 P♀ reported **more frequent waking at night or early morning, getting up to use bathroom, and feeling hot during sleep. T3 ♀ were more often awakened by inability to breathe comfortably and pain than T2 ♀, and latter suffered more on both indicators than NP ♀.** **Sleep medication was** rarely used by P♀; however, despite reported poor sleep quality as pregnancy advanced, few ♀ used non-pharmacological alternatives to promote restful sleep. There is preliminary evidence that **P♀ suffer significantly poorer sleep quality than NP♀**, and that sleep

Table 2.6 Low risk category with no explicit exclusion criteria (data analysis used and results of studies).

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/ standard error	OR/ regression coefficient/ (95% CI)	Covariates	Adjusted co- variates	Results
[13]Leung et al., Hong Kong, 2005	1. Student's t-test 2.Anova 3. x2	Frequency of self-reported snoring increased from 29.7% in T1 to 40.5% and 46.2% in T2, T3, respectively, with increase in prevalence of moderate or severe snoring from 1% in T1 to 7.2% in T3. Higher frequency of moderate-severe snoring intensity among subjects with BMI ≥25 vs. those with BMI <25 kg/m2 in T3 (20.8% vs. 5.3%).	n/a	n/a	n/a	Age, BMI, smoking, drinking, parity	n/a	The frequency of self-reported snoring increased from 29.7% in T1 to 40.5% and 46.2% in T2, T3, respectively, with an increase in the prevalence of moderate or severe **snoring from 1% in T1 to 7.2% in T3** (P < 0.01). There was a higher frequency of moderate to severe **snoring intensity among subjects with BMI _25 compared with those with BMI <25 kg/m2 in the third trimester** (20.8% vs 5.3%, P < 0.01). Subjective **sleepiness, as determined by the ESS, increased significantly from 8.6 to 9.4 and 9.6 in T1, T2, T3** respectively. **Frequent awakenings and difficulty falling asleep were common throughout T1, T2 and T3** of pregnancy although the latter was generally rated as mild.

Table 2.6 Low risk category with no explicit exclusion criteria (data analysis used and results of studies).

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/ standard error	OR/ regression coefficient/ (95% CI)	Covariates	Adjusted co- variates	Results
[14]Lopes et al., Brazil, 2004	Data was analyzed using Qui-square test and Fisher's exact test.	143 cases of Insomnia, 113 cases of sleep Breathing disorder, 54 cases of excessive daytime sleepiness EDS, 22 cases of specific awakenings. In the T2 there was an increase of 23% in insomnia complaints (p<0.005) In relation to Pre-pregnancy PG the rate of pregnant women with EDS was increased by 15% in the T1 (p<0.003), 55% in the T2 (p<0.001) and by 14% in the T3 (p<0.002), The rate of pregnant women with mild sleepiness was not different within the T1. In the T2 there was an increase of 33% (p<0.002) and in the T3 the increase detected was of 48% (p<0.001).The Specific Awakenings were very prevalent (p<0.001) in the T1, T2 and T3 compared to the PG state (T1=63%; T2 =80%; T3=84%)	n/a	n/a	n/a	Not reported	n/a	Rate of P♀ with **insomnia** increased by 23% in **T2** (p< 0.005); rate for **EDS** by **15%** in **T1** (p<0.003), **55% in T2** (p<0.001) and **14% in T3** (p<0.002); **rate for mild sleepiness increased by 33% in T2** (p<0.002) **and 48% in T3** (p<0.001); **rate for specific awakenings increased by 63% in T1, 80% in T2 and 84% in T3** (p<0.001). **Sleep disorders were more frequent during pregnancy vs. pre-pregnancy, mostly due to EDS and specific awakenings**.

Table 2.6 Low risk category with no explicit exclusion criteria (data analysis used and results of studies).

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/ standard error	OR/ regression coefficient/ (95% CI)	Covariates	Adjusted co-variates	Results
[15]Loprinzi et al ., USA, 2012	Wald test; F-value was estimated, logistic regression	n/a	n/a	n/a	Unadjusted results showed that for each 1-min increase in **meeting physical activity guidelines ,mean estimates of moderate vigorous and moderate to vigorus physical activity (MVPA), P♀ were 11% less likely to have leg cramps while sleeping (OR =1.11, 95% CI:1.04-1.18, p = 0.02).** When first adjusted model was controlled for depression and gestation (only variables associated with both MVPA and nocturnal leg cramps), relationship was attenuated and no longer significant (OR =	Age; race/ ethnicity; marital status; smoking status; BMI; parity; income	Depression and gestation; parity and income	Physical activity was only associated with two of 22 sleeping-related parameters assessed. After controlling for depression, gestation, income and parity, for each 1-min increase in moderate-to-vigorous physical activity, P♀ were 17% less likely to have difficulty finishing a meal due to tiredness/sleepiness (OR = 1.17, 95% CI: 0.98-1.38, p = 0.06). P♀ **engaging in more physical activity were less likely to have difficulty finishing a meal due to tiredness/sleepiness and regular participation in physical activity was**

Table 2.6 Low risk category with no explicit exclusion criteria (data analysis used and results of studies).

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/ standard error	OR/ regression coefficient/ (95% CI)	Covariates	Adjusted co-variates	Results
					1.04, 95% CI: 0.97-1.11,p = 0.20). Controlling for depression and gestation, **for each 1-min increase in MVPA,** P♀ were **28% less likely to have difficulty finishing a meal due to tiredness/sleepiness (OR = 1.28, 95% CI: 1.00-1.63, p = 0.04**). When controlling for a measure of parity and income, association was slightly attenuated (OR = 1.17, 95% CI: 0.98-1.38			**associated with fewer leg cramps while sleeping.** This finding is important as up to 30% of P♀ can be affected by leg cramps and up to 26% have RLS. The finding that more active P ♀ were less likely to have difficulty finishing a meal due to tiredness/sleepiness is also important since having sufficient energy to eat meals during pregnancy helps ensure proper dietary intake, which is key to maternal and offspring health. Data suggests a **weak relationship between objectively-measured physical activity** and sleep.
[19]Ohide et al., Japan, 2007	Logistic regression analyses	In 2002 survey, active smokers showed highest prevalence, statistically significant for all 6 items related to sleep disturbance: SIS 25%; DIS 27.9%; EMA 12.5%; SSD (<7 h) 31.6%; EDS 32.6%. In 2006 it was all 7: SIS 23.5%; DIS 23.2%; DMS 40.5%; EMA 11.7%; SSD (<7 h) 32.1%; EDS 32.7%; SB 3.3%.	n/a	n/a	OR for SB among non-smokers with enviromental tobacco smoke (ETS) was 1.25 (95% CI: 1.03-1.52) after adjusting for the 6 co-variates. Non-smokers exposed to ETS were significantly more likely to suffer from SB than non- smokers who were not exposed to ETS; active smokers were over twice as likely (OR=2.23, 95%CI: 1.50-3.32) to suffer from SB than non- smokers not exposed to ETS	age (under 20; 20-29; 30-39; 40+); schooling completed (junior, lower, or higher college); employment status; alcohol consumption. Items on pregnancy	Socio-demographic (age; final academic level; employment status; drinking status) and pregnancy-status (no. of pregnancies; pregnancy trimester)	**P♀ exposed to passive smoking were likely to have sleep disturbances (e.g. SIS, DIS, SSD, and SB)**. In addition, smoking P♀ also experienced **EDS and EMA**. Prevalence of **SIS, DIS, SSD, EDS, and SB** among non-smokers exposed to ETS showed a mean value between that of active smokers and non- smokers not exposed to ETS. **Passive smoking is independently associated with increased sleep disturbance during pregnancy.**

Table 2.6 Low risk category with no explicit exclusion criteria (data analysis used and results of studies).

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/ standard error	OR/ regression coefficient/ (95% CI)	Covariates	Adjusted co- variates	Results
		Among non-smoking ♀, prevalence of all sleep disturbance items was higher for those exposed to ETS than those who				status (no. of pregnancies: T1, T2, or subsequent); trimester (T1, T2, T3).		
[26]Schorr et al., USA, 1998	Unpaired t-test and repeated measure analysis of variance.	n/a	the pregnant patients had a significantly shorter percentage of total sleep time in delta sleep (4.9+/-1.9% vs 21.9+/-6.0%, p=0.03).	n/a	n/a	Weight Agerace	n/a	Qualitative differences in sleep between pregnancy patients and control subjects were evident. Control subjects displayed a normal appearance of slow-wave sleep in stages 3 and 4 (delta sleep). When pregnant patients did display delta sleep, it appeared abnormal secondary to extensive alpha-wave intrusion. Even when including this abnormal delta sleep in a quantitative comparison, the pregnant patients had a significantly shorter percentage of total sleep time in delta sleep (4.9+/-1.9% vs 21.9+/-6.0%, p=0.03). Sleep in pregnancy is characterized by loss of normal slow-wave sleep. Thus, sleep stages 3 and 4 are shortened during pregnancy, this have been responsible for symptoms of excessive tiredness and daytime sleepiness. This sleep alteration is persistent when followed longitudinally during pregnancy.

Table 2.6 Low risk category with no explicit exclusion criteria (data analysis used and results of studies).

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/ standard error	OR/ regression coefficient/ (95% CI)	Covariates	Adjusted co- variates	Results
[27]Signal et al., New Zealand, 2014	Proportions and 95% CIs used to describe categorical variables of interest; χ2-analyses used to determine differences in proportion of ♀: 1-by ethnicity: (Maori/non-Maori) within samples (P♀/ general population); 2-between samples for ♀ of same ethnicity. Multivariate analyses conducted for following outcome variables: total sleep time in 24h; sleep duration (short, normal, and long); daytime sleepiness (excessive or not). For continuous variables, ANOVA was employed using a generalized linear model.	Compared to non-Maori P♀, Maori P♀ were more likely to be aged 20–24; less likely to be aged 30–39 [$\chi2(4) = 101.04$, $P < 0.001$]; more likely not to be currently in paid work; more likely to do paid work including night shifts [$\chi2(2) = 20.13$, $P < 0.001$]; more likely to be long sleepers [$\chi2(2) = 18.53$, $P < 0.001$] and to report EDS [$\chi2(1) = 5.74$, $P = 0.017$]. In general population, compared to non-Maori ♀, Maori ♀ were: more likely not to be currently in paid work; more likely to do paid work including night shifts [$\chi2(2) = 10.79$, $P = 0.005$]; more likely to be short sleepers and less likely to be normal sleepers [$\chi2(2) = 15.62$, $P < 0.001$]; more likely to report EDS [$\chi2(1) = 4.71$, $P = 0.030$]. Logistic multivariate regression models used to determine independent predictors of short (vs. normal) sleep; long (vs. normal sleep) and EDS (vs. ESS <10).	n/a	n/a	Multivariate regression	Ethnicity; age; socio- economic status; employment status	Ethnicity; age; socio-economic status; employment status	P♀ average 30 min less **TST** than ♀ in general population. **TST** distribution was also greater in P♀, who were 3 times more likely to be short sleepers (≤6h) and 1.9 times more likely to be long sleepers (>9h). P♀ were 1.8 times more likely to report **EDS.** P♀ **under 30** experienced greater age- related declines in TST. Being **>30** independently increased risk of reporting sleeping ≤6 h/night and decreased risk of sleeping >9h/night. **Younger** ♀ (20-24) reported more sleep than older Maori ♀, being **unemployed ♀, and ♀ working night shifts** increased likelihood of reporting abnormal sleep duration across whole ♀ population. **EDS** more likely to occur in Maori ♀ and ♀ who were night workers. Changes in sleep duration in pregnancy are not as strongly influenced by **socio-economic status** as biological changes and other socio- demographic factors (e.g. age, employment), but sleep quality yet not assessed in this study.

Table 2.6 Low risk category with no explicit exclusion criteria (data analysis used and results of studies).

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/ standard error	OR/ regression coefficient/ (95% CI)	Covariates	Adjusted co-variates	Results
[28]Sugihara et al., Japan, 1998	Sleep log	sNAP was longer in primiparas than multiparas (17.5 min vs. 5.9 min). sFAB increased gradually over course of pregnancy from T1 to T3 (14.1min vs. 22.3 min), sTWB increased in T3.	n/a	n/a	n/a	Age; parity	n/a	More **sTWB** and **sFAB** were reported in P♀ than in NP♀, showing change of sleep characteristics towards poor sleep subjectively. This was more prominent **in T3**. Causative agents for changes were micturition, bodily changes and caring for child and husband. Shortage of night sleep led to longer **sNAP** in late pregnancy. Logs revealed **primiparas** napped in the morning and afternoon while **multiparas** napped mainly in the afternoon. Results suggest **primiparas** made up for sleep shortage by morning and afternoon napping, while multiparas have to take care of children and home. These social factors seem to be an important causative factor aggravating night sleep characteristics of multiparas. According to subjective evaluations, multiparas could not make up **night sleep shortages** with morning naps as primiparas could.

Table 2.7 Low risk category with explicit exclusion criteria (study participants and methods).

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Author, region, year ***Study title***	**Study design**	**Final Sample size**	**Sample population**	**Age & Mean age range (in years)**	**Gestational age**	***Exposure:*** **Definition of exposure**	***Outcome/s*:** **Definition of**	**Sleep assessment method**	**Inclusion/exclusion criteria**
[2]Cai et al., China, 2013 *The prevalence and associated risk factors of sleep disorder-related symptoms*	Case control	1,993 P♀ 598 NP♀.	Obstetric Clinic, Second Affiliated Hospital, Wenzhou Medical College. Healthy ♀ were also enrolled as controls in the same period during routine physical examination at outpatient clinic.	Not mentioned	T1 ,T2, T3	pregnancy	*Sleep disorder related symptoms* -Snoring -Nocturnal arousal -Insomnia -Daytime sleepiness -sleep talking/walking	-Berlin questionnaire - Other items adapted according to characteristics of P♀ in the study -ESS -PSQI	Inclusion: Married P♀ attending for routine pre- natal care at Obstetric Clinic, Second Affiliated Hospital, Wenzhou Medical College were enrolled in the study. Healthy NP ♀ were selected from outpatient clinic during routine physical examination.
[3]Facco et al., USA, 2010, *Sleep Disturbances in Pregnancy*	Cohort	189 ♀ completed both baseline and follow- up sleep surveys	Northwestern Memorial Hospital Participants recruited in the outpatient setting from ♀ receiving care at Northwestern-affiliated practices.	3 age groups: 1-under 24. 2- 24-34 3- 35 or over 29.7 ±5.5	T1, T2, T3	pregnancy	*Sleep* 1- Snoring 2-EDTS 3- RLS 4- Insomnia. 5-SSD	1-Berlin Questionnaire for Sleep Disordered Breathing 2-ESS 3-National Institutes of Health/International RLS question set 4- WHIIRS	Inclusion: healthy nulliparous with singleton gestation Exclusion: chronic hypertension, heart disease, chronic lung disease, pre-gestational diabetes, chronic renal disease, and autoimmune disease

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[5]Haney et al., Pittsburgh, USA, 2014 *Sleep disturbance and cardiometabolic risk factors in early pregnancy: a preliminary study*	Secondary analysis drawn from a longitudinal, prospective study Sleep in Pregnancy (SLIP) Cohort	161 Participants	P♀ residing in Greater Pittsburgh area recruited 10/2008-12/2010 by self or physician referral, local advertising, or via participation in University research registries. The breadth of advertising afforded a diverse and highly representative cohort.	19-40 29 ± 5	T1 ,T2	*Sleep* (a) SOL (amount of time between reported bedtime and sleep onset time); (b) WASO (amount of time awake after sleep onset); and (c) TST, (amount of time between sleep onset and offset).	*BMI* BMI was calculated as kg m *Blood pressure* Sitting values of SBP and DBP collected by study nurse. *Weight*	Daily Pittsburgh sleep diary and wore a wrist actigraph; participants had health assessment,including BP and weight measurements.	Inclusion: ♀ in general good health were recruited at approximately 10 wks gestation by self- or physician referral, local advertising or participation in university research registries. Exclusion : current diagnosis of depression, bipolar disorder or anxiety, self-reported sleep disorders (e.g., sleep apnoea, narcolepsy, hypersomnia or insomnia), current use of antidepressant, antipsychotic or anti- inflammatory medication, gynaecologic anatomical abnormality, hypertension, diabetes, HIV or other major chronic diseases
[7]Hertz et al., USA, 1992	Case control	12♀ in T3 and 10 age-matched NP controls	Obstetrics Department, Winthrop University Hospital	P: 22-40 30.5 ±5.1 Control: 28-41 31.6±5.4	T3	P♀ in T3	Total sleep time, SE, snoring, sleep latency , WASO, bad dreams	-Polysomnography -Stanford sleepiness scale	Inclusion: P♀ T3 recruited from Obstetrics Department, Winthrop University Hospital Exclusion:

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Author, region, year ***Study title***	**Study design**	**Final Sample size**	**Sample population**	**Age & Mean age range (in years)**	**Gestational age**	***Exposure:*** **Definition of exposure**	***Outcome/s*****: Definition of**	**Sleep assessment method**	**Inclusion/exclusion criteria**
Sleep in Normal Late Pregnancy							1-SE defined as total sleep time/total time in bed. 2-Sleep latency. 3-WASO 4-sleep stages 1,2,3/4		high-risk pregnancy, medical or psychiatric complications
[9]Karkan et al., Florida, 1968 *Characteristics of sleep patterns during late pregnancy and the postpartum period*	case-control	7 white ♀ from clinic in late pregnancy/ early postpartum vs. age-matched control.	7 white ♀ selected from Obstetrics-Gynecology Clinic , University of Florida Health Center	22-30 (mean 24.5)	T3	Pregnancy and postpartum	Sleep latency Sleep time Frequent awakenings	Electro-encephalograph	Inclusion: P♀ selected from Obstetric-Gynecology clinic (University of Florida health center) where they had been followed from early pregnancy. Exclusion: All had been examined and were free from any gross pathology.
[11]Lara-Carrasco et al., Canada 2014	Case-control prospective	57 P 59 NP♀.	Dream and Nightmare Laboratory, Hôpital du Sacré-Coeur de Montréal (Canada)	18-39 P♀ (mean ± SD, 28.70 ± 4.06)	T3	Pregnancy	*Dream* *Sleep quality* *Sleep duration*	- Spielberger STAI -EPDS -BDI-SF SDQ	Inclusion: Adverts in healthcare centres in Québec province (Canada) and word of mouth during 08-12/2010).All reported being French-speaking, recalling at

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Disturbed dreaming during the third trimester of pregnancy				NP♀ 26.83 ± 4.21			Participants were provided definitions distinguishing nightmares from bad dreams according to whether or not emotionally negative imagery woke them up, and they rated these as disturbed dreaming, vivid dream bad dream (don't wake you up) nightmare (wake you up). To assess sleep quality participants were instructed to indicate number of times they awoke at	-Home sleep and dream log	least one dream/wk, and being free from severe sleep and psychiatric disorders. None reported taking medications known to affect sleep. P♀ did not report any major obstetric complications.
[12]Lee et al., USA, 2000	Cohort	45 during follicular and luteal phases of	Newspaper and television adverts and flyers posted on	Nulliparous 30.5± 3.7 Multiparous	T2	Pregnancy, pre-pregnancy follicular phase	*1-total sleep time* (mins in stages 1, 2, 3– 4,and REM sleep)	polysomnography	Inclusion:

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Author, region, year ***Study title***	**Study design**	**Final Sample size**	**Sample population**	**Age & Mean age range (in years)**	**Gestational age**	***Exposure:*** **Definition of exposure**	***Outcome/s:*** **Definition of**	**Sleep assessment method**	**Inclusion/exclusion criteria**
Parity and Sleep Patterns During and After Pregnancy		menstrual cycle; 33 conceived and were studied during T1-T3 of pregnancy; 29 in months 1,3 postpartum	California University campus	31.5 ± 3.9 25–39			2- *SE* (proportion of time in bed actually spent asleep). 3-*SOL*		Healthy ♀ 25–39 yrs old who were planning a pregnancy within the next year were eligible. Exclusion : ♀ with diagnosed sleep problems or children not yet consistently sleeping through the night; ♀ with histories of mental health problems or taking
[16]Loube et al., San Antonio,USA, 1996 *Self-reported Snoring in Pregnancy* *Association With Fetal Outcome*	Case control Prospective non randomised screening	350 P♀ 110 age-matched NP♀	Brooke Army Medical Center (Fort Sam Houston) and Killeen (Darnall Army Community Hospital, Fort Hood)	P: 25±9 NP: 24±6	T2 and T3	pregnancy	*Snoring:* various degrees of snoring frequency in P♀ group reporting snoring were distributed as follows: 25% rarely, 26% sometimes, 33% often, 16% always.	-Self-reported snoring Hawaii scale -ESS -Nocturnal polysomnography (night watch system).	Inclusion : All P♀ presenting as routine (non-high risk)

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[17]Matsuzaki et al., Japan, 2011 *Factors related to the continuation of employment during pregnancy among Japanese women*	Cross-sectional	530 T1: 124 T2: 183 T3:223	Obstetrics Clinic in a Tokyo suburb for outpatients	30.4±4.6	T1 ,T2, T3 24.3 ±9.0	Healthy P♀	Reasons for stopping work during pregnancy, and effects of working conditions: sleep duration is one of the factors: night-time sleep (h), daytime sleep (min).	1- 12-item General Health Questionnaire 2-Subjective Fatigue Symptom scale	Inclusion: healthyP♀ with single fetus Exclusion: ♀ without pregnancy complications who were not suffering from an illness were enrolled.

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[20]Okun et al., Pittsburgh, USA, 2013 *Prevalence of Sleep Deficiency in Early Gestation and its Associations with Stress and*	cohort	160	recruited from Greater Pittsburgh 10/2008-12/2012 (as part of longitudinal study assessing pregnancy-related sleep disturbances in relation to perinatal outcomes using self-/physician	29.6 ±4.8	T1, T2	pregnancy	*SSD, insufficient sleep, or insomnia* 1-Sleep diary 2- actigraphy Diary assessed sleep duration was split at	1-PSQI Sleep diary 2- actigraphy Diary assessed sleep duration was split at <7/≥7h, while actigraphy-assessed sleep duration was split at <6/> 6h	Inclusion: P♀ (<14 wks) recruited from Greater Pittsburgh during 10/2008-12/2012 (as part of longitudinal study assessing pregnancy-related sleep disturbances in relation to perinatal outcomes. Recruitment was by self-/physician referral, local advertising, or via
Depressive Symptoms			referral, local advertising, or via participation in Pittsburgh University research registries				<7/≥7h, while actigraphy-assessed sleep duration was split at <6/≥ 6h		participation in University research registries. All ♀ intended to keep the pregnancy when enrolled. Exclusion: No self-reported sleep or psychological disorder, taking anti-depressant medication or receiving psychotherapy; No ♀ with chronic diseases e.g. diabetes, HIV or uterine abnormalities

[21]Okun et al., Pittsburgh, USA, 2014 *Low Socioeconomic Status Negatively* *Affects Sleep in Pregnant Women*	secondary analysis drawn from a longitudinal, prospective study Sleep in Pregnancy (SLIP) Cohort	170 P♀	P♀ residing in Greater Pittsburgh 10/2008-12/2010 recruited by self-/physician referral, local advertising, or participation in University research registries. The breadth of advertising afforded a diverse and highly representative cohort.	18-45 29.5±4.7	T1, T2 10-20 wks	*Socio-economic status in P♀.* Self reported annual household income in two groups: <$50,000/yr and >/equal to $50,000/yr. This cutoff represents median split and is consistent with previously	Sleep quality Sleep duration Sleep fragmentation	PSQI Wrist actigraphy	Inclusion: P♀ (<14 wks) recruited from Greater Pittsburgh during 10/2008-12/2012 (as part of longitudinal study assessing pregnancy-related sleep disturbances in relation to perinatal outcomes. Recruitment was by self-/physician referral, local advertising, or via participation in University research registries. All ♀ intended to keep the pregnancy when enrolled. Exclusion:

Table 2.7. Low risk category with explicit exclusion criteria (study participants and methods).

Author, region, year ***Study title***	**Study design**	**Final Sample size**	**Sample population**	**Age & Mean age range (in years)**	**Gestational age**	***Exposure:*** **Definition of exposure**	***Outcome/s*****: Definition of**	**Sleep assessment method**	**Inclusion/exclusion criteria**
						of P♀ in Pittsburgh (Levine, Marcus, & Leon-Verdin, 2008).			No self-reported sleep or psychological disorder, taking anti-depressant medication or receiving psychotherapy; No ♀ with chronic diseases e.g. diabetes, HIV or uterine abnormalities
[22]Osaikhuwuomwan et al., Nigeria, 2014 *Sleep disorders in women attending antenatal care at a tertiary hospital in Nigeria*	prospective Cross-Sectional Studies	203 P ♀ T1:57 T2:71 T3:75	P♀ attending antenatal clinic in Obstetrics Department, University of Benin Teaching Hospital 10/2011- 12/2012	30.9±4.9	T1 T2 T3	pregnancy	insomnia, sleep breathing disorders, EDS, mild sleepiness, significant specific awakenings	-Sleep and health questionnaire -ESS	Inclusion: P♀ attending antenatal clinic in Obstetrics Department, University of Benin Teaching Hospital 10/2011-12/2012 Exclusion: Multiple pregnancy or recently diagnosed health problems e.g. diabetes or hypertension in current pregnancy.
[29]Tauman et al., Israel, 2011 *Maternal snoring during pregnancy*	Cross section	246	admitted to labor and delivery service in active labor	20-44 31.2±4.6	39.3±1.1 wks (range: 37.0-41.4 wks) T3	pregnancy	*Sleep* snoring during the current pregnancy, sleep pauses and daytime	ESS	Inclusion: singleton, uncomplicated, full-term pregnancies Exclusion:

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Author, region, year *Study title*	Study design	Final Sample size	Sample population	Age & Mean age range (in years)	Gestational age	***Exposure:*** Definition of exposure	***Outcome/s*:** Definition of	Sleep assessment method	Inclusion/exclusion criteria
not associated with fetal growth restriction									♀ who reported any pregnancy/obstetric complications e.g. hypertension and gestational diabetes. ♀ with chronic medical condition (except mild asthma and hypothyroidism); ♀ without bed- partners
[30]Wilson et al., Australia, 2011 *Decreased sleep efficiency, increased wake after sleep onset and increased cortical arousals in late pregnancy*	Case control	27 ♀ T3 (30–38 wks) 21 ♀ T1 (9–14 wks) 24 NP♀ control	Outpatient Obstetrics Clinic, Mercy Hospital for Women NP ♀control recruited from adverts in Austin Health newsletter and from friends of P♀ participants	Control: 29.3 ± 5.9 T1: 29.6 ± 3.4 T2:32.3 ± 3.5	T1, T3	pregnancy	sleep efficiency, latency ,increased WASO, usual sleep duration, difficulties falling asleep. -SE (total sleep time⁄total dark time), sleep latency (3 epochs of stage 1 sleep or 1 epoch of any other sleep stage),REM sleep latency(number of awakenings during sleep and WASO.	Overnight polysomnography, questionnaires developed for study regarding sleep quality rating on 1-10 scale	Inclusion: 430 P♀ from Outpatient Obstetrics Clinic, Mercy Hospital for Women were consecutively approached to participate in the study; NP control ♀ recruited from adverts in Austin Health newsletter and from friends of P♀ participants. Exclusion: multiple or complicated pregnancy, significant medical, psychological or psychiatric disorder diagnosed by health professional, previously diagnosed sleep disorder (e.g. obstructive sleep apnoea, insomnia, hypersomnolence), or current using anti-depressant medication.

Table 2.8 Low risk category with explicit exclusion criteria (data analysis used and results of studies).

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Citation	**Data analysis used**	**Proportion/chi square test**	**Mean/t-test**	**SD/standard error**	**OR/regression coefficient/ (95% CI)**	**Co-variates**	**Adjusted co-variates**	**Results**
[2]Cai et al., China, 2013	mean±SD u tests one-way ANOVA, followed by Fisher Least Significant Difference post hoc test. Dunnett's T3 test was used to compare differences of sample with heterogeneity of variance. Kruskal-Wallis H test chi-square stepwise logistic regression.	Prevalence of sleep disorder-related problems in P and NP♀ is statistically significant (P<0.01): 56 and 29.9 %, respectively, Prevalence of sleep disorder-related symptoms in P and NP♀ was 30.2 vs. 7.1 % for snoring during sleep, 1.10 vs. 0.2 % for sleep apnea-like symptom, 23.7 vs. 3.5 % for mouth breathing, 46.5 vs. 0.7 % for nocturnal arousal, 35.1 vs. 26.8 % for insomnia, and 52.6 vs. 15.7 % for daytime sleepiness, respectively. PSQI score, prevalence of sleep apnea-like symptoms, mouth	n/a	n/a	Smoking, drinking, allergic rhinitis/asthma and obvious difference in neck circumference and waistline between T1, T3 were risk factors associated with sleep disorder-related symptoms. OR values were 3.39 (95% CI 1.09–10.57), 2.40 (95% CI 1.67-171) 3.44 (95% CI 1.13-2.60) 1.11 (95% CI 1.07–1.16)and 1.07 (95% CI 1.06–1.08)	age; ethnicity; residency; education; occup-ation; smoking; drinking; neck circumfer-ence and waistline	age; ethnicity; residency; education; occupation	Overall prevalence of sleep disorder-related symptoms in P♀ was significantly higher than for controls (56.1 vs. 29.9 %, P< 0.05). There was higher prevalence of **snoring** (30.2 %), observed sleep apnea (1.1 %), mouth breathing (23.7 %), **nocturnal arousal** (46.5 %), **insomnia** (35.1 %), and **daytime sleepiness** (52.6 %) in P♀. There were no significant differences of prevalence of bruxism (7.0 vs. 6.7 %), **sleep talking** (8.1 vs. 7.2%), and **sleep walking** (0.4 vs. 0.2%) between both groups (P>0.05). Nocturnal sleep time (8.0± 1.3 h) was less in T3 vs. NP♀ (8.2±1.1 h) (P<0.05). Smoking (OR3.39), drinking (OR02.40), allergic rhinitis/asthma (OR1.71), an obvious difference in neck circumference (OR01.11), and waistline (OR1.07) changes between T1 and T3 were risk factors for sleep disorder-related problems. Moreover, ♀ **living in rural areas, with higher education and with white collar jobs**, all have a reduced prevalence of sleep disorders during pregnancy, Furthermore, the present study demonstrates that **smoking, drinking,** allergic rhinitis/asthma, and an obvious difference **in neck circumference and waistline** between T1 and T3 are risk factors associated with sleep disorder-related symptoms during pregnancy.

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Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/standard error	OR/regression coefficient/ (95% CI)	Co-variates	Adjusted co-variates	Results
		breathing, and insomnia in T3 were significantly higher than those in T1, T2 (P<0.01), while no significant differences were found between T1 and T2(P>0.05). No significant differences in prevalence of sleep talking/walking at different pregnancy stages (P>0.05). Nocturnal sleep time (8.0±1.3 h) was less in T3 vs. T1 and T2 (8.2±1.2 and 8.2±1.2 h), as well as vs. NP♀ (8.2±1.1 h) (P<0.05).						
[3]Facco et al., USA, 2010,	1-t test 2-chi-square 3-McNemar test 4-Multi-variable logistic regression Differences in	n/a	Mean sleep duration was significantly shorter (7.4h [±1.2] vs. 7.0h[±1.3], P<.001	n/a	Obese, **Hispanic** ♀ more likely to report new onset short sleep duration in T3 (OR 2.4, 95% CI 1.00 – 5.96; and OR	Age; ethnicity; pregnancy BMI; employ-ment;	n/a	Mean **sleep duration** was significantly shorter (7.4h [±1.2] vs. 7.0h[±1.3], P<.001), and proportion of patients who reported frequent **snoring** in T3 was significantly greater (11% vs. 16.4%, P=.03). During T3, nearly 40% of participants reported sleeping <7h/night on average, and >16% reported frequent snoring. PSQI scores of >5 became significantly more common as

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Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/standard error	OR/regression coefficient/ (95% CI)	Co-variates	Adjusted co-variates	Results
	sleep characteristics between baseline and T3 were compared using paired *t* test or McNemar test for continuous or categorical data, respectively. Associations between sleep patterns and patient characteristics were explored using t test for continuous variables and chi-square test for categorical variables. Multivariable logistic regression used to estimate independent association of these patient characteristics with probability of sleep				2.9, 95% CI 1.02– 9.47, respectively).			pregnancy progressed (39.0% vs. 53.5%, P=.001). **Younge**r individuals (under 24) were less likely to report new onset of short sleep duration (OR 0.2, 95% CI 0.06–0.99). In contrast, obese, **Hispanic** ♀ were more likely to report new onset short sleep duration in T3 (OR 2.4, 95% CI 1.00 –5.96; and OR 2.9, 95% CI 1.02– 9.47, respectively). **Obesity** (BMI 30 or above) and **African-American** ethno-racial status were associated with frequent **snoring. Short sleep duration** was more common among **employed** participants. ♀ **over 35**, with **African-American or Hispanic** ethno-racial status were associated with poor overall **sleep quality** (PSQI score >5). In T3, the percentage of patients reporting significant **sleep disturbances** increased.

Table 2.8. Low risk category with explicit exclusion criteria (data analysis used and results of studies).

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/standard error	OR/regression coefficient/ (95% CI)	Co-variates	Adjusted co-variates	Results
	disturbance.							
[5]Haney et al., Pittsburgh, USA, 2014	1-Pearson's or Spearman's rank correlation analyses: to assess degree of linear relationship between continuous variables, as applicable. 2-Point biserial and polyserial correlation analyses: to assess degree of relation-ship between dichotomous and continuous measures, or ordinal and continuous measures 3-Mixed modelling techniques: to examine if binary	n/a	n/a	Evaluation of co-variates indicated pre-pregnancy weight was correlated with T1 SBP (r (93) = 0.46, p < 0.0001) and DBP (r (93) = 0.39, p = 0.0002) after adjusting for age; race; marital status; no. of children; stress and depressive symptoms. Married ♀ had shorter diary and actigraphy-assessed SOL (r (159) = _0.28, p = 0.0003; r (146) = _0.24,p = 0.0038) and WASO (r (146) = 0.33,p <0.0001) and longer actigraphy-assessed sleep	n/a	Age; race; marital status; exercise; no. of children; pre-pregnancy weight. Stress symptoms measured with: 10-item Perceived Stress Scale; self-reported symptoms of depression Inventory of Depressive Symptoms	Age; race; marital status; no. of children; stress; depressive symptoms	BMI and BP changed significantly across time. ♀ with persistent SOL ≥20 min had greater BMI than those without persistent SOL≥20 min prior to co-variate adjustment at T1 and T2; BMI values converged at T3. Similar results observed for persistent WASO≥30 min. Persistently long WASO (measured by actigraphy) was associated with elevated SBP, after controlling for co-variates. Consistent with anecdotal evidence, it appears that a subset of ♀ report substantial difficulty initiating and maintaining sleep during early pregnancy which may raise the risk of higher BP and BMI. Understanding these relationships is important as Cardio metabolic risk factors are linked to maternal and infant morbidity. Assessing sleep in early pregnancy may give time necessary for appropriate intervention.

Table 2.8. Low risk category with explicit exclusion criteria (data analysis used and results of studies).								
Citation	**Data analysis used**	**Proportion/chi square test**	**Mean/t-test**	**SD/standard error**	**OR/regression coefficient/ (95% CI)**	**Co-variates**	**Adjusted co-variates**	**Results**
	measures of sleep were associated with BMI and BP.			duration (r (146) = 0.26, p = 0.0012). Having more children at home was also associated with longer diary-assessed SOL (T1: r (153) = 0.22, p = 0.0138), greater weight (T1: r (148) = 0.23, p = 0.0119) and higher BMI (T1: r (145) = 0.24, p = 0.0102), but not SBP or DBP. Caucasian ♀ had shorter SOL (diary and actigraphy) (T1: r (159) = _0.27, p = 0.0005; r (146) = _0.24, p = 0.0035), less actigraphy-assessed WASO (T1: r (146) = _0.29, p = 0.0004) and				

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Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/standard error	OR/regression coefficient/ (95% CI)	Co-variates	Adjusted co-variates	Results
				longer actigraphy-assessed sleep duration (T1: r (146) = 0.32, p <0.0001).				
[7]Hertz et al., USA, 1992	1- chi-square tests 2-Mann-Whitney test and Wilcoxon signed rank test	P♀ vs. NP♀	awakening was found to be significantly higher in the P group (36.8 ± 10.5) as compared to control (22.8 ± 11.1)	n/a	n/a	n/a	n/a	**TST** P♀ demonstrated normal sleep onset and did not differ in total sleep time from NP♀. Although time in bed was higher in P♀ , sleep efficiency was significantly lowered vs. controls. **Decreased sleep efficiency** was mostly due to a marked increase in WASO in P♀. Other sleep changes in P♀ included a significant increase in sleep stage 1 and a significant decrease in REM sleep vs. the control group. There was a slight, but not significant decrease noted in slow-wave sleep. **Other sleep complaints reported significantly more frequently were lower back pain (75%), nocturnal leg cramps (75%) and morning headaches (58%). No significant differences were noted in reported snoring.** Reported **sleepiness** did not differ significantly among groups. A separate analysis was performed to examine changes in sleep over time during late pregnancy (wks 30-33 and 35-38). Mann-Whitney comparisons between both subgroups revealed no difference in sleep latencies, WASO and stages 1, 2 and slow-wave sleep, but the late group (wks 35-38) had a lower percentage of REM sleep p <0.02.
[9]Karkan et al., Florida,	Wilcoxon test	n/a	Sleep latency mean pre-	n/a	n/a	n/a	n/a	Overall sleep patterns observed in gestation seemed similar in some respects to insomnia and were statistically significant

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Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/standard error	OR/regression coefficient/ (95% CI)	Co-variates	Adjusted co-variates	Results
1968			delivery: 21.9 Control: 10.9 Sleep stage 4 mean pre-partum: 5.1 Control: 15.5					(**longer sleep latency, frequent awakening, shorter sleep time, and marked reduction of deep sleep stage 4).**
[11]Lara-Carrasco et al., Canada 2014	t-tests and v2-tests to identify potential covariates to include in subsequent between-groups analyses. One-way MANCOVA was performed, with pregnancy status (P, NP) as a between-group factor, and all the prospective and retrospective dream measures Sleep measures (sleep duration, sleep quality, night interruptions) for sleep periods	P♀ had higher retrospective dream recall than NP♀ (P = 0.01) a second v2-analysis assessing differences in proportions of ♀ recalling more than one nightmare/wk revealed a more substantial group difference (v2(116) = 4.97, P = 0.03): the proportion was three times higher among P♀ (21%) than among NP♀ 7%. 48 (84.2%) P♀ and 47 (80%) NP♀ reported disturbed dreaming across	n/a	n/a	n/a	Age, relation-ship status, employ-ment status, family income, education, and state–anxiety, personal history of psychiatric problems	Age, relationship status, employment status, family income, education, and state-anxiety.	Even though P and NP♀ showed similar prospective dream recall (P = 0.47), P♀ reported prospectively more **bad dreams** (P = 0.004). More P♀ (21%) than NP♀ (7%) reported **a nightmare** incidence exceeding moderately severe pathology (>1/wk) (P = 0.03). P♀ also reported overall **lower sleep quality** (P = 0.007) and **more night awakenings** (P = 0.003). Higher prospective recall of bad dreams (r = _0.40, P = 0.002) and nightmares (r = _0.32, P = 0.001) both correlated with lower sleep quality in P♀ but did not differ in mean **sleep duration** (P = 0.22).

Table 2.8. Low risk category with explicit exclusion criteria (data analysis used and results of studies).

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/standard error	OR/regression coefficient/ (95% CI)	Co-variates	Adjusted co-variates	Results
	with/without disturbed dreaming were compared using a 2x2 ANCOVA with group (P, NP) as a between-group factor, sleep period (with/ without disturbed dreaming) as a repeated measure factor	the 14-day period of the study. Nonetheless, post-hoc v2-analysis revealed that more P♀ (31%) were disturbed by repeated disturbed dreaming (P2 disturbed dreaming) occurring on the same night than NP♀ (11%; v2(95) = 6.07, P = 0.01). P♀ had overall lower sleep quality (P = 0.007) and more night interruptions (P = 0.003) than NP♀, but did not differ in mean sleep duration (P = 0.22)						
[12]Lee et al., USA,	1-Mean and SD 2-t-test	n/a	Total sleep time (min)	n/a	n/a	Age; ethnicity	n/a	Compared with pre-pregnancy sleep characteristics, significant changes in sleep patterns were evident by 11–12 wks'

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2000			and sleep efficiency are significant in pregnancy 11–12 wks			education; employ-ment parity; marital satisfac-tion		gestation, with significant increase in **total sleep time** but less **deep sleep** and **more awakening** during sleep. T1 **sleep time** was significantly higher than during pre-pregnancy baseline. Total sleep time for the sample during T1 averaged a high of 446 mins and a low of 372; however, **SE** remained significantly lower than baseline pre-pregnancy values. Results showed that sleep is different for **nullipara**s and **multiparas** pre- and post-pregnancy. Although **multiparas** had children sleeping through the night, their sleep pre-pregnancy was less efficient than **nulliparas** due to frequent brief awakenings.
[16]Loube et al., San Antonio, USA, 1996	1- t-tests 2-Mann-Whitney test 3.x2 tests used to compare observed frequency of events	P frequent snorer vs. P non-snorer. Frequent snoring was reported in 14% of P♀ vs. 4% of NP♀	n/a	n/a	n/a	Age, height, BMI, gestational age	N/A	**Self-reported frequent snoring is more prevalent in P♀ than in NP♀** (49 of 350 patients [14% vs. 4 of 110 patients [4%]; x2=6.2; df=l; p<0.05). Self-reported sleepiness in P♀ did not increase in pregnancy; P♀ were not significantly sleepier overall than NP♀ ESS. This finding is consistent with other studies evaluating changes in sleep and daytime function in pregnancy.
[17]Matsuzaki et al., Japan, 2011	1-chi square test 2-Kruskal-Wallis Test 3.-ANOVA	Participants were grouped by trimester: T1, T2, T3. In each trimester, basic attributes and lifestyle behaviors were compared				Age, gestational week, number of births, life style behavi-ours,		As for lifestyle behaviours, average **night-time sleep** duration for P♀ **who stopped working** during their pregnancy in T3 was 6.2 ± 1.1 h (mean ± standard deviation), which was **shorter** than that for **employed P♀** (7.0 ±1.1 h) and **full-time housewives** (6.8 ± 0.1 h), P♀ who stopped working during their pregnancy would have benefited from mental health support. A significant association was seen between **night-time sleep duration and the work situation in T3** (*P* >0.05).

Table 2.8. Low risk category with explicit exclusion criteria (data analysis used and results of studies).

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/standard error	OR/regression coefficient/ (95% CI)	Co-variates	Adjusted co-variates	Results
		using either Kruskal-Wallis test or chi-square test in three work situation groups: full-time housewives, ♀ who stopped working during pregnancy, and employed P♀. For employed P♀, employment status and work conditions in each trimester were compared using either Kruskal-Wallis test or the chi-square test.				mental health, fatigue.		With regard to average daytime sleep duration for each work situation, the length of a daytime nap was significantly shorter for the employed P♀ in each trimester, thus confirming a **significant association with the work situation and daytime sleep duration** (T1, T2, T3: *P* >0.001)
[17]Matsuzaki et al., Japan, 2011	1-chi square test 2-Kruskal-Wallis Test 3.-ANOVA	Participants were grouped by trimesters: T1 , T2, T3. In each trimester, basic attributes and lifestyle behaviours were compared using either Kruskal-Wallis test or chi-square test				Age, gestational week, number of births, life style behav-iours, mental health, fatigue.		As for lifestyle behaviours, average **night-time sleep** duration for the P♀ **who stopped working** during their pregnancy in T3 was 6.2 ± 1.1 h (mean ± standard deviation), which was **shorter** than that for the **employed P♀** (7.0 ±1.1 h) and **full-time housewives** (6.8 ± 0.1 h), P♀ who stopped working during their pregnancy would have benefited from mental health support. A significant association was seen between **night-time sleep duration and the work situation in T3** (*P* >0.05). With regard to the average daytime sleep duration for each work situation, the length of a daytime nap was significantly

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Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/standard error	OR/regression coefficient/ (95% CI)	Co-variates	Adjusted co-variates	Results
		among the following three work situation groups: full-time housewives, ♀ who stopped working during pregnancy, and employed P♀. For employed P♀, their employment status and work conditions in each trimester were compared by using either Kruskal-Wallis test or chi-square test.						shorter for the employed P♀ in each trimester, thus confirming a **significant association with the work situation and daytime sleep duration** (T1, T2, T3: *P* >0.001)
[20]Okun et al., Pittsburgh, USA, 2013	1-Chi-square 2-Linear mixed models	Three groups were identified: 1-Sleep deficient (met criteria for sleep deficiency at all time points); 2-Intermittent sleep deficient (met criteria for least one time point, but not all; 3-not sleep deficient (did not meet criteria for	n/a	n/a	n/a	Age; BMI; race; smoker; exercise; sleeping habits; marital status; education; income; parity	Race/ ethnicity; marital status; education; parity	Up to 40% of♀in **early gestation reported short sleep duration, insufficient sleep, or met case definition for insomnia. Approximately 28–38% met criteria for sleep deficiency** for at least one time point in early gestation. ♀who were **sleep deficient across all time points reported more perceived stress** than those who were not sleep deficient (p <0.01). Depressive symptoms were higher among ♀ with diary-defined sleep deficiency across all time points (p = 0.02).

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Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/standard error	OR/regression coefficient/ (95% CI)	Co-variates	Adjusted co-variates	Results
		sleep deficiency at any time point)						
[21]Okun et al., Pittsburgh, USA, 2014	Linear regression models	♀ of lower SES were more likely to have poorer sleep quality as indicated by higher PSQI scores (β = –.21, p = .005) after adjustment for race, marital status, parity, and perceived stress. This significant association remained significant following adjustment for financial strain (β = –.19, p = .01). In this model, only T1 perceived stress (β = .44, p <. 001) was correlated with poor sleep quality. ♀ with lower SES had more sleep fragmentation (β = –.26, p = .006), after adjusting for	n/a	n/a	n/a	Age ; race; marital status; parity; BMI; perceived stress; depressive symptoms	race; marital status; parity; perceived stress; financial strain	On average, lower SES♀reported modestly poor sleep quality (M = 5.4, SD = 2.7), short sleep duration (391[55.6] min) and fragmented sleep index (SFI M = 33.9, SD = 10.4. A household income <$50,000/yr was associated with poorer sleep quality (β = –.18, p < 0.05) and greater sleep fragmentation (β = –.18, p < 0.05) following covariate adjustment. **Low SES was associated with poorer sleep quality and fragmented sleep, even after statistical adjustments.** **Perceived stress and financial strain attenuated SES-sleep** associations indicating that psychosocial situations preceding pregnancy are also important to consider.

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Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/standard error	OR/regression coefficient/ (95% CI)	Co-variates	Adjusted co-variates	Results
		age, race, marital status, parity and perceived stress. No other co-variates were associated with sleep fragmentation. Low SES, defined as having an income <$50,000/yr, was not associated with sleep duration (*p*s >0.05).						
[22]Osaikhuwu-omwan et al., Nigeria, 2014	1-t-test 2-chi square 3-Logistic regression model	n/a	n/a	n/a	Logistic regression	n/a	n/a	Only insomnia and specific awakenings were statistically significant (p=0.007 and 0.031 respectively). Sleep Breathing Disorder (P=0.0001) and mild sleepiness (P=0.009) were associated significantly with BMI, and insomnia significantly associated with gestational age p=0.006 The logistic regression model showed that nulliparity (p=0.0001) increased BMI and previous adverse obstetric events had significant independent associations with sleep disorders. Sleep disorders are common in pregnancy, notably in T1, T3.
[29]Tauman et al., Israel, 2011	1-Independent t-test or chi square test	1- Snorers and non-snorers. 2- Habitual snorers	n/a	n/a	n/a	Age; number of previous pregnan-	n/a	Seventy-eight ♀ (32%) **reported habitual snoring** during pregnancy. Of those, 20 (26%) were chronic snorers and 58 (74%) were new-onset snorers. Frequent breathing pauses during sleep (≥4 nights/wk) in 14.5% of habitual snoring ♀.

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Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/standard error	OR/regression coefficient/ (95% CI)	Co-variates	Adjusted co-variates	Results
	2-ANOVA	vs. non-snorers. 3- Chronic snorers (habitual snorers who snored before pregnancy), new-onset snorers (habitual snorers who began to snore during pregnancy) and non-snoring controls				cies; BMI pre-pregnancy; weight gain; smoking; Gesta-tional age; infant birth weight; Apgar scores		Increased rate of **nulliparous** ♀ was found in new-onset **snorers** compared with both chronic snorers and non-snorers (54% vs. 25% and 29% respectively; p=0.001). No significant differences in **maternal age** (31.0±4.7 vs. 31.3±4.6 yrs), **maternal weight gain** as a percentage of body weight (23.8±9.6 vs. 21.5±8.9 %) and **smoking** rate (3.8 vs. 6.0 %) were found between habitual snorers and non- snorers. No significant differences were found in **ESS** scores between habitual snorers and non-snorers (7.9±3.5 vs. 7.7±4.2 respectively).
[30]Wilson et al., Australia, 2011	1-Chi-square test 2-MANCOVA 3-univariate ANOVA	Sleep efficiency is statistically significant and reduced gradually: 90% in control vs. 84.9% T1, 80.1% T3. WASO is also significant, increasing gradually: 28% in control vs. 49.4% in T1, 62.2% in T3. Sleep efficiency is significantly poor in nulliparous vs. multiparous in T3.	n/a	n/a	n/a	Age; BMI; Married; Nulli-parous; Tertiary educated; Employ-ment	n/a	**P**♀ reported significantly more **overnight awakenings vs. controls and were more likely to report difficulty falling back asleep.** **T3**♀ had **poorer sleep efficiency, more awakening, less stage 4 sleep, more stage 1 sleep and fewer minutess in REM sleep vs. control group**. **Nulliparous** ♀ in **T3 had significantly poorer sleep efficiency than multiparous** ♀ **in T3.** Sleep in T1 was unaffected by parity. This appears mostly because of more time in stage 2 sleep in the multiparous ♀. T3 P♀ were more likely to report **frequently waking during the night because of discomfort, back pain and leg cramps when compared to controls or T1**♀ Awakening because of urinary frequency was reported often for both P groups. T3 ♀ experienced more cortical arousals, especially as a consequence of limb movements or respiratory.

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Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/standard error	OR/regression coefficient/ (95% CI)	Co-variates	Adjusted co-variates	Results
		Difficulty in falling asleep after waking was significant in pregnancy in T3 63% vs. control 8.3% and T1 47%.						**T1**: Sleep during T1 was affected to a lesser extent, with **more wake time after sleep onset and less stage 4 sleep when compared to the controls events, compared to either T1 or NP♀.**

Table 2.9. GDM category (study participants and methods).

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Author, region, year *Study title*	Study design	Final Sample size	Sample population	Age & Mean age range	Gestational age	***Exposure:*** Definition of exposure	***Outcome/s*:** Definition of	Sleep assessment method	Inclusion/exclusion criteria
[1]Bisson et al., Canada, 2014 *GDM and Sleep-Disordered Breathing*	Case–control	26 cases 26 control	Tertiary obstetric centers of Centre Hospitalier Universitaire de Québec and McGill University Health Centre (Montreal). Participants in case and control groups identified from blood test results of P♀ routinely screened for GDM by OGTT at 24-0/7 and 32-6/7 wks of gestation.	Case : 32.8±6.1 Control: 32.7±3.8	T2, T3	***GDM:*** No definition of exposure	***Sleep:*** Sleepiness Sleep duration Sleep quality Snoring	Polysomnography; Sleepiness score (ESS); subjective sleep quality (PSQI)	Inclusion: aged 18 or older; singleton pregnancy; planned delivery at one of study centers. Exclusion: P♀ with diagnosis of sleep apnea, type 1 or 2 diabetes, or chronic hypertension pre-pregnancy or diagnosed before 20 wks gestation, no follow-up, uncontrolled thyroid dysfunction, or pre-pregnancy BMI
[4]Facco et al., Chicago, USA, 2010 *Self-reported short sleep duration and frequent snoring in pregnancy: impact on glucose metabolism*	Prospective cohort study	189 ♀	Secondary analysis of data from a prospective, observational study designed to evaluate prevalence of and trends in sleep disturbances throughout pregnancy. Patients were recruited from ♀ receiving care at Northwestern Memorial Hospital's affiliated	18- ≥35 29.7±5.5	T1, T2, T3	***Short sleep duration:*** <7 hrs of sleep/night ***Frequent snoring:*** snoring ≥3 nights/wk	***Included 1-hour OGTT results and presence of GDM:*** 1-hour OGTT values≥130, and GDM	1-Berlin Questionnaire for Sleep-Disordered Breathing. 2-ESS. 3-National Institutes of Health/International RLS question set. 4- WHIIRS	Inclusion: nulliparous and singleton gestation. Exclusion: chronic hypertension, heart disease, chronic lung disease, pre-GDM, chronic renal disease, and autoimmune disease (excluding treated hypothyroidism)

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[6]Herring et al., USA, 2014 *Objectively measured sleep duration and hyperglycemia in pregnancy*	Cohort	63 P♀	Recruitment began July 2008 at five university-affiliated outpatient pre- natal care clinics, Philadelphia	<25- ≥25 23.4±4.8	T2	***Sleep duration:*** 1-Total nocturnal sleep duration (= average total time in hrs spent sleeping on all available nights); 2-Total nap duration (average total time in hrs spent napping on days participants	***Maternal glycemic control:*** using 1-h OGTT defined as 1-h OGTT values ≥130 mg/dL	1-Wrist actigraphs 2- Daily sleep log, recording night-time sleep-onset time, morning wake time, and daytime naps ≥5 mins	Inclusion: included <16 weeks' gestation at enrollment, English or Spanish fluency, and current residence in Philadelphia. Exclusion: excluded women from our analysis who had pre-existing DM , at high risk for sleep apnea using the Berlin Questionnaire or delivered twins.
[18]O'Brien et al., Michigan, USA 2012 *Pregnancy-onset habitual snoring, gestational hypertension, and pre-eclampsia: prospective*	Prospective cohort	1,712 P♀ 202 NP ♀	Tertiary medical center	18-45 P: 29.7± 5.9 Control: 31.2± 7.8	T3	***Habitual Snoring:*** Snoring at least 3-4 times/wk. Similarly apneas were considered present if ♀ "stopped breathing or gasped for air" at least 3-4 times/wk.	***GDM:*** proportion of ♀ with abnormal glucose levels, defined as ≥140 mg/dL	Questionnaire about habitual snoring and whether ♀ had "stopped breathing or gasped for air" Sleep symptom questionnaire. .	Inclusion: P ♀ ≥18 yrs old and ≥28 wks with single fetus. Exclusion: None

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Author, region, year *Study title*	**Study design**	**Final Sample size**	**Sample population**	**Age & Mean age range**	**Gestational age**	***Exposure:*** **Definition of exposure**	***Outcome/s*:** **Definition of**	**Sleep assessment method**	**Inclusion/exclusion criteria**
[23]Qiu et al., USA, 2010	Cohort	1,290 ♀	Prenatal care clinics affiliated with Swedish Medical Center (Seattle, Washington)	<35 yrs ≥ 35 yrs 33.3±4.4	<20 wks gestation T1, T2	***Sleep:*** 1-Sleep duration: ≤ 4, 5-8, 9, and ≥ 10	***Glucose tolerance:*** glucose levels, defined as ≥140 mg/dL	Structured questionnaire including number of hrs of sleep before and	Inclusion: ♀ initiated prenatal care before 20wks gestation; 18 yrs old or over; could speak

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Glucose intolerance and gestational diabetes risk in relation to sleep duration and snoring during pregnancy: a pilot						hrs. ♀ who reported sleeping 9 hrs /night were the reference group. 2-Snoring: frequency of snoring	***GDM:*** ♀ were diagnosed with GDM if two or more of 100-g OGTT glucose levels exceeded american diabetic association (ADA) criteria	during early pregnancy and frequency of snoring	and read English; planned to carry pregnancy to term and to deliver at either hospital. Exclusion: ♀ with pre-gestational diabetes.
[24]Reutrkul et al., USA, 2011 *Sleep disturbances and their relationship to glucose tolerance in pregnancy*	Cross-sectional	169 ♀	Hospital	28.5 ±5.5	26.2±4.4 T2	***Sleep:*** Sleep duration Sleep disorder breathing Frequent snoring	***Glucose tolerance*** If value was ≥140 mg/dL, ♀ underwent 100-g OGTT to formally confirm or exclude GDM. Subjects with 1-h glucose value of ≥200 mg/dL post 50-g glucose challenge were diagnosed as having GDM without further testing.	ESS, Berlin Sleep Questionnaire, PSQI, Nocturia, Nocturnal Enuresis, and Sleep-Interruption Questionnaire	Inclusion: P ♀ scheduled to undergo 50-g OGTT in T2 of gestation. Exclusion: P ♀ with history of pre-GDM; sleep disorders; severe pulmonary, cardiac, or renal diseases; steroid use; substance abuse; current neurologic or psychiatric disorders; use of prescription or over-the- counter medications known to affect sleep or glucose metabolism; smokers; significant alcohol or caffeine consumption; recent travel across time zones; and shift work

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Author, region, year *Study title*	**Study design**	**Final Sample size**	**Sample population**	**Age & Mean age range**	**Gestational age**	***Exposure:*** **Definition of exposure**	***Outcome/s*:** **Definition of**	**Sleep assessment method**	**Inclusion/exclusion criteria**
[25]Reutrakul et al., USA, 2013	Observational case-control study	15 NP♀, with normal glucose tolerance (NP-NGT);	Obstetrics Clinic (University of Chicago) and fliers posted in University of Chicago Medical Center	NP-NGT 29.2±5.2 P-NGT 28.5 ±5.9	T2, T3	***GDM-Non pregnant*:** two abnormal values from confirmatory 100-g OGTT criteria or if 1-	***OSA diagnosis*** OSA was deemed to be present if AHI = 5 or over. OSA severity was graded as: mild	Poly-somnography	Inclusion: P ♀ with singleton pregnancy in late T2- early T3 with either normal glucose tolerance (P-NGT) or GDM (P-GDM).

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Author, region, year ***Study title***	Study design	Final Sample size	Sample population	Age & Mean age range	Gestational age	***Exposure:*** **Definition of exposure**	***Outcome/s*:** **Definition of**	Sleep assessment method	Inclusion/exclusion criteria
Interactions between pregnancy, obstructive sleep apnea, and GDM		15 P♀ (P-NGT); 15 P♀ with GDM (P-GDM)		P-GDM 29.2±5.6		hr glucose value after 50-g OGTT is 200 mg/dL or greater. ***Pregnancy non diabetic*:** if fasting plasma glucose less than 100 mg/dL and 2-hour value after a 75-g oral glucose administration of less than 140 mg/dL.	(AHI≥5 and<15), moderate (AHI≥15 and<30), or severe (AHI≥30). ***Wake up after sleep onset*** *(WASO)* total time (mins) that participants were awake between SO and end of recording. ***Sleep duration***		Exclusion: multiple pregnancies; known diabetes pre-pregnancy; pre-existing sleep disorders; severe pulmonary, cardiac, or renal disease; steroid use; substance abuse; current neurological or psychiatric disorders; use of prescription or over-the- counter medications known to affect sleep or glucose metabolism; smokers; significant alcohol (≥7 drinks/wk) or caffeine consumption (≥400 mg/d); recent travel across time zones; and shift work.

Table 2.10. GDM category (data analysis used and results of studies)

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Citation	**Data analysis used**	**Proportion/chi square test**	**Mean/t-test**	**SD/standard error**	**OR/regression coefficient/ (95% CI)**	**Co-variates**	**Adjusted co- variates**	**Results**
[1]Bisson et al., Canada, 2014	Data expressed as mean±SD for continuous variables or as % for categorical variables analyzed by x2 t- test or Fisher's exact test, as appropriate (e.g. RLS, depression, sleepiness). Groups compared using Student's t test for continuous data. Assumption of normality verified using Shapiro-Wilk test. Brown and Forsythe's variation of Levene's test statistic verified homogeneity of variances. Variables with univariate test P< .25 values were candidates for logistic and linear multivariate model building. Stepwise and backward variable selection	Snoring frequency for past month as reported by bed partner/roommat e was similar in both groups: habitual snoring reported in 17% of GDM ♀ and 24% of control ♀. Self-reported sleep time did not differ between groups. Neither recorded nor reported total sleep time values were associated with BMI or glycemia post–50- g OGTT. Subjective sleep quality was similar between groups. Sleepiness score was significantly higher in women with GDM ♀ compared with	n/a	n/a	n/a	Pre-pregnancy BMI	Pre-pregnancy BMI adjusted	**No significant difference in either subjective or objective sleep- disordered breathing between ♀ with and without GDM**. Participants reported similar frequency of habitual **snoring**. The finding that sleep-disordered breathing prevalence and severity were not greater among GDM ♀ without morbid obesity highlights need to evaluate role of obesity in further studies to assess mechanisms and consequences of maternal obstructive sleep apnea–hypopnea. GDM ♀ demonstrated significantly more subjective **daytime sleepiness.** Subjective **sleep quality** was similar between groups. Self- reported sleep time did not differ between groups.

Table 2.10. GDM category (data analysis used and results of studies)								
Citation	**Data analysis used**	**Proportion/chi square test**	**Mean/t-test**	**SD/standard error**	**OR/regression coefficient/ (95% CI)**	**Co-variates**	**Adjusted co- variates**	**Results**
[4]Facco et al., Chicago,USA, 2010	1-t-test 2-chi square 3.Multivariable logistic regression models	48% reported short sleep duration (SSD) and 18.5% frequent snoring (FS).	SSD and FS were associated with higher OGT values: SSD (116±31 vs. 105±23; *P*=.008) and FS (118±34 vs. 108±25; *P*=.04).	n/a	♀ who reported SSD during pregnancy were also more likely to have 1-hr OGT values of ≥130 (OR, 2.6; 95% CI, 1.3–5.7). ♀ with SSD and FS also have a greater frequency of overt GDM: OR 10.6 (95% CI, 1.3–85.5) and OR 4.9 (95% CI, 1.3–18.1), respectively.	Maternal age; race/ ethnicity; pre-pregnancy BMI	Age; race/ ethnicity; pre-pregnancy BMI; adjusting for SSD and FS.	Of 189 ♀ participants, 48% reported SSD and 18.5% FS. Both **SSD** (116±31 vs. 105±23; *P*=.008) **and FS** (118±34 vs. 108±25; *P*=.04) **were associated with higher OGT values**. Both SSD (10.2% vs. 1.1%; *P*=.008) and FS (14.3% vs. 3.3%; *P*=.009) were also associated with a higher incidence of GDM. Even after controlling for potential confounders, SSD and FS remained associated with GDM (adjusted OR, 2.4; 95% CI, 1.1–5.3) and development of GDM (adjusted OR, 11.7;95% CI, 1.2–114.5). Likewise, after adjusting for demographic factors and SSD, FS remained associated with increased risk of GDM (adjusted OR, 6.7;95% CI, 1.4 –33.8).

Table 2.10. GDM category (data analysis used and results of studies)

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/standard error	OR/regression coefficient/ (95% CI)	Co-variates	Adjusted co- variates	Results
[6]Herring et al., USA, 2014	Multivariable logistic regression used to evaluate independent associations between sleep parameters and hyperglycemia	Fisher exact tests used for categorical variables; x2 t-tests used for continuous variables relaxing the assumption of equal variances when indicated. Pearson's *r* and two-sided t-tests used to assess relationships of sleep duration parameters and nap frequency with 1-h OGTT values. All parametric comparisons confirmed using Mann–Whitney U tests and Spearman's rho to ensure that violations of normality did not affect results.	n/a	n/a	Shorter night-time sleep was associated with hyperglycemia, even after controlling for age and BMI (adjusted OR, 0.2 [95% CI, 0.1–0.8])	maternal age; race/ ethnicity; parity; medical insurance (income proxy); education; history of GDM in prior pregnancy; smoking habits; BMI	Age; BMI	♀ with **shorter night-time sleep duration (NSD)** had increased risk of gestational hyperglycemia. No association **of daytime sleep duration (DSD) and nap frequency (NF)** with 1-h OGTT values or hyperglycemia. Inverse correlation between NSD and 1-h OGTT values (r =-0.28, P = .03) meant every hr of shorter NSD was associated with 8.2 mg/dL increase in glucose. Neither DSD nor NF were associated with higher glucose values. Some 7 ♀ (11%) classified with hyperglycemia using 1-h OGTT (≥130 mg/dL). Mean NSD was 1hr shorter among participants with hyperglycemia (6.0 ± 1.0hr/night) than those without hyperglycemia (7.0 ± 0.8h/night, P = .007). Even after controlling for age and early pregnancy BMI, shorter NSD was associated with hyperglycemia but **longer sleep duration was protective against hyperglycemia** (adjusted OR: 0.2; 95% CI: 0.1, 0.8). No association of DSD or NF with hyperglycemia in unadjusted or adjusted models.

Table 2.10. GDM category (data analysis used and results of studies)

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/standard error	OR/regression coefficient/ (95% CI)	Co-variates	Adjusted co- variates	Results
[18] O'Brien et al., Michigan, USA, 2012	1-Chi square and t- test 2-Logistic regression	n/a	n/a	n/a	No relationship found with pregnancy onset snoring and GDM (OR, 1.29; 95% CI, 0.96 – 1.74; *P* =.09). However, chronic snoring was associated with GDM (OR, 1.67; 95% CI, 1.10 –2.52; *P* =.015).	Maternal age; race; pre-pregnancy BMI; gravidity; smoking; educa-tional level; individual or family history of gestational hyper-tension/ pre-eclampsia	Maternal age; race; pre-pregnancy BMI; weight gain in excess of IOM recommend-actions; gravidity; smoking; educational level; individual or family history of gestational hypertension /pre-eclampsia	**Blood glucose levels at 24-26-wk gestation 1-hr OGTT using 50-g load were higher in snorers than non-snorers** (124.0 vs. 117.2 mg/dL, *P* = .001), as was proportion of ♀ with abnormal glucose levels, defined as ≥140 mg/dL (30.2% vs. 22.1%, *P*=.003). Glucose levels were not compared between ♀ with and without pregnancy-onset snoring, as glucose was assessed in T2**. Neither pregnancy-onset nor chronic snoring was found to be associated with GDM in a multivariate model; however pre- pregnancy BMI and maternal age were associated.**

Table 2.10. GDM category (data analysis used and results of studies)								
Citation	**Data analysis used**	**Proportion/chi square test**	**Mean/t-test**	**SD/standard error**	**OR/regression coefficient/ (95% CI)**	**Co-variates**	**Adjusted co- variates**	**Results**
[23]Qiu et al., USA, 2010	Linear regression. The study fitted generalized linear models, using a log link function, to derive RR and 95% CIs of the associations between sleep duration and snoring variables with glucose	Approximately 5.3% of study cohort developed GDM (68 of 1,290).	n/a	n/a	Mean glucose concentrations 1h after 50-g oral glucose challenge were 16.3 mg/dl higher in ♀ who reported sleeping ≤ 4h (95% CI 1.1-31.6, p = 0.04), 2.3 mg/dl higher for	Maternal age; race/ ethnicity; BMI; medical bill payment status; marital status; smoker; medication	maternal age; race/ ethnicity; BMI	After adjusting for maternal age and race/ethnicity**, GDM risk was increased among ♀ women sleeping ≤ 4h compared with those sleeping 9h/night** (RR = 5.56; 95% CI 1.31-23.69). The corresponding RR for lean ♀ (<25 kg/m2) was 3.23 (95% CI 0.34-30.41) and 9.83 (95% CI 1.12-86.32**) for overweight** ♀ (≥ 25 kg/m2). **Overall, snoring was associated with a 1.86-fold increased risk of GDM** (RR = 1.86; 95% CI 0.88-3.94). **The risk of GDM was particularly elevated among overweight ♀ who snored**. Compared with lean ♀ who did not snore, those who were overweight and snored had a 6.9-fold increased risk of GDM (95% CI 2.87-16.6).

Table 2.10. GDM category (data analysis used and results of studies)

Citation	Data analysis used	Proportion/chi square test	Mean/t-test	SD/standard error	OR/regression coefficient/ (95% CI)	Co-variates	Adjusted co- variates	Results
[24] Reutrakul et al., USA, 2011	1-Chi square 2-Logistic regression	GDM vs. normal glucose test 41% had excessive daytime sleepiness 64% had poor sleep quality; 25% snored frequently; 29% had increased risk of sleep-disordered breathing (SDB); 52% experienced short sleep (SS); 19% had both increased SDB risk and SS (SDB/SS); and 14% had	n/a	n/a	Increased likelihood of GDM was found in ♀ with increased SDB risk (OR 3.0 [95% CI 1.2–7.4]), SS (2.4 [1.0–5.9]), SDB/SS (3.4 [1.3–8.7]), and frequent snoring (3.4 [1.3–8.8])	Age; ethnicity; pre-pregnancy BMI; current weight and height; medical and family history.	BMI	Some 64% of ♀ had overall **poor sleep quality** shown by PSQI >5 (mean of 7.4 ± 4.0), and 41% reported **excessive daytime sleepiness** ([ESS] >8). Some 29% of ♀ had increased SDB risk, and 25% **were frequent snorers** (snoring 3–4 days/wk). Some **52% ♀ experienced SS (7h/night), and 19% had both increased SDB risk** and SS (SDB/SS). Daytime dysfunction was reported by 14%. Only 18% of ♀ had normal sleep-wake regulation with normal overall sleep quality (PSQI ≤5, ESS ≤8, and no SDB risk). Of the participants, 68% had NGT based on 50-g OGTT. Of those who failed 50-g OGTT and underwent 100-g OGTT, 15% met GDM criteria. Some 27 ♀ had an abnormal 50-g OGTT but their 100-g test was not diagnostic of GDM. There was an inverse correlation between sleep duration and 1- h glucose values post-50-g OGTT (r = 20.21, P , 0.01) meaning **that every hour of shorter sleep duration was associated with 4% glucose increase.**

Table 2.10. GDM category (data analysis used and results of studies)								
Citation	**Data analysis used**	**Proportion/chi square test**	**Mean/t-test**	**SD/standard error**	**OR/regression coefficient/ (95% CI)**	**Co-variates**	**Adjusted co-variates**	**Results**
								Compared with NGT group, GDM subjects were older, had a higher pre-pregnancy BMI, and were more likely to have a personal history of GDM. ♀ were more likely to **have GDM if they had an elevated SDB risk** (OR 3.0 [95% CI 1.2–7.4]; P = 0.02), if they reported frequent snoring (3.4[1.3–8.8]; P = 0.01 after BMI adjustment), if they experienced SS (2.4 [1.0–5.9]; P =0.06), and if they had the combination SDB/SS (3.4 [1.3–8.7]; P = 0.01). Of ♀ participants, **41% had excessive daytime sleepiness; 64% had poor sleep quality; 25% snored frequently; 29% had increased risk of SDB; 52% experienced SS; 19% had both increased SDB risk and SS (SDB/SS); and 14% had daytime dysfunction. Their reported sleep duration inversely correlated with glucose values from 50-g OGTT (r = 20.21, P, 0.01).** Increased **likelihood of GDM was found in ♀ with increased SDB risk** (OR 3.0 [95% CI 1.2–7.4]) SS (2.4 [1.0–5.9]), SDB/SS (3.4

Table 2.10. GDM category (data analysis used and results of studies)								
Citation	**Data analysis used**	**Proportion/chi square test**	**Mean/t-test**	**SD/standard error**	**OR/regression coefficient/ (95% CI)**	**Co-variates**	**Adjusted co-variates**	**Results**
[25]Reutrakul et al., USA, 2013	This study was designed to assess: impact of pregnancy on sleep and metabolic measures in women with normal glucose tolerance; association between GDM and OSA diagnosis	OSA was more prevalent in P-GDM than in P-NGT ♀ (73% vs. 27%)	P-NGT ♀ had a higher AHI than NP-NGT ♀ (median 2.0 vs. 0.5) and more disrupted sleep shown by higher	n/a	GDM diagnosis was associated with OSA diagnosis (OR 6.60 [95% CI 1.15–37.96])	Race; age at time of PSG; height, weight; detailed medical and family history.	Pre-pregnancy BMI	P-NGT ♀ had a higher AHI than NP-NGT ♀ (median 2.0 vs. 0.5), **more disrupted sleep shown by higher wake time after sleep onset** (median 66 vs. 21) and higher microarousal index (median 16.4 vs. 10.6, *P*=.01). Among P ♀, **P-GDM had markedly lower total sleep time** (median 397 vs. 464) and higher AHI than P-NGT ♀ (median 8.2 vs. 2.0). OSA was more prevalent in P-GDM than P-NGT ♀ (73% vs. 27%, *P*=.01). After adjustment for pre-pregnancy BMI, GDM diagnosis was associated with OSA diagnosis (OR 6.60 [95% CI 1.15–37.96]). **Total sleep time in P-GDM ♀ was over 1h shorter than for**

Table 2.10. GDM category (data analysis used and results of studies)								
Citation	**Data analysis used**	**Proportion/chi square test**	**Mean/t-test**	**SD/standard error**	**OR/regression coefficient/ (95% CI)**	**Co-variates**	**Adjusted co- variates**	**Results**
	pregnancy, adjusting for potential confounders; the relationship between sleep and metabolic parameters during pregnancy. Data analysis used: 1-x2 *t* tests and Wilcoxon rank-sum tests 2-Chi and Fisher 3- Logistic regression analysis		onset (median 66 vs. 21). Among P ♀, P-GDM had markedly lower total sleep time (median 397 vs. 464) and higher AHI than P-NGT ♀ (median 8.2 vs. 2.0).					shown by higher microarousal index. Time spent in each stage of sleep (REM, stage 1, stage 2, and slow wave sleep) was similar between both groups. In P-NGT ♀, pregnancy was associated with increased OSA risk and more disturbed sleep. **P-NGT ♀ with pre-pregnancy BMI similar to that of NP-NGT ♀ had a significantly higher AHI and more wake time after sleep onse**t. These changes may put pregnant ♀, especially those who are **overweigh**t, at risk of developing OSA. These findings are congruent with prospective data in pregnant ♀, especially those with higher BMI.

Table 2.10. GDM category (data analysis used and results of studies)								
Citation	**Data analysis used**	**Proportion/chi square test**	**Mean/t-test**	**SD/standard error**	**OR/regression coefficient/ (95% CI)**	**Co-variates**	**Adjusted co- variates**	**Results**
	intolerance and GDM risk. Separate models were fitted for sleep duration and snoring. Potential confounders were selected from a list of variables associated with sleep duration and snoring (from prior studies conducted among men and NP ♀) that met criteria for confounding based on literature review and assessment of potential causal				women who reported sleeping ≥ 10h (95% CI -0.5-13.2, p = 0.07) compared with those who reported sleeping 9h/night.			These preliminary findings suggest associations of short sleep duration and snoring with glucose intolerance and GDM.

Chapter 3

Differences in sleep characteristics amongst pregnant and non-pregnant women

3.1 Summary

This Chapter examines seven self-reported sleep characteristics female participants in the UK Household Longitudinal Survey who had been identified as pregnant or non-pregnant at interview/questionnaire completion, the latter selected on the basis that they had a similar age range to those who were pregnant (i.e. 16-49yrs); before and after adjusting for potential (sociodemographic and health) confounders that had been identified using a causal path diagram (in the form of a directed acyclic graph; DAG). The analyses found substantive differences: in sleep duration; latency; late night/early morning awakening; medication use; overall quality; and daytime sleepiness, with less favourable sleep reported on five of these characteristics (the exception being a lower frequency of sleep medication use) by pregnant women. These differences were only modestly attenuated after adjustment for potential confounders, or by excluding pregnant and non-pregnant women who were nulliparous and who report using sleep medication in the month preceding interview/questionnaire completion. These analyses therefore confirm that pregnancy is associated with less favourable sleep across a wide number of sleep characteristics, with the exception of sleep medication use (pregnant women reporting its use less frequently) and (trouble sleeping due to) coughing/snoring loudly.

3.2 Introduction

Although some might argue that the changes in sleep that accompany human pregnancy have only been recognised relatively recently (Kimura et al., 1996), this fails to acknowledge the many historical accounts describing women's experiences of sleep from conception, through pregnancy, to the postnatal period and beyond (Karacan et al., 1968). In fact, it seems likely that those who view this as a relatively recent 'discovery' do so primarily on the basis of the rather surprising fact that it was only in 1990 that the American Academy of Sleep Medicince (AASM) included 'Pregnancy-Associated Sleep Disorder' (PASD; pp297-300) in the first edition of The International Classification of Sleep Disorders: Diagnostic and Coding Manual (Thorpy, 1990); meaning that pregnancy-associated sleep changes were formally recognised by the sleep medicine establishment. Yet this fails to acknowledge the attention afforded sleep in pregnancy in generic and specialist clinical journals (as evidenced by even cursory examination of articles and correspondence published prior to 1990, including: Savona, 1947; Laska, 1956; Pena, 1962; Williams, 1967). There is also the fact that, far from being unknown prior to its inclusion as a 'disorder' in the AASM's classification, the changes in sleep experienced by pregnant women were largely considered normal correlates of the hormonal, physiological, metabolic and anatomical changes that accompany pregnancy. As such, it is unclear how the inclusion of PASD as a 'proposed disorder' in the AASM's first classification of sleep disorders – however well-intentioned its inclusion might be - might benefit the physical and mental health of pregnant women and their unborn child, beyond more clearly defining, for future identification and examination, an experience that appears commonplace amongst pregnant women and can be, for some, of severe clinical concern. Instead, this formal diagnosis/classification of a commonly occurring characteristic of an entirely normal physiological state risks creating unnecessary anxiety, just as the medicalization of childbirth led to extending anaesthesia and unnecessary caesarean section (see Johanson et al., 2002). Although the unnecessary medicalization of pregnancy remains highly contentious, clinical guidance on sleep in pregnancy can be found amongst some of the earliest texts of modern medicine (e.g. Burnett, 1824), and in the absence of substantive evidence that

PASD is a determinant of health issues that are amenable to clinical intervention, labelling the changes in sleep that women experience during pregnancy a 'disorder' runs a substantial risk of generating treatment of the side effects.

In the absence of normative reference values for what constitutes 'healthy' sleep, and how such values might vary amongst individuals and amongst groups at different stages of the life course, it is perhaps premature to classify the changes that occur during pregnancy as a 'disorder' if these are simply a natural consequence of the pregnancy- related changes in hormonal, physiological and anatomical processes required for foetal growth and delivery, however different and/or unpleasant such changes in sleep may be. In order to gain a better understanding of how sleep changes during pregnancy, as the first step towards characterising and quantifying these changes, it is therefore important to differentiate between those that might be candidates for advice on modifiable behaviours and lifestyles (both preceding and during pregnancy) and those that indicate significant conditions that might benefit from preventive, therapeutic clinical action.

The aim of the present study was therefore to compare self-reported sleep characteristics of for pregnant and non-pregnant women, the latter selected on the basis that they had a similar age range to those who were pregnant (i.e. 16-49yrs). The study drew on contemporary data generated by the UK Household Longitudinal Study (UKHLS), a large prospective survey designed to provide extensive data on a representative sample of households (and household members) within the UK (Buck and McFall, 2011). These data were chosen to address three key weaknesses in previous analyses which were discussed in the systematic review of sleep amongst pregnant and non-pregnant women (see Chapter 2). The first is the reliance of many of these studies on small and statistically underpowered samples of participants recruited from women attending antenatal care (pregnant) and routine clinical examination (non-pregnant). Second, is a tendency for most studies to use instruments or datasets measuring few of the many different characteristics of sleep; and third, is the failure to collect data on, and/or appropriately adjust for, potential confounders - i.e. to adjust for sociodemographic and health-related differences

between pregnant and non-pregnant women – or to use datasets where data on few such variables were available. The data provided by the UKHLS avoid each of these weaknesses: all of its data were prospectively collected using interview-administered and/or self-completed questionnaires on a core/main sample of over 50,000 individual household members; its adult self-completion questionnaires contains items on seven distinct sleep characteristics; and its interview-administered questionnaires contain items covering an extensive range of relevant variables for consideration as measures of (or proxies for) potential confounders.

3.3 Methods

3.3.1 Study sample

The UKHLS was initiated in 2009 using a dedicated sampling frame designed to achieve a broadly representative sample of households across each of the UK's four constituent nations (England, Wales, Scotland and Northern Ireland). In the first wave of data collection for the UKHLS (conducted over two years, from 2009-2011) n=30,169 households consented to participate, providing data on n=23,207 male and n=27,784 female adult (aged ≥16 years) household residents. Subsequent biennial waves of data collection have continued to collect data from original study participants and for new participants, as and when these join the original participants' households on either a permanent or temporary basis. In addition, dedicated 'boost' samples (such as one aimed at increasing the numbers of ethnic minority participants) have been added, together with the integration of participants from the former British Household Panel Survey (Buck and McFall, 2011;) see also 'Understanding Society' in Appendix 3.2). In each wave of data collection, general household information is obtained from computer-assisted interviews with a single key informant,(main household) with additional individual-level data collected using a range of 'self-completion' questionnaires (though in later Waves, many of these items became incorporated into the computer-assisted interviews. To-date, 7 waves of data collection have been undertaken, the data from which have been released into the public domain approximately 24 months following initial collection. Wave 6 will be released in

November/December 2016.

3.3.2 Identification of pregnant and non-pregnant women in the UKHLS

Careful examination of the main household and adult self-completion questionnaires used in each wave of the UKHLS to date identified a number of variables capable of identifying which of the adult female participants were pregnant at the time of interview/questionnaire completion. The most important of these items asked the key household informant: "Do you think you will have [any more/any] children?", one response to which was: "Self/partner currently pregnant". An item included in questionnaires from Wave 2 onwards helped to identify female participants in preceding waves who may have been unaware or unwilling to disclose that they were pregnant when interviewed: "Since last wave, have you been pregnant at all, even if this did not result in a live birth?", one response to which was: "Pregnant at last interview". Related follow-up questions also generated contemporaneous self-reports of pregnancy which proved useful for identifying pregnant participants (particularly in Wave 4), including a question which asked: "Last time we interviewed you, you were pregnant. Did this/your next pregnancy result in a live birth with a normal delivery or by caesarean section?", for which one of the possible responses was: "Current pregnancy."

Since it is unknown whether multiple pregnancies might affect sleep during pregnancy, and since such pregnancies are comparatively rare, it was decided to include only women with singleton pregnancies in the present study. Thus, in order to establish which of the women identified as pregnant in Waves 1 and 4 had multiple pregnancies, another item in questionnaires from the subsequent wave (i.e. Waves 2 and 5, respectively) was used, namely: "Did you have a multiple birth such as twins or triplets with this pregnancy? If interviewed at prior wave?", for which one of the possible answers was: "No, it was a single birth."

3.3.3 Availability of data on sleep and potential confounders

A dedicated 'sleep module' was included in the adult self-completed questionnaire for

one wave of data collection (Waves 1, in 2009-2011) and in the main survey (computer-assisted) instrument in Wave 4 (2012-2014). These modules comprise seven discrete items adapted from a widely used tool for generating self-reported sleep data, the Pittsburgh Sleep Quality Index (Buysse et al., 1989). These items provided data on sleep (duration; latency; disturbance/awakening; coughing/snoring; medication; and quality); and on daytime sleepiness. Thus, and for the purposes of the present study (which aimed to compare the self-reported sleeping characteristics of pregnant and non-pregnant women), the availability of sleep data for women of child-bearing age, collected just twice to-date within the UKHLS, was a key determinant of the numbers of pregnant and non-pregnant women on whom these analyses could be completed. However, given that the sociodemographic and economic circumstances of pregnant and non-pregnant women are likely to act as important potential confounders in any relationship between pregnancy and sleep, the availability of data on variables capable of capturing variation in these circumstances (amongst and between pregnant and non-pregnant women) was also an important determinant of the numbers of participants on whom the analyses could be conducted.

For this reason, a list of individual- and household-level sociodemographic and health characteristics known to be associated with both pregnancy and sleep was generated from the literature (see Chapter 2) to identify those likely to act as potential confounders, on the basis that such characteristics precede, and are likely to act as causal risk factors for, both pregnancy and sleep. A subsequent search for items capable of capturing these characteristics in UKHLS Wave 1 and 4 questionnaires (i.e. those waves in which self-reported sleep data were also generated) identified 8 such variables: age; ethnicity; educational qualifications; partnership status (i.e. marital status/cohabitation with a partner); household composition (based on separate items on the presence of additional adults, couples and children in the household); pre-existing clinical diagnoses of chronic health conditions; parity; and employment status. The precise wording/definition of each of the original and derived variables used in this Chapter's analyses can be found in Appendix 3.1.

Finally, since there is substantial evidence that self-reported sleep varies during the

course of pregnancy (i.e. from trimester one through to trimester three (Hedman et al., 2002; Osaikhuwuomwan et al., 2014), and that behaviours with potential relevance to sleep often change as pregnancy progresses, including diet (McGowan and McAuliffe,2013) and exercise (Leppänen et al., 2014), it was necessary to estimate the 'gestational age at interview/questionnaire completion' for each of the pregnant women in Waves 1 and 4 of the UKHLS. This involved using data on the date of interview in each of these waves, and data on the date of conception (collected only in Wave 4_, and data on the date of birth recorded in the subsequent wave (i.e. from Wave 2 for women identified as pregnant in Wave 1). Date of conception was also generated from a follow-on question to those participants who had reported "Pregnant at last interview" (see above), which asked: "In what month and year did you become pregnant?"; while data on date of birth was recorded confidentially, and required an application to the UK Data Archive for 'Special License Access' prior to analysis. Estimated gestational age was then calculated from these variables using the following formulae:

Gestational age at interview (Wave 1) = Date of birth – Date of interview (in Wave 1)

Gestational age at interview (Wave 4) = Date of interview – Date of conception (in Wave 4).

The resulting estimates were converted from days to weeks and thereafter to trimester (1-12 weeks: trimester one; 13-27 weeks: trimester two; 28-Term weeks: trimester three). Finally, to correct those estimates of gestational age calculated from data on date of birth (rather than on date of conception) and where birth had occurred early (i.e. prematurely) or late (i.e. post-dates), three more items from questionnaires in subsequent waves were used to apply an appropriate correction. These three items asked, first: "Was [child's name] born within one week of the expected due date?"; those respondents who answered "No" were then asked: "Was [child's name] born early or late?"; followed by a final item asking simply: "How many weeks early/late?." Although this approach provided robust estimates of gestational age at interview/questionnaire completion, these relied upon data on date of conception,

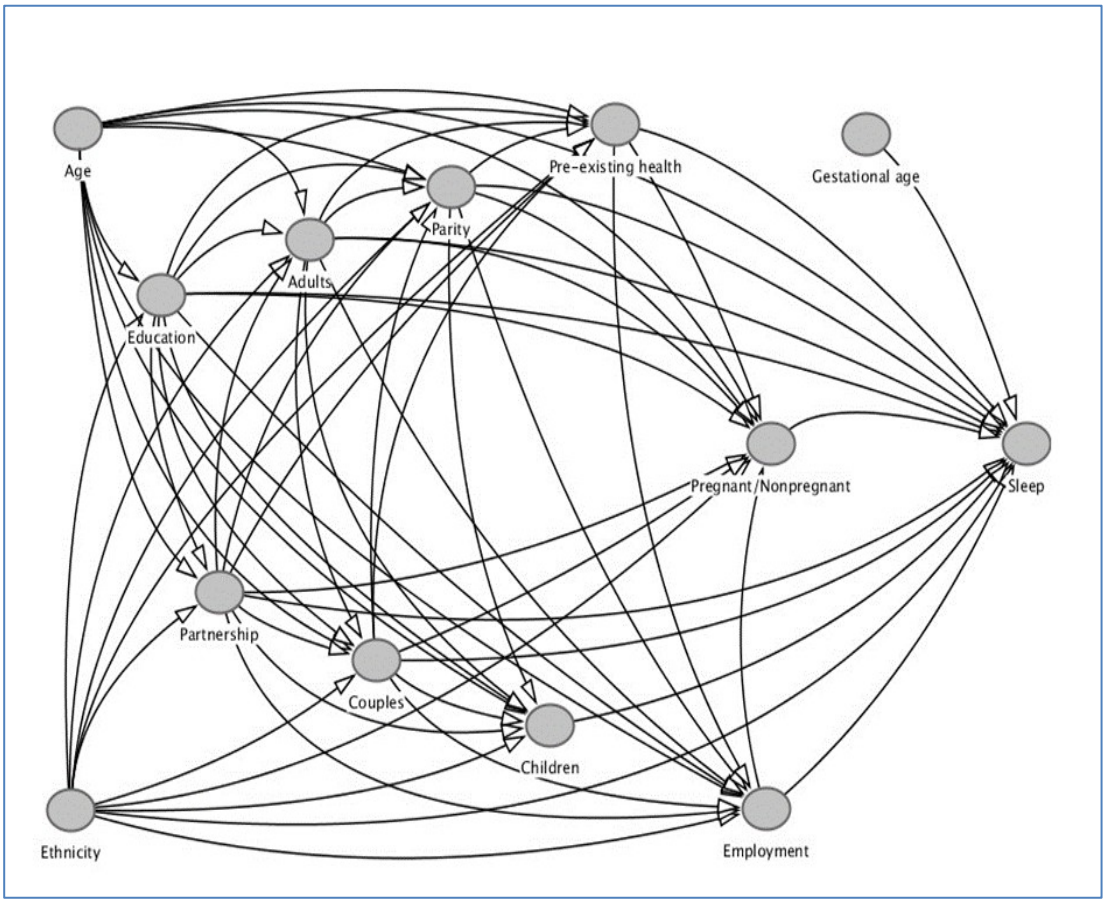
date of birth and early/late births that would only be available for those women who were present in the household in Waves 1 and 2 or in Wave 4; and who actually completed the relevant items in each of the respective questionnaires.

3.4 Statistical analyses

Summary descriptive statistics were used to compare the sociodemographic, health and self-reported sleep characteristics of pregnant and non-pregnant women with complete and incomplete data on potential confounders and outcome variables; with the results of these summaries presented as frequencies with percentages in parentheses (%). Separate multivariable logistic regression analyses were then conducted for each of the seven sleep characteristics to establish the direction and strength of any differences observed between pregnant and non-pregnant women before and after adjustment for potential confounding. These analyses were informed by a causal path diagram in which the ten measured covariates (and estimated gestational age at interview/questionnaire completion) were arranged in a hypothesised temporal sequence using a saturated directed acyclic graph (DAG) to identify those acting as potential confounders or competing exposures in any relationship between pregnancy status and sleep. DAGs are causal path diagrams where prior knowledge of functional and empirically-determined causal relationships (as well as speculative causal links) are summarised visually on a causal path diagram where interrelationships between variables are summarised using arrows (Greenland et al. 1999; Law and Shane 2012; Textor et al., 2017). When conducting epidemiological analyses of data from non-experimental studies, the advantage of using DAGs is that they allow researchers to present a clear and logical description of the 'known, likely and speculative causal relationships' between variables relevant to the hypothesis and any related questions which may arise. (Law et al.2012) (see Figure 3.1). Additional multivariable analyses were conducted after excluding nulliparous (pregnant and non-pregnant) women and those reporting sleep medication use; to address the possibility that the sleep of women who had yet to have children might differ systematically from those who already have children, and that any changes in sleep medication during

pregnancy might influence their self-reported sleep characteristics. The results of these analyses were presented as relative risk ratios (RRRs See in Glossary of Terminology) for multinomial logistic regression models or odds ratios (ORs See Glossary of Terminology) for logistic regression models, with 95% confidence intervals (95%CIs) in parentheses. All analyses were conducted using Stata-IC 14 (StataCorp LP, TX).

Figure 3.1 Causal path diagram in the form of a directed acyclic graph (DAG) summarising the theorised temporal relationships between pre-pregnant sociodemographic, economic and health factors, pregnancy and sleep. Drawn using http://www.dagitty.net; see (Appendix 3.3) for Model Code.



3.5 Ethical approval

Most of the data for the UKHLS sample was obtained from publicly available datasets (available at: https://www.understandingsociety.ac.uk/), although a 'Special License Access' was required and granted by the UK Data Archive, for date of birth data to facilitate the estimation of gestational age at interview/questionnaire completion, as described earlier (UKDA Usage Number: 84718; see Appendix 3.4).

3.6 Data security

All data derived from the UKHLS are pseudo-anonymised (with no possibility that users can link these data to personal identifiers held securely by the UKHLS team). Once each of the UKHLS datasets had been downloaded, it was saved on the University of Leeds servers, and secured using password-only access – the data being held within a dedicated (password-protected) account on the
N-drive (the Division of Epidemiology and Biostatistics server). Access to these data was restricted to the present study's research team alone.

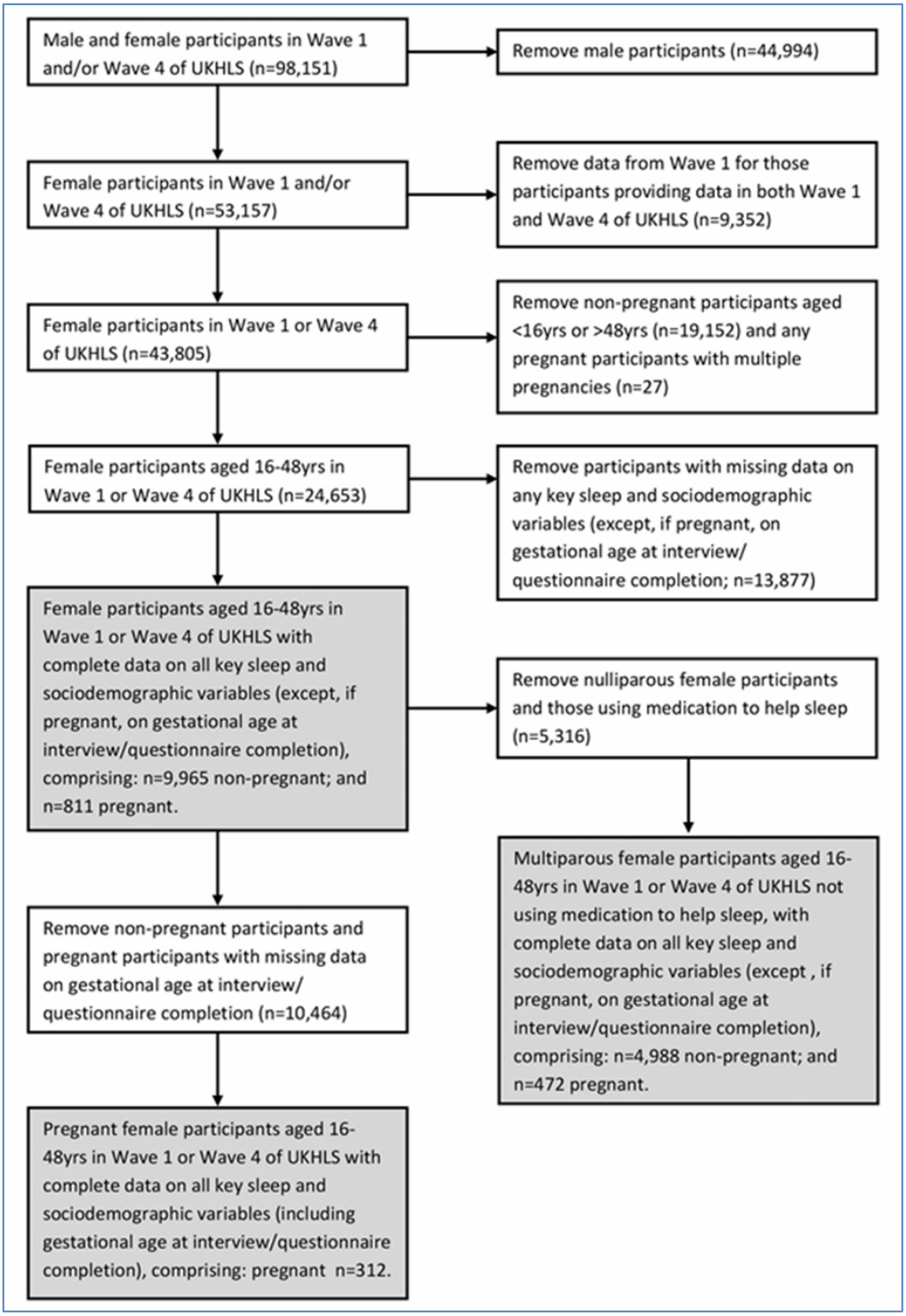
3.7 Results

3.7.1 Sample selection

Figure 3.2 summarises each of the steps taken to generate the three samples of UKHLS participants on which the present Chapter's analyses were undertaken. Of the n=53,157 female participants in Waves 1 and 4, n=9,352 participated in both Waves; and after excluding data collected from these participants during Wave 1 – and from both the n=19,152 non-pregnant participants who were younger (<16yrs) or older (>48yrs) than pregnant participants, and the n=27 pregnant participants who had multiple pregnancies – the sample of non-pregnant women, and pregnant women, the former selected on the basis that they had a similar age range to those who were pregnant (i.e. 16-49yrs) (with singleton pregnancies), totalled n=24,653 (fewer than half of all female participants in Waves 1 and 4). Finally, after excluding participants with missing data on one or more of the sleep, sociodemographic or health variables, the remainder comprised n=811 pregnant and n=9965 non-pregnant women on whom multivariable statistical analyses could then be performed. Further exclusion of nulliparous (pregnant

and non-pregnant) women and those who reported using medication to help them sleep in the month preceding interview/questionnaire completion, generated a sample of just n=472 pregnant women, and n=4,988 non-pregnant women (on whom unadjusted and adjusted analyses exploring the relationship between pregnancy and self-reported sleep characteristics were then be repeated). Likewise, the exclusion of non-pregnant women, and of pregnant women with missing data on gestational age at interview/questionnaire completion, generated a final sample of just n=312 amongst whom variation in self-reported sleep characteristics could be examined before and after (additional) adjustment for gestational age.

Figure 3.2 Sampling flowchart summarising the two subsamples of pregnant women identified within Waves 1 and 4 of the UKHLS and the clinical GDM 'at risk' sample on which the multivariable analyses that follow are based.



3.7.2 Sample characteristics

The sociodemographic, health and sleep characteristics of the three key (sub)samples of pregnant and non-pregnant women (i.e. those with complete or missing data on one or more variable; those with complete data on all variables except gestational age; and those with complete data on all these variables who were multiparous and did not report using sleep medication during the month preceding interview/questionnaire completion), have been summarised in Table 3.1. By comparing the distribution of these characteristics amongst each of the three (sub)samples of UKHLS participants it is evident that, in the broadest sense, the three (sub)samples were generally comparable. However, there were a number of differences in sociodemographic characteristics (such as the older age distribution of multiparous non-pregnant women; and variation in household composition amongst the three [sub]samples) that indicate a potential for selection bias that needs to be taken into account in the interpretation and extrapolation of the analyses that follow.

Table 3.1 A comparison of sociodemographic, health and sleep characteristics amongst all women aged 16-48yrs included in the 'General Population Sample' for Wave 1 and/or Wave 4 of the UKHLS who were identified as pregnant (n=995) and non-pregnant (n=23,658) women, and two subsamples of these: those pregnant (n=811) and non-pregnant (n=9,965) women with complete data on all sociodemographic, health and sleep variables (except gestational age at interview/questionnaire completion); and those multiparous pregnant (n=472) and non-pregnant (n=4,988) women with complete data on all sociodemographic, health and sleep variables who did not report taking "medicine (prescribed or 'over the counter') to help you sleep". All results are presented as frequencies (n) with percentages in parentheses (%).

	All female participants in W1 and/or W4 of UKHLS aged 16-48yrs (n=24,653)		Female participants in W1 and/or W4 of UKHLS aged 16-48yrs with data on all variables (except gestational age; n=10,776)		Multiparous female participants in W1 and/or W4 of UKHLS not using sleep mediation with data on all variables (except gestational age; n=5,460)	
	Non-pregnant (n=23,658) n (%)	Pregnant (n=995) n (%)	Non-pregnant (n=9,965) n (%)	Pregnant (n=811) n (%)	Non-pregnant (n=4,988) n (%)	Pregnant (n=472) n (%)
Age group						
16-23	5,173 (21.8)	121 (12.1)	1,870 (18.7)	136 (16.7)	167 (3.3)	51 (10.8)
24-31	3,323 (14.0)	330 (33.1)	2,158 (21.6)	331 (40.8)	823 (16.5)	176 (37.2)
32-39	3,666 (15.4)	532 (53.4)	2,563 (25.7)	301 (37.1)	1,657 (33.2)	214 (45.3)
40-48	11,496 (48.5)	12 (1.2)	3,374 (33.8)	43 (5.3)	2,341 (46.9)	31 (6.5)
Missing	0 (0.0)	0 (0.0)	n/a	n/a	n/a	n/a
Ethnicity-based DM risk						
Low risk	17,993 (76.0)	751 (75.4)	7,808 (78.3)	639 (78.79)	3,707 (74.3)	371 (78.6)
High risk	5,451 (23.0)	243 (24.4)	2,157 (21.6)	172 (21.21)	1,281 (25.6)	101 (21.4)
Missing	214 (0.9)	1 (0.1)	n/a	n/a	n/a	n/a
Educational qualifications[1]						
≥Degree	9,242 (38.9)	423 (42.5)	4,267 (42.8)	362 (44.6)	2,033 (40.8)	200 (42.3)
<Degree	12,595 (53.2)	495 (49.7)	5,203 (52.2)	396 (48.8)	2,664 (53.4)	236 (50.0)
None	1,593 (6.7)	76 (7.6)	495 (5.0)	53 (6.5)	291 (5.8)	36 (7.6)
Missing	228 (0.9)	1 (0.1)	n/a	n/a	n/a	n/a
Partnership status						
Partner	13,856 (58.5)	812 (81.6)	4,355 (43.7)	668 (82.3)	3,676 (73.7)	401 (84.9)
No Partner	9,765 (41.2)	182 (18.2)	5,610 (56.3)	143 (17.6)	1,312 (26.3)	71 (15.0)
Missing	37 (0.1)	1 (0.1)	n/a	n/a	n/a	n/a
Additional adults in household						
0	17,743 (75.0)	749 (75.2)	4,806 (48.2)	625 (77.0)	2,882 (57.7)	382 (80.9)
≥1	5,915 (25.0)	246 (24.7)	5,159 (51.7)	186 (22.9)	2,106 (42.2)	90 (19.0)
Missing	0 (0.0)	0 (0.0)	n/a	n/a	n/a	n/a
Additional couples in household						
0	4,731 (20.0)	154 (24.7)	3,398 (34.1)	118 (14.5)	1,433 (28.7)	75 (15.8)
≥1	18,927 (80.0)	749 (75.3)	6,567 (65.9)	693 (85.4)	3,555 (71.2)	397 (84.1)
Missing	0 (0.0)	0 (0.0)	n/a	n/a	n/a	n/a
Parity						
Nulliparous	9,208 (38.9)	421 (42.3)	4,303 (43.1)	309 (38.1)	n/a	n/a
Multiparous	14,450 (61.0)	574 (57.6)	5,662 (56.8)	502 (61.9)	4,988 (100)	472 (100)
Missing	0 (0.0)	0 (0.0)	n/a	n/a	n/a	n/a
Children in household						
0	7,571 (32.0)	317 (31.8)	3,549 (35.6)	270 (33.2)	350 (7.0)	0 (0.0)
≥1	16,087 (68.0)	678 (68.2)	6,416 (64.3)	541 (66.7)	4,638 (92.9)	472 (100)
Missing	0 (0.0)	0 (0.0)	0 (0.0)	n/a	n/a	n/a

Table 3.1. Continued.

	All female participants in W1 and/or W4 of UKHLS aged 16-48yrs (n=24,653)		Female participants in W1 and/or W4 of UKHLS aged 16-48yrs with data on all variables (except gestational age; n=10,776)		Multiparous female participants in W1 and/or W4 of UKHLS not using sleep mediation with data on all variables (except gestational age; n=5,460)	
	Non-pregnant (n=23,658) n (%)	Pregnant (n=995) n (%)	Non-pregnant (n=9,965) n (%)	Pregnant (n=811) n (%)	Non-pregnant (n=4,988) n (%)	Pregnant (n=472) n (%)
Pre-existing health conditions						
No	16,560 (70.0)	703 (70.6)	7,300 (73.2)	613 (75.5)	3,675 (73.6)	366 (77.5)
Yes	7,898 (33.3)	222 (22.3)	2,665 (26.7)	198 (24.4)	1,313 (26.3)	106 (22.4)
Missing	800 (3.3)	70 (7.0)	n/a	n/a	n/a	n/a
Employment status[2]						
High status	9,586 (40.5)	390 (39.1)	4,025 (40.3)	339 (41.8)	2,044 (40.9)	175 (37.0)
Low status	4,886 (20.6)	149 (14.9)	1,939 (19.4)	121 (14.9)	1,023 (20.5)	65 (13.7)
Unemployed	9,186 (38.8)	456 (45.8)	4,001 (40.1)	351 (43.2)	1,921 (38.5)	232 (49.1)
Missing	0 (0.0)	0 (0.0)	n/a	n/a	n/a	n/a
Gestational age at interview/questionnaire completion						
1st Trimester	n/a	53 (5.3)	n/a	53 (6.5)	n/a	53 (11.2)
2nd Trimester	n/a	168 (16.8)	n/a	168 (20.7)	n/a	168 (35.6)
3rd Trimester	n/a	91 (9.1)	n/a	91 (11.2)	n/a	91 (19.2)
Missing	23,658 (100)	683 (68.6)	9,965 (100)	499 (61.5)	n/a	160 (33.8)
Sleep duration						
<5hrs	1,430 (6.0)	45 (4.5)	475 (4.7)	42 (5.18)	204 (4.1)	28 (6.0)
≥5hrs to <6hrs	2,572 (10.8)	78 (7.8)	645 (6.5)	71 (8.7)	374 (7.5)	48 (10.1)
≥6hrs to <7hrs	5,134 (21.7)	203 (20.4)	1,849 (18.5)	184 (22.6)	1,001 (20.0)	122 (25.8)
≥7hrs to ≤9hrs	10,135 (42.8)	506 (50.8)	6,473 (64.9)	462 (56.9)	3,211 (64.3)	248 (52.5)
>9hrs	1,954 (8.2)	57 (5.7)	523 (5.3)	52 (6.4)	198 (4.0)	26 (5.5)
Missing	2,433 (10.2)	106 (10.6)	n/a	n/a	n/a	n/a
Cannot get to sleep within 30 minutes[3]						
Rarely/never	8,880 (37.5)	335 (33.6)	4,221 (42.3)	308 (37.9)	2,447 (49.0)	197 (42.0)
Infrequent	4,250 (17.9)	134 (13.4)	2,048 (20.5)	158 (19.4)	923 (18.5)	81 (17.1)
Regular	3,377 (14.2)	152 (15.2)	1,522 (15.2)	138 (17)	705 (14.1)	72 (15.2)
Frequent	2,528 (10.6)	121 (12.1)	1,180 (11.8)	111 (13.6)	511 (10.2)	58 (12.2)
Always	2,291 (9.6)	110 (11.0)	994 (10.0)	96 (11.8)	402 (8.0)	64 (13.5)
Missing	2,332 (9.9)	106 (10.6)	n/a	n/a	n/a	n/a
Wake up middle of the night/early morning[3]						
Rarely/never	6,111 (25.8)	134 (13.4)	3,027 (30.3)	126 (15.5)	1,607 (32.2)	90 (19.0)
Infrequent	3,798 (16.0)	104 (10.4)	1,758 (17.6)	96 (11.8)	837 (16.7)	48 (10.1)
Regular	4,085 (17.2)	167 (16.7)	1,852 (18.5)	149 (18.3)	919 (18.4)	90 (19.1)
Frequent	3,721 (15.7)	207 (20.8)	1,709 (17.1)	193 (23.8)	839 (16.8)	104 (22.0)
Always	3,685 (15.5)	280 (28.1)	1,619 (16.2)	247 (30.4)	786 (15.7)	140 (29.6)
Missing	2,258 (9.5)	103 (10.3)	n/a	n/a	n/a	n/a

Table 3.1. Continued.

	All female participants in W1 and/or W4 of UKHLS aged 16-48yrs (n=24,653)		Female participants in W1 and/or W4 of UKHLS aged 16-48yrs with data on all variables (except gestational age; n=10,776)		Multiparous female participants in W1 and/or W4 of UKHLS not using sleep mediation with data on all variables (except gestational age; n=5,460)	
	Non-pregnant (n=23,658) n (%)	Pregnant (n=995) n (%)	Non-pregnant (n=9,965) n (%)	Pregnant (n=811) n (%)	Non-pregnant (n=4,988) n (%)	Pregnant (n=472) n (%)
Cough or snore loudly[3]						
Rarely/never	16,325 (69.0)	671 (67.4)	7,873 (79.0)	629 (77.5)	4,002 (80.2)	374 (79.2)
Infrequent	1,711 (7.2)	83 (8.3)	818 (8.2)	75 (9.2)	376 (7.5)	38 (8.0)
Regular	1,099 (4.6)	54 (5.4)	534 (5.4)	50 (6.1)	272 (5.5)	27 (5.7)
Frequent	781 (3.3)	29 (2.9)	362 (3.6)	25 (3.2)	174 (3.5)	14 (3.0)
Always	819 (3.4)	36 (3.6)	378 (3.8)	32 (3.9)	164 (3.3)	19 (4.0)
Missing	2,923 (12.3)	122 (12.2)	n/a	n/a	n/a	n/a
Use of medicine to help sleep[3]						
Rarely/never	19,014 (80.3)	848 (85.2)	8,811 (88.4)	762 (93.9)	4,988 (100)	472 (100)
Infrequent	907 (3.8)	20 (2.0)	423 (4.2)	16 (1.9)	n/a	n/a
Regular	538 (2.2)	12 (1.2)	239 (2.4)	10 (1.2)	n/a	n/a
Frequent	1,201 (5.0)	25 (2.5)	492 (4.9)	23 (2.8)	n/a	n/a
Missing	1,998 (8.4)	90 (9.0)	n/a	n/a	n/a	n/a
Sleep quality overall						
Very good	5,558 (23.4)	155 (15.5)	2,638 (26.4)	139 (17.1)	1,414 (28.3)	76 (16.1)
Fairly good	10,952 (46.2)	477 (47.9)	5,048 (50.6)	424 (52.2)	2,548 (51.1)	237 (50.2)
Fairly bad	4,083 (17.2)	225 (22.6)	1,740 (17.4)	200 (24.6)	812 (16.3)	130 (27.5)
Very bad	1,159 (4.8)	50 (5.0)	539 (5.4)	48 (5.9)	214 (4.3)	29 (6.1)
Missing	1,906 (0.1)	88 (8.8)	n/a	n/a	n/a	n/a
Trouble staying awake during the day[3]						
Rarely/never	18,559 (78.4)	750 (75.3)	8,636 (86.6)	668 (82.3)	4,515 (90.5)	410 (86.8)
Infrequent	1,734 (7.3)	83 (8.3)	761 (7.6)	74 (9.1)	272 (5.5)	34 (7.2)
Regular	909 (3.8)	53 (5.3)	382 (3.8)	52 (6.4)	127 (2.6)	17 (3.6)
Frequent	473 (1.9)	19 (1.9)	186 (1.9)	17 (2.1)	74 (1.5)	11 (2.3)
Missing	1,983 (8.3)	90 (9.0)	n/a	n/a	n/a	n/a

[1]≥Degree [Educational] qualifications was recoded from "Degree", "Other higher degree"; <Degree from "A-level" and "GCSE" and "Other qualification"; None from "No qualifications".
[2]High [employment] status was recoded from "Employee: Management and Professional", "Employee: and Intermediate" and "Employee: Small Employers and own account"; Low status from "Employee: Lower supervisory and technical" and "Employee: Semi-routine, Routine and Never worked long term"; and Unemployed from "Unemployed", "Maternity leave", "Student" and "Long-time sick".
[3]Rarely/never was recoded from "Not during the past month"; Infrequent from "Less than once a week"; Regular from "Once or twice a week"; Frequent from "Three or more times a week"; and Always from "More than once most nights".

3.7.3 Self-reported sleep characteristics of pregnant and non-pregnant women

The analyses summarised in the first two columns of Table 3.2 which compare pregnant and non-pregnant women, the latter selected on the basis that they had a similar age range to those who were pregnant (i.e. 16-49yrs) with complete data on all sociodemographic and health variables (except gestational age at interview/questionnaire completion) indicate that, compared to non-pregnant female participants in the UKHLS, pregnant participants were more likely to report: shorter (<7hrs) and longer (>9hrs) sleep duration than that recommended by the National Sleep Foundation (Hirshkowitz et al., 2015); more frequent trouble getting to sleep within 30 minutes; more frequent waking in the middle of the night/early morning; and more frequent difficulties staying awake while eating, driving and/or socialising. While pregnant participants were no more (or less) likely to report frequent trouble sleeping due to "coughing or snoring loudly", they were far less likely to report using medication to help them sleep and were far more likely to report their overall sleep quality as less than good.

Importantly, these findings were largely unaffected following adjustment for preceding potential confounders (including pre-existing chronic health conditions). This indicates that the differences in sleep between pregnant and non-pregnant UKHLS participants were not simply the result of sociodemographic and/or health differences between women who could (and did) become pregnant and those who could not (or chose not to do so). With the exception of coughing/snoring, these results appear to confirm the findings of previous studies on samples from both clinical and non-clinical contexts (e.g. Ko et al., 2010; 2012), and indicate that pregnant women in the UK report less favourable sleep duration, latency, disturbance, quality and daytime sleepiness than non-pregnant women.

To explore whether differences in the use of sleep medication might have contributed to the differences in sleep observed between pregnant and non-pregnant women, and to strengthen the matching of these two populations (by excluding pregnant and non-pregnant women who had not yet had a child), the analyses were repeated in a second sample of multiparous pregnant and non-pregnant women, all of whom reported that

they had not used sleep medication in the preceding month (see Table 3.2, columns 3 and 4). Despite the 40-50% reduction in sample sizes for both pregnant (n=472/811; 58.2%) and non-pregnant women (n=4,988/9,965; 50.1%), the remaining pregnant women reported very similar patterns of less favourable sleep to those observed in the preceding analyses, and the strength of the associations between pregnancy status and each of the sleep characteristics was largely unaffected by adjustment for preceding potential confounders. However, the only exception was the elevated frequency of difficulty staying awake while eating, driving and/or socialising, observed in the first and second columns of Table 3.2 (RRR:1.73; 95%CI:1.26,2.38), which was no longer statistically significant amongst the subsample of multiparous women who had not used sleep medication in the previous month (RRR:1.29; 95%CI:0.75,2.21). However, this appears to have been the result of the lower sample size used in the second set of analyses, and the associated loss of statistical power for this effect (as is evident from the wider confidence intervals and only moderately attenuated effect size). As such, these analyses indicate that the less favourable sleep reported by pregnant women (as opposed to their non-pregnant counterparts) was not simply the result of their less frequent use of sleep medication, or of any health and/or social consequences associated with their ability (and decision to) become pregnant.

While the analyses summarised in Table 3.2 seem to provide convincing evidence that the self-reported sleep characteristics of pregnant and non-pregnant women are very different, they disregarded the gestational age at which pregnant women completed the sleep module of the UKHLS questionnaires, and the fact that self-reported sleep characteristics (and a host of related behaviours) are known to change during the course of pregnancy. To better understand the overall impact of pregnancy on the self-reported sleep of pregnant women, it is necessary to adjust for the contribution that gestational age at interview/questionnaire completion might make to variation in each of the seven sleep characteristics. Unfortunately, for the reasons explained above, data on gestational age at interview/questionnaire completion could only be estimated for n=312/811 (38.5%) of the pregnant women in Waves 1 and 4 of the UKHLS, and most of these women (n=168; 53.8%) were interviewed in Trimester two, with fewer than a

third (n=91; 29.2%) and fewer than a fifth (n=53; 17.0%) in Trimesters three and one, respectively.

To minimise the impact of this reduction in sample size on analyses comparing the self-reported sleep of pregnant and non-pregnant women, before and after adjustment (and/or stratification) for gestational age, sleep duration was coded in binary categories (with a 'least unfavourable' category (7hrs and ≤9hrs per night) and a 'least favourable' category (<7hrs or >9hrs), while all of the remaining sleep characteristics were coded in binary categories as close as possible to the median prevalence of reported frequencies and/or quality. The analyses summarised in Table 3.2 (columns 1 and 2) were then repeated on the exact same sample (n=10,776), using the binary categories self-reports as outcome variables in multivariable logistic regression analyses (see Table 3.3, column to assess whether the use of binary outcome variables had any effect on the associations observed. These analyses found very similar associations between pregnancy and sleep as those summarised in Table 3.2, pregnant women having: higher odds of less favourable sleep duration, latency, disturbance, quality and daytime sleepiness; lower odds of sleep medication use; and similar odds of coughing/snoring loudly, as compared to non-pregnant women (see Table 3.3, columns 1 and 2). While these findings were also largely unaffected by adjustment for preceding sociodemographic and health factors (Table 3.3, column 2), subsequent analyses based on the smaller sample (n=312) from which pregnant women with missing data on gestational age had been removed, strengthened the odds of reporting less favourable sleep and less frequent use of sleep medication, with the exception of trouble staying awake while eating, driving and/or socialising which was no longer statistically significant (Table 3.3, columns 3 and 4). These results offer a better assessment of the overall odds of pregnant women reporting less favourable sleep characteristics and less frequent use of sleep medication, irrespective of gestational age, while the final two columns of Table 3.3 (i.e. columns 5 and 6) indicate the extent to which self-reported sleep characteristics vary during the course of pregnancy – analyses that were restricted to the n=312 pregnant women for whom it was possible to estimate gestational age at interview/questionnaire completion.

The findings summarised in the last two columns of Table 3.3 indicate that pregnant

women tend to report less favourable sleep in Trimesters one and three, as compared to Trimester two (the referent in these analyses). In addition, while the low numbers of pregnant women with sufficient data to permit the estimation of gestational age at interview/questionnaire completion had a substantial impact on the statistical power of these analyses (and the precision of the effect sizes observed), it is clear that in both Trimester one and three, pregnant women had: higher odds of more frequently reporting extended sleep latency (Trimester one OR:1.53; 95%CI:0.80,2.91; Trimester three OR:1.96; 95%CI:1.13,3.40) and trouble staying awake while eating, driving and/or socialising (Trimester one OR:1.24; 95%CI:0.51,3.00; Trimester three OR:1.72; 95%CI:0.86,3.43). Although insufficient women in Trimester three reported using sleep medication to permit the calculation of the associated odds, those in Trimester one actually reported much higher odds of using sleep medication than those in Trimester two (OR:6.54; 95%CI:0.58,73.71). Pregnant women in Trimester three also had elevated odds of: less favourable sleep duration (OR: 1.62; 95%CI: 0.97,2.71); more frequent sleep disturbance (i.e. waking in the middle of the night/early morning; OR:2.47; 95%CI: 1.25,4.85); more frequent trouble sleeping due to coughing and/or snoring loudly (OR:1.46; 95%CI:0.78,2.73); and reporting their overall sleep quality as being less than good (OR:3.03; 95%CI:1.76,5.20). All of these findings suggests that the third trimester poses the greatest challenge to the self-reported sleep of pregnant women.

Table 3.2: Multinomial logistic regression analyses examining the risk of less favourable responses to items on seven self-reported sleep characteristics amongst: all pregnant and non-pregnant (referent) female participants in Waves 1 and/or 4 of the UKHLS with complete data on sociodemographic and health variables (except gestational age at interview/questionnaire completion); and those multiparous pregnant and non-pregnant (referent) female participants who did not report using sleep medication. All results are presented as relative risk ratios (RRRs) with 95% confidence intervals (95%CI) in parentheses, before and after adjustment for potential confounders.[1].

	Female participants in W1 and/or W4 of UKHLS aged 16-48yrs with data on all variables (except gestational age; n=10,776)			Multiparous female participants in W1 and/or W4 of UKHLS aged 16-48yrs who did not report taking medicine to help sleep with data on all variables (except gestational age; n=5,460)		
Sleep characteristic (referent)	Non-pregnant (n=9,965) (referent)	Pregnant (n=811) Unadjusted RRR (95%CI) Column(1)	Adjusted[1] RRR (95%CI) Column(2)	Non-pregnant (n=4,988) (referent)	Pregnant (n=472) Unadjusted RRR (95%CI) Column(3)	Adjusted[1] RRR (95%CI) Column(4)
Sleep duration (≥7hrs and ≤9hrs per night)						
<5hrs per night	1.00	1.23 (0.89,1.72)	**1.58 (1.12,2.23)**	1.00	**1.77 (1.17,2.69)**	**2.03 (1.30,3.16)**
≥5hrs and <6hrs per night	1.00	**1.54 (1.18,2.00)**	**1.71 (1.30,2.26)**	1.00	**1.66 (1.19,2.30)**	**1.64 (1.16,2.32)**
≥6hrs and <7hrs per night	1.00	**1.39 (1.16,1.66)**	**1.57 (1.30,1.89)**	1.00	**1.57 (1.25,1.98)**	**1.59 (1.25,2.02)**
>9hrs per night	1.00	**1.39 (1.03,1.88)**	**1.49 (1.08,2.05)**	1.00	**1.70 (1.10,2.61)**	1.36 (0.87,2.14)
Cannot get to sleep within 30min (Rarely/never: Not during past month)						
Infrequent: Less than once a week	1.00	1.05 (0.86,1.28)	1.07(0.87,1.32)	1.00	1.09 (0.83,1.42)	1.09 (0.82,1.44)
Regular: Once or twice a week	1.00	**1.24 (1.00,1.53)**	**1.37 (1.10,1.70)**	1.00	1.26 (0.95,1.68)	**1.36 (1.01,1.82)**
Frequent: Three or more times a week	1.00	**1.28 (1.02,1.61)**	**1.44 (1.13,1.82)**	1.00	**1.42 (1.04,1.92)**	**1.44 (1.04,1.99)**
Always: More than once most nights	1.00	**1.32 (1.04,1.68)**	**1.55 (1.20,2.00)**	1.00	**1.97 (1.46,2.67)**	**2.06 (1.49,2.85)**
Wake up middle of the night/early morning (Infrequent: Less than once a week or Rarely/never: Not during past month)						
Infrequent: Less than once a week	1.00	1.31 (0.99,1.72)	**1.39 (1.05,1.84)**	1.00	1.02 (0.71,1.46)	1.18 (0.81,1.72)
Regular: Once or twice a week	1.00	**1.93 (1.51,2.46)**	**2.09 (1.62,2.68)**	1.00	**1.78 (1.31,2.43)**	**1.87 (1.37,2.57)**
Frequent: Three or more times a week	1.00	**2.71 (2.15,3.42)**	**2.94 (2.31,3.74)**	1.00	**2.21 (1.64,2.97)**	**2.33 (1.71,3.16)**
Always: More than once most nights	1.00	**3.66 (2.93,4.58)**	**4.18 (3.31,5.28)**	1.00	**3.18 (2.40,4.20)**	**3.24 (2.42,4.35)**
Cough or snore loudly (Rarely/never: Not during past month)						
Infrequent: Less than once a week	1.00	1.14 (0.89,1.47)	1.21 (0.93,1.57)	1.00	1.08 (0.76,1.53)	1.16 (0.80,1.68)
Regular: Once or twice a week	1.00	1.17 (0.86,1.58)	1.24 (0.90,1.69)	1.00	1.06 (0.70,1.59)	1.13 (0.73,1.73)
Frequent: Three or more times a week	1.00	0.86 (0.57,1.30)	1.03 (0.67,1.58)	1.00	0.86 (0.49,1.49)	1.20 (0.67,2.14)
Always: More than once most nights	1.00	1.05 (0.73,1.53)	1.15 (0.78,1.70)	1.00	1.23 (0.76,2.01)	1.22 (0.73,2.04)

Table 3.2. Continued.

Sleep characteristic (referent)	Female participants in W1 and/or W4 of UKHLS aged 16-48yrs with data on all variables (except gestational age; n=10,776)			Multiparous female participants in W1 and/or W4 of UKHLS aged 16-48yrs who did not report taking medicine to help sleep with data on all variables (except gestational age; n=5,460)		
	Non-pregnant (n=9,965) (referent)	Pregnant (n=811) Unadjusted RRR (95%CI) Column(1)	Pregnant (n=811) Adjusted[1] RRR (95%CI) Column(2)	Non-pregnant (n=4,988) (referent)	Pregnant (n=472) Unadjusted RRR (95%CI) Column(3)	Pregnant (n=472) Adjusted[1] RRR (95%CI) Column(4)
Use of medicine to help sleep (Rarely/never: Not during past month)						
Infrequent: Less than once a week	1.00	**0.43 (0.26,0.72)**	**0.41 (0.25,0.70)**	n/a	n/a	n/a
Regular: Once or twice a week	1.00	**0.48 (0.25,0.91)**	0.58 (0.30,1.11)	n/a	n/a	n/a
Frequent: Three or more times a week	1.00	**0.54 (0.35,0.82)**	0.65 (0.41,1.01)	n/a	n/a	n/a
Sleep quality overall (Very good)						
Fairly good	1.00	**1.59 (1.31,1.94)**	**1.54 (1.26,1.89)**	1.00	**1.73 (1.32,2.25)**	**1.59 (1.20,2.09)**
Fairly bad	1.00	**2.18 (1.74,2.73)**	**2.28 (1.80,2.88)**	1.00	**3.01 (2.21,4.00)**	**2.72 (1.99,3.71)**
Very bad	1.00	**1.69 (1.12,2.37)**	**2.15 (1.50,3.08)**	1.00	**2.52 (1.60,3.95)**	**2.83 (1.76,4.57)**
Trouble staying awake during the day (Rarely/never: Not during past month)						
Infrequent: Less than once a week	1.00	1.25 (0.97,1.61)	1.24 (0.96,1.62)	1.00	1.37 (0.95,1.99)	1.39 (0.94,2.05)
Regular: Once or twice a week	1.00	**1.75 (1.31,2.40)**	**1.73 (1.26,2.38)**	1.00	1.47 (0.87,2.46)	1.29 (0.75,2.21)
Frequent: Three or more times a week	1.00	1.18 (0.71,2.10)	1.46 (0.86,2.46)	1.00	1.63 (0.86,3.10)	1.97 (0.99,3.93)

[1]Adjusted for: age group; ethnicity-based DM risk; educational qualifications; partnership status; household composition; parity; pre-existing diagnoses of chronic health conditions; employment status.

Table 3.3: Multivariable logistic regression analyses examining the risk of less favourable responses to items on seven self-reported sleep characteristics amongst pregnant and non-pregnant (referent) female participants in Waves 1 and/or 4 of the UKHLS with either data on all variables except gestational age at interview/questionnaire completion (n=10,776) or data on all variables including gestational age (n=10,277); with additional analyses only on pregnant women with complete data on gestational age (n=312), disaggregated by trimester at interview/questionnaire completion (referent: trimester 2). All results are presented as odds ratios (ORs) with 95% confidence intervals (95%CI) in parentheses, before and after adjustment for sociodemographic and health confounders.1

Sample:	Female UKHLS participants in W1 and/or W4 with data on all variables *except* gestational age (n=10,776)		Female UKHLS participants in W1 and/or W4 with data on all variables *including* gestational age (n=10,277)		Pregnant female UKHLS participants in W1 and/or W4 with data on all variables *including* gestational age (n=312)	
(Referent; n):	(Non-pregnant; n=9,965)		(Non-pregnant; n=9,965)		(Trimester 2; n=168)	
	Pregnant (n=811)		Pregnant (n=312)		Trimester 1 (n=53)	Trimester 3 (n=91)
Sleep characteristic (referent)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[2] OR (95%CI)	Unadjusted OR (95%CI)	Unadjusted OR (95%CI)
Sleep duration (≥7hrs and ≤9hrs per night)						
<7hrs or >9hrs per night	**1.40 (1.21, 1.61)**	**1.57 (1.35,1.83)**	**1.63 (1.30,2.04)**	**1.91 (1.51,2.41)**	1.10 (0.59,2.05)	1.62 (0.97,2.71)
Cannot get to sleep within 30min (Rarely/never: Not during past month)						
≥ Infrequent: Less than once a week	**1.20 (1.03,1.39)**	**1.30 (1.11,1.51)**	1.20 (0.95,1.52)	**1.37 (1.08,1.73)**	1.53 (0.80,2.91)	**1.96 (1.13,3.40)**
Wake up middle of the night/early morning (Infrequent: Less than once a week or Rarely/never: Not during past month)						
≥ Regular: Once or twice a week	**2.45 (2.08,2.87)**	**2.61 (2.21,3.08)**	**2.77 (2.13,3.59)**	**3.07 (2.36,4.00)**	0.95 (0.48,1.86)	**2.47 (1.25,4.85)**
Cough or snore loudly (Rarely/never: Not during past month)						
≥ Infrequent: Less than once a week	1.08 (0.91,1.29)	1.18 (0.99,1.41)	0.93 (0.70,1.23)	1.07 (0.80,1.42)	1.06 (0.48,2.36)	1.46 (0.78,2.73)
Use of medicine to help sleep (Rarely/never: Not during past month)						
≥ Infrequent: Less than once a week	**0.49 (0.36,0.65)**	**0.53 (0.39,0.73)**	**0.07 (0.02,0.23)**	**0.08 (0.02,0.28)**	6.54 (0.58,73.71)	n/a
Sleep quality overall (Fairly good or Very good)						
≤Fairly bad	**1.48 (1.27,1.73)**	**1.65 (1.40,1.95)**	**1.59 (1.24, 2.02)**	**1.86 (1.45, 2.40)**	1.11 (0.54,2.25)	**3.03 (1.76,5.20)**
Trouble staying awake during the day (Rarely/never: Not during past month)						
≥ Infrequent: Less than once a week	**1.39 (1.15,1.68)**	**1.41 (1.16,1.73)**	1.15 (0.84,1.58)	1.27 (0.92,1.76)	1.24 (0.51,3.00)	**1.72 (0.86,3.43)**

[1]Adjusted for: age group; ethnicity-based DM risk; educational qualifications; partnership status; household composition; parity; pre-existing diagnoses of chronic health conditions; and employment status (not gestational age at interview/questionnaire completion).
[2]Adjusted for: age group; ethnicity-based DM risk; educational qualifications; partnership status; household composition; parity; pre-existing diagnoses of chronic health conditions; employment status; and gestational age at interview/questionnaire completion as a competing exposure.

3.8 Discussion

3.8.1 Potential limitations

While the present study provides a unique contemporary insight into the self-reported sleep characteristics of a substantial sample of pregnant women, drawn from a broadly representative sample of adult women in a western European country (likely to be generalizable to other, similar, high-income contexts), the analyses are subject to a number of important limitations, including: the potential misclassification of the key exposure variable (pregnant/non-pregnant status); its reliance on self-reported sleep characteristics; the absence of longitudinal data on pre-existing/pre-pregnant sleep; the shortage of data on gestational age at interview/questionnaire completion; and the impact of that on the sample size available for analyses that require data on this variable.

There are two reasons why the exposure variable (pregnant/non-pregnant status) is likely to have been non-precisely specified: first, because all female respondents who chose the response "Self/partner currently pregnant" in Wave 1 were considered to be pregnant, and it is possible that this will have included some respondents in same-sex relationships whose female partners, and not themselves, were pregnant. Second, the substantial numbers of female respondents who chose the response "Pregnant at last interview" in the Wave 2 and Wave 5 questionnaires but had not chosen the response "Self/partner currently pregnant" in the preceding waves, indicates that there were some female respondents who did not know they were pregnant when interviewed in these waves, or were unwilling to report this. For those who were not re-interviewed in subsequent waves, there would have been no opportunity to update this response, and they would therefore have been incorrectly classified as non-pregnant in the present study's analyses.

Although it is not possible to identify women incorrectly classified as pregnant or non-pregnant (for the first and second reason, respectively) in the data collected by the UKHLS, the impact of this misclassification here should only have been to attenuate rather than increase any differences in self-reported sleep observed between pregnant and non-pregnant respondents. Moreover, since the numbers of women involved are

likely to be small in comparison to both the sizeable number of pregnant women and the very much larger number of non-pregnant women in the analyses, it is unlikely that any bias would have been substantive.

Whilst it is true that self-reported sleep characteristics can only provide a subjective assessment of sleep, and are subject to all of the potential biases that affect self-reported phenomena/characteristics, including response and recall bias (Kessler, 2003; Coughlin, 1990), it could be argued that such self-reports are simply 'different', as opposed to 'inferior', measures of sleep to those provided by the use of objective techniques (such as actigraphy or polysomnography). Moreover, since objective techniques rely exclusively on physiological, neurological and/or behaviour-related indicators of sleep rather than on the way these are actually experienced by the individuals concerned, it can be argued that self-reported sleep characteristics offer a more sensitive and meaningful assessment of sleep (as experienced by the individuals concerned) than the 'objective' measurement techniques available. Since the seven items included in the UKHLS sleep module were derived/adapted from a widely used (and extensively well-validated) sleep questionnaire (the PSQI), the sleep data collected by the UKHLS are comparable with the larger number of studies exploring sleep in pregnancy that used subjective (rather than objective) measures of sleep, many of which used the PSQI as the key psychometric instrument for collecting self-reported sleep data. As such, the use of PSQI-derived variables likely to be capable of detecting important variations in the experience of sleep across a range of seven distinct sleep characteristics is arguably less of a limitation and more of a strength in the present study.

Nonetheless, because the UKHLS has yet to generate sufficient longitudinal data on sleep to permit analyses of changes in self-reported sleep characteristics both before and during pregnancy, the present study had to rely on a comparison of self-reported sleep characteristics of pregnant and non-pregnant women that, even after adjustment for measured potential confounders, was still likely to be susceptible to under-adjustment. Fortunately, the availability of data on a substantial number of potential sociodemographic and health-related confounders within the UKHLS datasets

generated during Wave 1 and Wave 4 helped to minimise the risk of under-adjustment for confounding in the present study. Despite this, it remains questionable whether comparing the self-reported sleep of pregnant women with that reported by a heterogeneous sample of non-pregnant women (consisting of those who already had one or more children and those who were yet to have children, including some who would never have any children) offers a suitable alternative for establishing the changes in sleep that might occur during pregnancy using a longitudinal study design.

If, for example, nulliparous non-pregnant women were to exhibit more (or, indeed, less) favourable sleep characteristics than multiparous non-pregnant women, then the inclusion of the former would increase (or attenuate, respectively) any observed differences between the self-reported sleep of pregnant and non-pregnant women. In order to address this potential bias, the present study repeated the analyses presented in Table 3.2 (columns 1 and 2) after excluding nulliparous pregnant and non-pregnant women, and those who reported using medication to help them sleep in the month before interview/questionnaire completion. While this resulted in a substantial reduction in the number of pregnant and non-pregnant women included in the analyses (and an associated decline in the precision of some of the effect sizes obtained), these analyses largely confirmed the findings presented in Table 3.2 (columns 1 and 2). However, it remains to be seen whether similar disparities in self-reported sleep exist between nulliparous pregnant and non-pregnant women.

Finally, the limited availability of data on gestational age at interview/questionnaire completion constitutes a substantive limitation to the information provided by, and the generalizability of, the findings summarised in Table 3.1 (columns 1 and 2), given that these findings were based upon a sample of pregnant women with an uneven distribution of gestational age (only 6.5% in Trimester one; 20.7% in Trimester two; and 11.2% in Trimester three; with 61.5% lacking the data required to estimate gestational age at interview/questionnaire completion). Indeed, it is clear from the subsequent analyses presented in Table 3.3 (columns 5 and 6) that the self-reported sleep characteristics of pregnant women were very different at the beginning, middle and end of pregnancy (sleep being least favourable in Trimester three than in trimester one

or two, in that order). Indeed, if all of those pregnant women with missing data on gestational age at interview/questionnaire completion provided self-reported sleep data in only one of the three trimesters, then the results presented in Table 3.3 (columns 1 and 2) would over-estimate or under-estimate the less favourable sleep of

pregnant women averaged across all three trimesters (i.e. were all such women to have been interviewed within Trimesters three or one, or within Trimester two, respectively). To address this concern, the analyses conducted in Table 3.3 (columns 1 and 2) were repeated again, though this time on a sample of pregnant and non-pregnant women with sufficient data to permit the estimation of gestational age at interview/questionnaire completion. The results of these analyses (presented in Table 3.3, columns 3 and 4) provided little evidence to suggest that the uneven distribution of gestational age (and unknown gestational age) in the original sample of n=811 pregnant women (i.e. those included in Table 3.2 columns 1 and 2) had any substantive effect on the size or direction of the differences in self-reported sleep between pregnant and non-pregnant women observed in the earlier analyses (i.e. as reported in Table 3.2, columns 1 and 2).

3.8.2 Differences in sleep characteristics amongst pregnant and non-pregnant women

These limitations in the availability and quality of data within the UKHLS, together with the limited sample sizes of pregnant women, mean that the analyses conducted by the present study generated effect size estimates with limited precision and limited statistical power. These samples were lower still when refined to exclude those women who were nulliparous; who used sleep medication; and for whom it was not possible to estimate 'gestational age at interview/questionnaire completion'. However, it remains clear from these analyses that pregnant women report less favourable sleep across a broad range of sleep characteristics; and that these are likely to be broadly generalizable to pregnant women across the UK and similar high-income contexts. As such, the present study confirms that pregnancy is associated with: both longer (>9hrs) and shorter (<7hrs) sleep duration; more frequently reported difficulty getting to sleep

within 30 minutes; less frequent use of sleep medication; more frequently disturbed sleep and more frequent daytime sleepiness; and sleep quality that is more frequently described as less than 'good' overall. These differences (between pregnant and non-pregnant women) are slightly increased after adjustment for potential confounding (see Table 3.2, column 2) but even following the exclusion of nulliparous women and those reporting the use of sleep medication in the month preceding interview (see Table 3.2, column 4), and those missing estimates of gestational age at interview/questionnaire completion (Table 3.3, columns 4-6), they are still clear. It is therefore likely that these reflect genuine differences in self-reported sleep that result from pregnancy itself (whether from the hormonal, physiological and anatomical changes, or changes in behaviour, lifestyle and wellbeing that accompany pregnancy). Amongst the background of these differences in sleep duration, latency, disturbance, medication use, quality and daytime sleepiness, the absence of any differences in the frequency with which pregnant and non-pregnant women reported trouble sleeping due to coughing/snoring loudly is striking. Indeed, given the substantial changes in body weight that accompany pregnancy in well-nourished women within high-income countries, together with the well-established relationship between obesity, snoring and obstructive sleep apnoea in both men and women (Gabbay and Lavie, 2012), it is surprising that pregnant women did not report a greater frequency of coughing/snoring than non-pregnant women in the present study. Three possible explanations for this are worth exploring. First, pregnant women may be less aware of coughing/snoring than non-pregnant women, a phenomenon that would be generated, if only in part, were pregnant women more likely than non-pregnant women to sleep alone, or at different times, to their bed partner (Tsai et al., 2012). Second, hormonal, physiological and/or anatomical changes that occur during pregnancy are somehow protective of coughing/snoring, as is known from the therapeutic use of progesterone for obstructive sleep apnoea (Maasilta et al., 2001). Third, the sleeping practices and patterns of pregnant women, including a preference for sleeping on one's side rather than on one's back, and a greater frequency of awakenings (McIntyre et al., 2016) may reduce the risk of coughing/snoring. All three possibilities warrant further investigation.

Finally, the extent to which the substantially lower frequency of self-reported sleep medication use amongst pregnant women might contribute to the less favourable sleep they report remains unclear. The present study's efforts to address this question, by re-analysing self-reported sleep data after excluding pregnant and non-pregnant women who reported the use of sleep medication during the month preceding interview, is unlikely to have adequately addressed this issue. This is because non-pregnant women who do not use sleep medication are more likely to be those who do not need to use this (or feel they would not benefit from using this). On the other hand, pregnant women who do not use sleep medication are more likely to avoid using this (given established contra-indications and related concerns regarding the use of most over-the-counter and prescribed medication during pregnancy) even if they did feel they needed, or would benefit from, this. Further research, using longitudinal observational designs (of sleep medication users and non-users before and during pregnancy), or experimental designs (comparing the sleep of pregnant and non-pregnant women with/without access to safe sleep medication) will be required to address this question.

3.9 Key findings

The present study provides the largest contemporary analysis of self-reported sleep characteristics amongst pregnant and non-pregnant women using a nationally representative sample from a high-income country with data on seven discrete sleep characteristics, and with robust adjustment for a carefully identified range of potential confounders. Pregnant women are less likely to report using medication to help them sleep, and do not report coughing/snoring more frequently than non-pregnant women. However, pregnant women report less favourable sleep duration, latency, disturbance, overall quality and daytime sleepiness than non-pregnant women. These findings remain largely unaffected by adjustment for measured confounders, or by the exclusion of: nulliparous women; those reporting the use of medication to help them sleep; and those for whom it was not possible to estimate gestational age at interview/questionnaire completion. Despite the smaller number of women with estimates of gestational age who were available for analysis, analyses of these women indicated that sleep was less favourable in the third trimester of pregnancy than in the

second, with self-reported sleep during the first trimester of pregnancy falling somewhere between the third and second.

These results confirm that the self-reported sleep of pregnant women differs to that of non-pregnant women, and appears less favourable across all but two of the seven sleep characteristics examined (the use of sleep medication and coughing/snoring). It remains to be seen whether these differences in sleep reflect, or are sensitive to variation in maternal or foetal health during the antenatal period; or are correlates, predictors and/or determinants of maternal or foetal health later in pregnancy, perinatally or postnatally.

Chapter 4

The relative importance of sociodemographic, health and lifestyle factors as potential determinants of sleep in pregnancy

4.1 Summary

The present Chapter focused on potential determinants of variation in (seven self-reported) sleep characteristics amongst the n=1,022 female UKHLS participants with singleton pregnancies identified in Waves 1 and 4 of the Survey. Using a causal path diagram (in the form of a directed acyclic graph) it was possible to identify a range of (pre-existing/pre-pregnant) sociodemographic and health characteristics and (contemporaneous) behavioural, anthropometric and health variables (i.e. those relevant to variation in lifestyles during pregnancy) as potential determinants of self-reported sleep; and to identify which of these might act as potential confounders (or competing exposures) in the relationships between any of the other variables and (each of the seven) sleep characteristics. Using this approach to specify the multivariable statistical models for each variable as the (specified) 'exposure' (i.e. potential determinant), enabled these analyses to demonstrate that a range of pre-existing and within-pregnancy social, behavioural and health variables were associated with substantial variation in self-reported sleep. However, the importance of pregnancy-specific (hormonal, physiological and anatomical) changes was also evident in analyses of a (sub)sample of participants with complete data on gestational age at interview/questionnaire completion – analyses which offered a marker of the very different changes occurring during successive stages/trimesters of pregnancy. As such, this Chapter indicates that changes that are specific to pregnancy (as well as characteristics and behaviours preceding, and/or subject to change during, pregnancy) all display important independent associations with self-reported sleep amongst pregnant women.

4.2 Introduction

Chapter 3 provided clear evidence that the self-reported sleep of pregnant women differed to that reported by non-pregnant women (even after adjustment for potential, preceding pre-pregnant differences in sociodemographic characteristics and health). However, Chapter 1 also confirmed that self-reported sleep varied substantially during different trimesters of pregnancy. Given the hormonal, physiological and anatomical changes that accompany pregnancy are known to vary in intensity and magnitude in successive trimesters, these findings suggested that it may be these changes that play the most important role in self-reported changes in sleep. Nevertheless, it is also known that changes in behaviour and lifestyle (and health) are commonplace during pregnancy (McGowan and McAuliffe, 2013; Leppänen et al., 2014) – some occuring as a result of the physical (hormonal, physiological and anatomical) changes, and some likely to change for other, unrelated reasons (including sociocultural and psychological responses to pregnancy). The aim of the present study was therefore to examine the relative importance of sociodemographic, health and lifestyle factors (and particularly changes/variation in the latter that may occur during pregnancy) as potential determinants of variation in sleep amongst pregnant women.

4.3 Methods

4.3.1 Sample specification

Much of the information described in Chapter 3 (describing the identification of pregnant women in the UKHLS) also apply to the analyses undertaken in the present Chapter; but these details have been repeated here to assist the reader in understanding where these differed for the analyses focussing solely on pregnant women (i.e. for the analyses undertaken in the present Chapter; Chapter 4). These analyses also drew on data collected from participants enrolled in the UK Household Longitudinal Study (UKHLS). The UKHLS was initiated in 2009 using a sampling frame designed to achieve a broadly representative sample of households across each of the UK's four constituent nations (England, Wales, Scotland and Northern Ireland). The first

wave of data collection, conducted over two years (2009-2011), recruited a total of n=30,169 households and generated data from n=23,207 male and n=27,784 female participants (all aged ≥16 years). Subsequent waves of data collection, again occurring over two-year periods, have continued to collect data from the original study participants as well as new participants, including: those who joined original participants' households (on either a permanent or temporary basis); and those recruited for additional samples (including a dedicated 'ethnicity boost' sample and participants integrated from the former British Household Panel Survey (Buck and McFall, 2011). In each wave of data collection, general household information is obtained from computer-assisted interviews with a single key informant, with additional individual-level data collected using a range of 'self-completion' postal questionnaires. To-date, seven waves of data collection have been undertaken, the data from which were released into the public domain approximately 24 months following collection.

4.3.2 Self-reported sleep characteristics

A dedicated 'sleep module' was originally included in the questionnaires of just two of the UKHLS waves: the adult self-completed questionnaire for Wave 1 (2009-2011) and the main questionnaire for Wave 4 (2012-2014). This module included a preface which stated: *"The following questions relate to your usual sleep habits during the last month. Please indicate the most accurate reply for the majority of days and nights in the past month",* and then presented seven discrete items adapted from the Pittsburgh Sleep Quality Index, a widely used tool for generating self-reported sleep data (Buysse et al., 1989). These items generated data on the following aspects of sleep: duration; latency; disturbance/awakening; coughing/snoring; medication; quality; and daytime sleepiness.[1]

[1] See: https://www.understandingsociety.ac.uk/files/design/materials/questionnaires/wave1/main_adult_sc_questionnaire.pdf

4.3.3 Identification of pregnant and non-pregnant women in the UKHLS

Given that self-reported sleep data are currently only available for participants interviewed in Waves 1 and 4 of the UKHLS, the present study sought to identify only those participants who were pregnant in one or both of these waves. Careful examination of the main household and adult self-completion questionnaires identified a number of variables capable of identifying which of the female participants were pregnant at the time of interview/questionnaire completion. The most important of these items/ questions asked the key household informant: "Do you think you will have [any more/any] children?", and one of the possible responses to this was: "Self/partner currently pregnant". Similarly, an item included in questionnaires from Wave 2 onwards helped to identify those female participants in preceding waves who may have been unaware or unwilling to disclose at that time that they were pregnant. One of the possible responses to the question: "Since last wave, have you been pregnant at all, even if this did not result in a live birth?" was: "Pregnant at last interview". A related follow-up question also generated contemporaneous self-reports of pregnancy which proved useful for identifying pregnant participants (though only for participants in Wave 4), namely: "Last time we interviewed you, you were pregnant. Did this/your next pregnancy result in a live birth with a normal delivery or by caesarean section?", for which one of the possible responses was: "Current pregnancy."

Since it is unknown whether multiple pregnancies might affect sleep during pregnancy, and since such pregnancies are comparatively rare, it was decided to include only women with singleton pregnancies in the present study. Thus, in order to to establish which of the women identified as pregnant in Waves 1 and 4 had multiple pregnancies, another item in questionnaires from the subsequent wave (i.e. Waves 2 and 5, respectively) was used, namely: "Did you have a multiple birth such as twins or triplets with this pregnancy? If interviewed at prior wave?", for which one of the possible answers was: "No, it was a single birth."

4.3.4 Estimation of gestational age at interview/questionnaire completion

Finally, since there is substantial evidence that self-reported sleep varies during the course of pregnancy (i.e. from trimester one through to trimester three (Hedman et al., 2002; Osaikhuwuomwan et al., 2014), and that behaviours with potential relevance to sleep often change as pregnancy progresses, including diet (McGowan and McAuliffe, 2013) and exercise (Leppänen et al., 2014), it was necessary to estimate the 'gestational age at interview/questionnaire completion' for each of the pregnant women in Waves 1 and 4 of the UKHLS. This involved using data on the date of interview in each of these waves, and data on the date of conception (collected only in Wave 4_, and data on the date of birth recorded in the subsequent wave (i.e. from Wave 2 for women identified as pregnant in Wave 1). Date of conception was also generated from a follow-on question to those participants who had reported "Pregnant at last interview" (see above), which asked: "In what month and year did you become pregnant?"; while data on date of birth was recorded confidentially, and required an application to the UK Data Archive for 'Special License Access' prior to analysis. Estimated gestational age was then calculated from these variables using the following formulae:

Gestational age at interview (Wave 1) = Date of birth – Date of interview (in Wave 1)

Gestational age at interview (Wave 4) = Date of interview – Date of conception (in Wave 4)

The resulting estimates were converted from days to weeks and thereafter to trimester (1-12 weeks: trimester one; 13-27 weeks: trimester two; 28-Term weeks: trimester three). Finally, to correct those estimates of gestational age calculated from data on date of birth (rather than on date of conception) and where birth had occurred early (i.e. prematurely) or late (i.e. post-dates), three more items from questionnaires in subsequent waves were used to apply an appropriate correction. These three items asked, first: "Was [child's name] born within one week of the expected due date?"; those respondents who answered "No" were then asked: "Was [child's name] born early or late?"; followed by a final item asking simply: "How many weeks early/late?."

Although this approach provided robust estimates of gestational age at interview/questionnaire completion, these relied upon data on date of conception,date of birth and early/late births that would only be available for those women who were present in the household in Waves 1 and 2 or in Wave 4 ; and who actually completed the relevant items in each of the respective questionnaires.

4.3.5 Sociodemographic, health and lifestyle predictors of self-reported sleep

To explore the relative importance of sociodemographic, health and lifestyle factors as potential determinants of self-reported sleep in pregnancy, each of the questionnaires used in successive waves of the UKHLS was carefully examined for suitable items relevant to each of these domains. These questionnaires contained core items that were repeated at every wave which focussed on social and demographic characteristics considered central to describing the composition and socioeconomic circumstances of each household, and the health of household members. However, items examining the views, behaviours and lifestyle of household members were not always included in every wave and were occasionally contained in consecutive questionnaires (for example, in every second or third questionnaire, as for those on self-reported sleep characteristics).

To a large extent this approach to data collection in the UKHLS is intended to optimise the range of items included while balancing this with the survey's capacity to detect trends in responses over time (Buck and McFall, 2011). Thus, as mentioned above, the sleep module items have only been included in questionnaires from two waves to date (Waves 1 and 4), while those relevant to dietary habits, participation in sport, smoking, and alcohol consumption have only been included in questionnaires for Waves 2 and 5. As a result, while substantial contemporaneous data were generated on a range of sociodemographic and health factors (including: age, ethnicity, educational qualifications, marital status/cohabitation, household composition, prior diagnoses of chronic disease, parity, employment status and current health) in both Waves 1 and 4 (when the self-reported sleep data were generated), lifestyle data for Wave 1 was only available some 18-24 months later in the Wave 2 questionnaire. Similarly, self-reported data on height, weight and body mass index (BMI) were only collected in Wave 1 and

are therefore only available as contemporaneous indicators of body mass index (BMI) for those participants identified as pregnant in Wave 1.

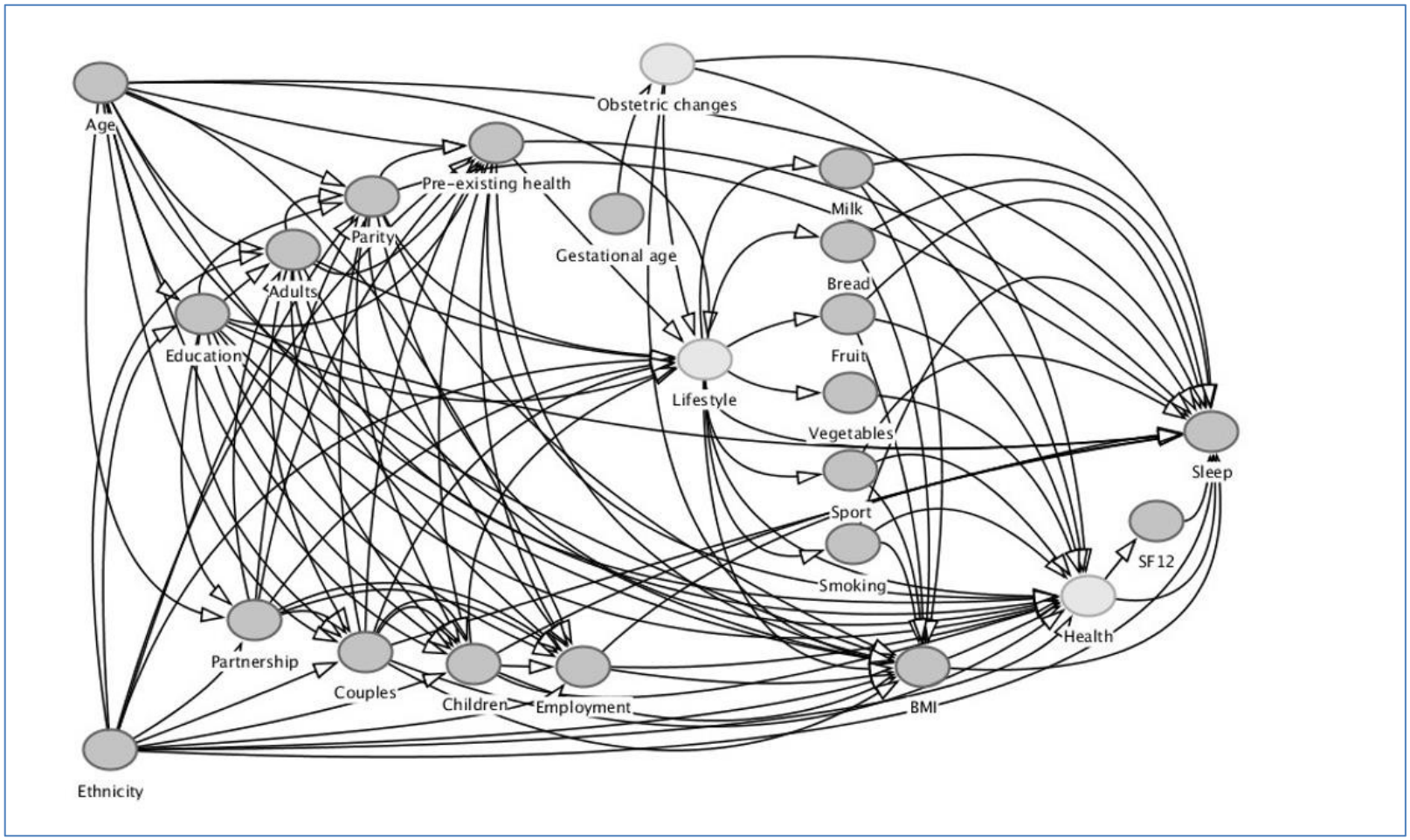
Given that behavioural and lifestyle items were not included in every single wave, wherever necessary the present study used data relating to these questions from the next consecutive wave. Therefore, data on lifestyle and behaviour were obtained from Wave 2 for participants identified as pregnant in Wave 1 while for participants identified as pregnant in Wave 4, relevant lifestyle and behaviour data were obtained from the Wave 5 questionnaires wherever necessary. Although there was a loss of precision involved with using data on lifestyle and behaviour collected 18-24 months after the data on sleep had been collected, this approach was adopted to optimise the availability of data on as many lifestyle variables as possible. The precise wording/definition of each of the original and derived variables used in this Chapter's analyses can be found in Appendix 3.1.

4.4 Statistical analysis

Summary descriptive statistics were used to compare the sociodemographic, health, lifestyle and self-reported sleep characteristics of study participants with complete and incomplete data on these variables, with the results of these summaries presented as frequencies with percentages in parentheses (%). Separate multivariable logistic regression analyses were then conducted for each of the seven sleep characteristics to establish the direction and strength of any differences observed between pregnant women with different (sociodemographic, health and lifestyle) characteristics before and after adjustment for potential confounding. These analyses were informed by a causal path diagram in which the n=20 measured covariates and estimated gestational age at interview/questionnaire completion were arranged in a hypothesised temporal sequence using a saturated directed acyclic graph (DAG) to identify those acting as potential confounders or competing exposures in any relationship between each self-reported sleep characteristic and different potential determinants thereof DAGs are causal path diagrams where prior knowledge of functional and empirically-determined causal relationships (as well as speculative causal links) are summarised visually on a

causal path diagram where interrelationships between variables are summarised using arrows (Greenland et al. 1999; Law and Shane 2012; Textor et al., 2017). When conducting epidemiological analyses of data from non-experimental studies, the advantage of using DAGs is that they allow researchers to present a clear and logical description of the 'known, likely and speculative causal relationships' between variables relevant to the hypothesis and any related questions which may arise. (Law et al.2012). (see Figure 4.1). The results of these analyses were presented as odds ratios (ORs See Glossary of Terminology) for the logistic regression models, or relative risk ratios (RRRs See in Glossary of Terminology) for the multinomial logistic regression models, with 95% confidence intervals (95%CIs) in parentheses. All analyses were conducted using Stata-IC 14 (StataCorp LP, TX)**.**

Figure 4.1 Causal path diagram in the form of a directed acyclic graph (DAG) summarising the theorised temporal relationships between sociodemographic, health and lifestyle factors as potential determinants of sleep in pregnancy n=20 measured covariates. Filled nodes indicate (observed) variables for which data were available; clear nodes indicate hypothesised (latent) variables for which no data were available. Drawn using *http://dagitty.net;* see Appendix 4.1 for Model Code.



4.5 Ethical approval

Most of the data for the UKHLS sample was obtained from publicly available datasets (available at: https://www.understandingsociety.ac.uk/), although a 'Special License Access' was required and granted by the UK Data Archive, for date of birth data to facilitate the estimation of gestational age at interview/questionnaire completion, as described earlie (UKDA Usage Number: 84718; see Appendix 3.4).

4.6 Data security

All data derived from the UKHLS are pseudo-anonymised (with no possibility that users can link these data to personal identifiers held securely by the UKHLS team). Once each of the UKHLS datasets had been downloaded, it was saved on the University of Leeds servers, and secured using password-only access – the data being held within a dedicated (password-protected) account on the N-drive (the Division of Epidemiology and Biostatistics server). Access to these data was restricted to the present study's research team alone.

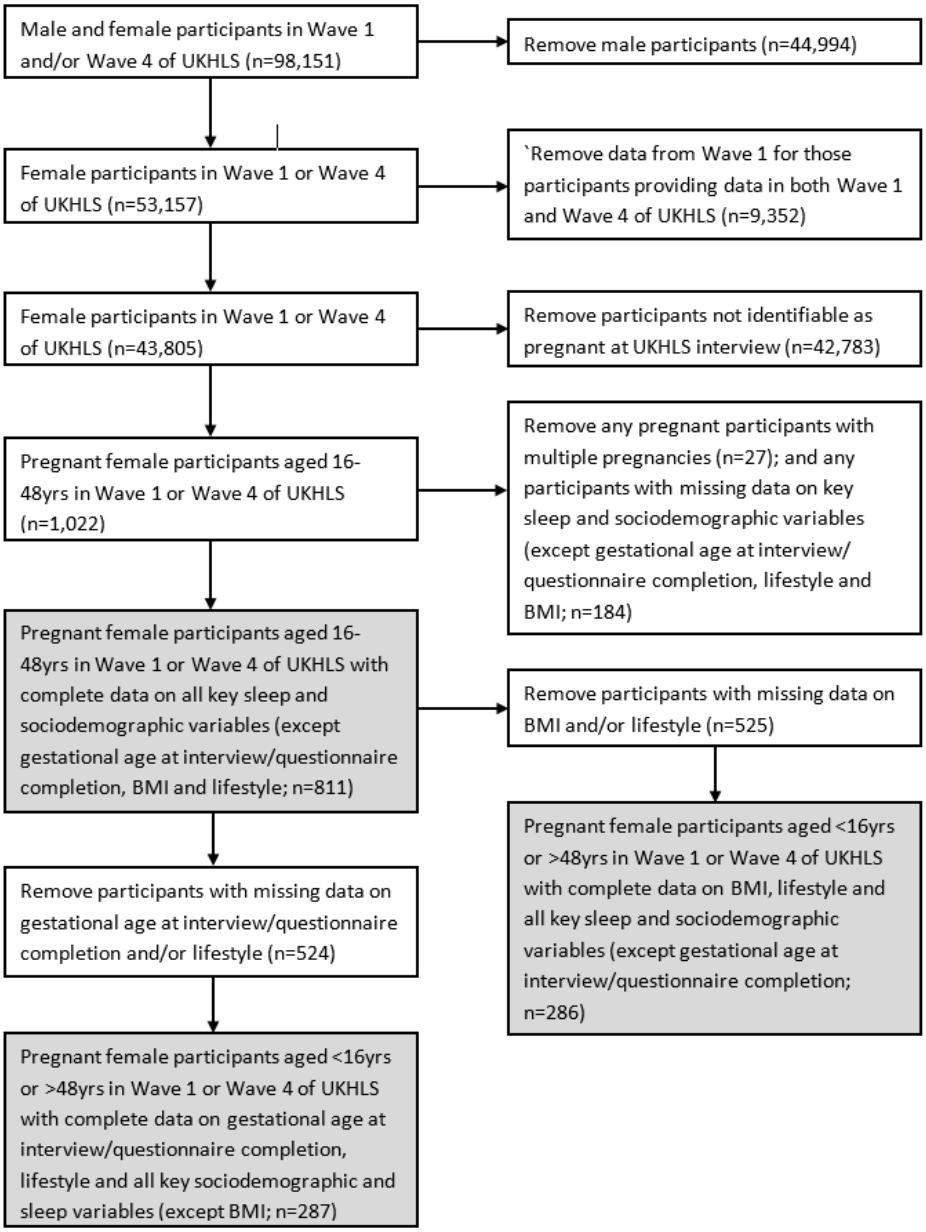
4.7 Results

4.7.1 Sampling

Figure 4.2 summarises each of the steps taken to generate the two samples of UKHLS participants on which the present Chapter's analyses were undertaken. Of the n=53,157 female participants in Waves 1 and 4, n=9,352 participated in both Waves; and after excluding data collected from these participants during Wave 1 (and from both non-pregnant participants and the n=27 pregnant participants who had multiple pregnancies); the sample of pregnant women (with singleton pregnancies) totalled n=1,022. Finally, after excluding participants with missing data on one or more of the sleep, sociodemographic, health and/or lifestyle variables (except for BMI and/or gestational age at interview/questionnaire completion), the remainder comprised n=811 pregnant women on whom multivariable statistical analyses could then be performed. Further exclusion of women who had missing data on BMI or on gestational age at interview/questionnaire completion, resulted in two much smaller subsamples:

n=287 with complete data on all variables *including* gestational age (*but not* BMI); and n=286 with complete data on all variables *including* BMI (*but not* gestational age).

Figure 4.2 Sampling flowchart summarising the three subsamples of pregnant women identified within Waves 1 and 4 of the UKHLS on which the multivariable analyses that follow are based.



4.7.2 Sample characteristics

The sociodemographic, health, lifestyle and sleep characteristics of the four key (sub)samples of pregnant UKHLS participants (i.e. those with complete or missing data on one or more variable; those with complete data on all variables except gestational age and/or BMI; and those with complete data on all variables but also on either gestational age or BMI) have been summarised in Table 4.1. By comparing the distribution of these characteristics amongst these four (sub)samples of UKHLS participants it is evident that, in the broadest sense, the three (sub)samples appear comparable, and representative of the sample of (n=1,022) pregnant women from which they were drawn. However, there were a number of subtle differences in lifestyle and contemporaneous health variables (such as the lower frequency of smoking amongst those with complete data on BMI; the higher frequency of those with 'healthy' SF12PCS scores amongst those with complete data on gestational age; and the higher prevalence of 'less healthy' SF12MCS scores amongst all of the [sub]samples with complete vs. incomplete data) that indicate a modest potential for selection bias which needs to be taken into account in the interpretation and extrapolation of the analyses that follow.

Table 4.1 A comparison of sociodemographic, economic, health (pre-existing and current), lifestyle and sleep characteristics amongst all female participants in Waves 1 and/or 4 of the UKHLS who were identified as pregnant (n=995), and three subsamples: (n=811); (n=287); and (n=286)

	All pregnant UKHLS participants in W1 and/or W4 (n=995)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic, economic, pre-existing health and sleep variables (n=811)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic, economic, pre-existing health and sleep variables, and lifestyle, current health and gestational age (n=287)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic economic, pre-existing health and sleep variables, and lifestyle, current health and BMI (n=286)
	n (%)	n (%)	n (%)	n (%)
Age group				
16-23yrs	164 (16.4)	136 (16.7)	38 (13.2)	46 (16.0)
24-31yrs	403 (40.5)	331 (40.8)	111 (38.6)	127 (44.4)
32-39yrs	373 (37.4)	301 (37.1)	128 (44.6)	94 (32.8)
40-48yrs	55 (5.5)	43 (5.3)	10 (3.4)	19 (6.6)
Missing	0 (0.0)	0 (0.0)	n/a	n/a
Ethnicity-based GDM risk				
Low risk	751 (75.4)	639 (78.8)	241 (83.9)	214 (74.8)
High risk	243 (24.4)	172 (21.2)	46 (16.0)	72 (25.1)
Missing	1 (0.1)	0 (0.0)	n/a	n/a
Educational qualifications[1]				
≥Degree	423 (42.5)	362 (44.6)	136 (47.5)	134 (46.8)
<Degree	495 (49.7)	396 (48.8)	137 (47.9)	134 (46.8)
None	76 (7.6)	52 (6.4)	13 (4.5)	18 (6.2)
Missing	1 (0.1)	1 (0.1)	n/a	n/a

Table 4.1. Continued.

	All pregnant UKHLS participants in W1 and/or W4 (n=995)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic, economic, pre-existing health and sleep variables (n=811)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic, economic, pre-existing health and sleep variables, and lifestyle, current health and gestational age (n=287)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic economic, pre-existing health and sleep variables, and lifestyle, current health and BMI (n=286)
	n (%)	n (%)	n (%)	n (%)
Partnership status				
Partner	812 (81.6)	668 (82.3)	241 (83.9)	240 (83.9)
No Partner	182 (18.2)	143 (17.6)	46 (16.0)	46 (16.0)
Missing	1 (0.1)	n/a	n/a	n/a
Additional adults in household				
0	749 (75.2)	625 (77.0)	232 (80.8)	228 (79.7)
≥1	246 (24.7)	186 (22.9)	55 (19.1)	58 (20.2)
Missing	0 (0.0)	n/a	n/a	n/a
Additional couples in household				
0	154 (24.7)	118 (14.5)	33 (11.5)	41 (14.3)
≥1	749 (75.3)	693 (85.4)	254 (88.5)	245 (85.6)
Missing	0 (0.0)	n/a	n/a	n/a
Parity				
Nulliparous	421 (42.3)	309 (38.1)	193 (67.2)	109 (38.1)
Multiparous	574 (57.6)	502 (61.9)	94 (32.7)	177 (61.8)
Missing	0 (0.0)	n/a	n/a	n/a
Children in household				
0	317 (31.8)	270 (33.2)	84 (29.2)	96 (33.5)
≥1	678 (68.2)	541 (66.7)	203 (70.7)	190 (66.4)
Missing	0 (0.0)	n/a	n/a	n/a
Pre-existing health conditions				
None	703 (70.6)	613 (75.5)	240 (83.6)	207 (72.3)
≥1	222 (22.3)	198 (24.4)	47 (16.3)	79 (27.6)
Missing	70 (7.0)	n/a	n/a	n/a

Table 4.1. Continued.

	All pregnant UKHLS participants in W1 and/or W4 (n=995)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic, economic, pre-existing health and sleep variables (n=811)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic, economic, pre-existing health and sleep variables, and lifestyle, current health and gestational age (n=287)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic economic, pre-existing health and sleep variables, and lifestyle, current health and BMI (n=286)
	n (%)	n (%)	n (%)	n (%)
Employment status[2]				
High status	390 (39.1)	339 (41.8)	130 (45.3)	121 (42.3)
Low status	149 (14.9)	121 (14.9)	38 (13.2)	48 (16.7)
Unemployed	456 (45.8)	351 (43.2)	119 (41.4)	117 (40.9)
Missing	0 (0.0)	n/a	n/a	n/a
Gestational age at interview/questionnaire completion				
1st Trimester	58 (5.8)	58 (7.2)	47 (16.3)	n/a
2nd Trimester	147 (14.7)	147 (18.1)	160 (55.7)	n/a
3rd Trimester	90 (9.0)	90 (11.1)	80 (27.8)	n/a
Missing	700 (70.4)	516 (63.6)	n/a	n/a
Usual type of milk consumed				
Skimmed or soya	707 (71.0)	549 (67.6)	210 (73.1)	203 (70.9)
Not skimmed or soya	233 (23.4)	214 (26.3)	77 (26.8)	83 (29.0)
Missing	55 (5.5)	48 (5.9)	n/a	n/a
Type of bread most frequently eaten				
Brown or wholemeal or wholegrain	295 (29.6)	286 (35.2)	99 (34.4)	122 (42.6)
Not brown or wholemeal or wholegrain	645 (64.8)	477 (58.8)	188 (65.5)	164 (57.3)
Missing	55 (5.5)	48 (5.9)	n/a	n/a
Days per week fruit eaten				
≥4	650 (65.3)	485 (59.8)	185 (64.4)	186 (65.0)
<4	290 (29.1)	284 (35.0)	102 (35.5)	100 (34.9)
Missing	55 (5.5)	42 (5.1)	n/a	n/a

Table 4.1. Continued.

	All pregnant UKHLS participants in W1 and/or W4 (n=995)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic, economic, pre-existing health and sleep variables (n=811)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic, economic, pre-existing health and sleep variables, and lifestyle, current health and gestational age (n=287)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic economic, pre-existing health and sleep variables, and lifestyle, current health and BMI (n=286)
	n (%)	n (%)	n (%)	n (%)
Portions of fruit/ vegetables eaten				
≥4	425 (42.7)	356 (43.8)	115 (40.0)	129 (45.1)
<4	515 (51.7)	449 (55.3)	172 (59.9)	157 (54.9)
Missing	55 (5.5)	6 (0.6)	n/a	n/a
Habitual sport activity (0=None; 10=Very active)				
≥5	650 (65.3)	559 (68.9)	208 (72.4)	203 (70.9)
<5	345 (34.6)	252 (31.0)	79 (27.5)	83 (29.0)
Missing	0 (0.0)	0 (0.0)	n/a	n/a
Smoking in pregnancy				
No	800 (80.4)	694 (85.5)	249 (86.7)	272 (95.1)
Yes	125 (12.5)	75 (9.2)	38 (13.2)	14 (4.9)
Missing	70 (7.0)	42 (5.1)	n/a	n/a
BMI from self-reported height and weight				
<25kg·m^{-2}	315 (31.6)	315 (38.8)	n/a	146 (51.0)
≥25 <30kg·m^{-2}	163 (16.3)	163 (20.0)	n/a	84 (29.3)
≥30kg·m^{-2}	101 (10.1)	101 (12.4)	n/a	56 (19.5)
Missing	n/a	232 (28.6)	n/a	n/a
SF12PCS Physical health summary (SF12PCS score)				
>53 – healthiest 50%	490 (49.2)	374 (46.1)	171 (59.5)	137 (47.9)
≤53 – least healthy 50%	493 (49.5)	425 (52.4)	116 (40.4)	149 (52.1)
Missing	12 (1.2)	12 (1.4)	n/a	n/a

Table 4.1. Continued.

	All pregnant UKHLS participants in W1 and/or W4 (n=995)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic, economic, pre-existing health and sleep variables (n=811)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic, economic, pre-existing health and sleep variables, and lifestyle, current health and gestational age (n=287)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic economic, pre-existing health and sleep variables, and lifestyle, current health and BMI (n=286)
	n (%)	n (%)	n (%)	n (%)
SF12MCS Mental health summary (SF12MCS score)				
>53 – healthiest 50%	580 (58.2)	449 (55.3)	122 (42.5)	125 (43.7)
≤53 – least healthy 50%	403 (40.5)	350 (43.1)	165 (57.4)	161 (56.2)
Missing	12 (1.2)	12 (1.4)	n/a	n/a
Sleep duration				
<5hrs	45 (4.5)	42 (5.2)	21 (7.3)	11 (3.8)
≥5hrs to <6hrs	78 (7.8)	71 (8.7)	35 (12.2)	15 (5.2)
≥6hrs to <7hrs	203 (20.4)	184 (22.6)	64 (22.3)	60 (20.9)
≥7hrs to ≤9hrs	506 (50.8)	462 (56.9)	152 (52.9)	181 (63.2)
>9hrs	57 (5.7)	52 (6.4)	15 (5.2)	19 (6.6)
Missing	106 (10.6)	n/a	n/a	n/a
Cannot get to sleep within 30min				
Rarely/never: Not during past month	347 (34.8)	308 (37.9)	106 (36.9)	112 (39.1)
Infrequent: Less than once a week	159 (15.9)	158 (19.4)	48 (16.7)	66 (23.0)
Regular: Once or twice a week	152 (15.2)	138 (17.0)	47 (16.3)	51 (17.8)
Frequent: Three or more times a week	121 (12.1)	111 (13.6)	50 (17.4)	28 (9.7)
Always: More than once most nights	110 (11.0)	96 (11.8)	36 (12.5)	29 (10.1)
Missing	106 (10.6)	n/a	n/a	n/a

Table 4.1. Continued.

	All pregnant UKHLS participants in W1 and/or W4 (n=995)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic, economic, pre-existing health and sleep variables (n=811)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic, economic, pre-existing health and sleep variables, and lifestyle, current health and gestational age (n=287)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic economic, pre-existing health and sleep variables, and lifestyle, current health and BMI (n=286)
	n (%)	n (%)	n (%)	n (%)
Sleep quality overall				
Very good	155 (15.5)	139 (17.1)	49 (17.0)	47 (16.4)
Fairly good	477 (47.9)	424 (52.2)	146 (50.8)	159 (55.5)
Fairly bad	225 (22.6)	200 (24.6)	72 (25.0)	66 (23.0)
Very bad	50 (5.0)	48 (5.9)	20 (6.9)	14 (4.9)
Missing	88 (8.8)	n/a	n/a	n/a
Trouble staying awake during the day				
Rarely/never: Not during past month	750 (75.3)	668 (82.3)	250 (87.1)	234 (81.8)
Infrequent: Less than once a week	83 (8.3)	74 (9.1)	16 (5.5)	29 (10.1)
Regular: Once or twice a week	53 (5.3)	52 (6.4)	13 (4.5)	17 (5.9)
Frequent: Three or more times a week	19 (1.9)	17 (2.1)	8 (2.7)	6 (2.1)
Always: More than once most nights	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Missing	90 (9.0)	n/a	n/a	n/a

[1]≥Degree [Educational] qualifications was recoded from "Degree", "Other higher degree"; <Degree from "A-level" and "GCSE" and "Other qualification"; None from "No qualifications".
[2]High [employment] status was recoded from "Employee: Management and Professional", "Employee: and Intermediate" and "Employee: Small Employers and own account"; Low status from "Employee: Lower supervisory and technical" and "Employee: Semi-routine, Routine and Never worked long term "; and Unemployed from "Unemployed", "Maternity leave", "Student" and "Long-time sick".

Table 4.1. Continued.

	All pregnant UKHLS participants in W1 and/or W4 (n=995)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic, economic, pre-existing health and sleep variables (n=811)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic, economic, pre-existing health and sleep variables, and lifestyle, current health and gestational age (n=287)	All pregnant UKHLS participants in W1 and/or W4 with complete data on sociodemographic economic, pre-existing health and sleep variables, and lifestyle, current health and BMI (n=286)
	n (%)	n (%)	n (%)	n (%)
Wake up middle of the night/early morning				
Rarely/never: Not during past month	134 (13.4)	126 (15.5)	34 (11.8)	42 (14.6)
Infrequent: Less than once a week	104 (10.4)	96 (11.8)	37 (12.8)	37 (12.9)
Regular: Once or twice a week	167 (16.7)	149 (18.3)	49 (17.0)	51 (17.8)
Frequent: Three or more times a week	207 (20.8)	193 (23.8)	73 (25.4)	68 (23.7)
Always: More than once most nights	280 (28.1)	247 (30.4)	94 (32.7)	88 (30.7)
Missing	103 (10.3)	n/a	n/a	n/a
Cough or snore loudly				
Rarely/never: Not during past month	671 (67.4)	629 (77.5)	230 (80.1)	207 (72.3)
Infrequent: Less than once a week	83 (8.3)	75 (9.2)	21 (7.3)	35 (12.2)
Regular: Once or twice a week	54 (5.4)	50 (6.1)	17 (5.9)	20 (6.9)
Frequent: Three or more times a week	29 (2.9)	25 (3.0)	7 (2.4)	11 (3.8)
Always: More than once most nights	36 (3.6)	32 (3.9)	12 (4.1)	13 (4.5)
Missing	122 (12.2)	n/a	n/a	n/a
Use of medicine to help sleep				
Rarely/never: Not during past month	848 (85.2)	762 (93.9)	283 (98.9)	255 (89.1)
Infrequent: Less than once a week	20 (2.0)	16 (1.9)	1 (0.3)	10 (3.5)
Regular: Once or twice a week	12 (1.2)	10 (1.2)	1 (0.3)	7 (2.4)
Frequent: Three or more times a week	25 (2.5)	23 (2.8)	1 (0.3)	14 (4.9)
Always: More than once most nights	0 (0.0)	0 (0.0)	1 (0.3)	0 (0.0)
Missing	90 (9.0)	n/a	n/a	n/a

4.7.3 Pre-pregnant sociodemographic and health factors as potential determinants of sleep in pregnancy

The multivariable analyses conducted on the first and largest of these three samples (n=811), which explored sociodemographic and health factors preceding pregnancy as potential determinants of sleep *during* pregnancy, is summarised in Tables 4.2.1,4.2.2 and 4.3. These analyses reveal that most of these factors had strong relationships with at least one sleep characteristic and that the sleep characteristic most sensitive to variation in socociodemographic circumstances was sleep duration (see Table 4.2.1 column 1; and Table 4.3).

Perhaps as a result of the comparatively narrow age distribution of the pregnant women examined (which spanned just 32 years from 16-48yrs), and the classification of ethnicity into those considered at elevated risk of gestational diabetes mellitus (GDM), For Ethnicity coding (see Appendix 3.1) Precise wording for the derived variables used in UKHLS sample). There was little evidence that older pregnant women, or those from ethnic minorities, were less likely to exhibit less favourable sleep than younger, ethnic majority participants. However, older participants did have lower odds of more frequently reporting trouble getting to sleep within 30 minutes than younger participants (OR:0.73; 95%CI:0.55,0.97), and ethnic minority participants had higher odds of shorter sleep (≥6hrs and <7hrs) than ethnic majority women (RRR:1.92; 95%CI:1.29,2.85).

Better educated pregnant women (those having a degree, or higher educational qualification) were generally less likely to report unfavourable sleep duration (particularly > 9hrs: RRR:0.38; 95%CI:0.19,0.75) than their less well educated counterparts and, perhaps as a result, were also less likely to report using medication to help them sleep (OR:0.44; 95%CI:0.22,0.87). Single pregnant women (i.e. those who were neither married nor cohabiting) were also generally *less* likely to report unfavourable sleep duration (again, particularly >9hrs: RRR:0.36; 95%CI:0.19,0.69) than married participants or those cohabiting with a partner; and they were also *less* likely to report having difficulty getting to sleep within 30 minutes (OR:0.61; 95%CI:0.40,0.93). In contrast, pregnant mothers living in households with one or more couple(s) were much more likely to report frequent difficulty in getting to sleep within

30 minutes (OR:4.17; 95%CI:1.57,11.03), although this decreased in cases when one child or more was present (both before and after adjustment for preceding sociodemographic variables that include partnership status and the presence of other adults and/or couples; OR:0.39; 95%CI:0.17,0.92).

Indeed, while multiparous participants (i.e. those likely to have one or more of their own children living with them) were more likely to report relatively short (≥6hrs and <7hrs; RRR:1.62; 95%CI:1.08,2.41), very short (≥5hrs and <6hrs; RRR:1.60; 95%CI:0.89,2.87) and extremely short (<5hrs; RRR:2.45; 95%CI:1.08,5.53) sleep duration than nulliparous participants; and were more likely than this group to report bad or very bad sleep quality (OR:1.49; 95%CI:1.05,2.09); they were actually less likely to report trouble staying awake while eating, driving and/or socialising than nulliparous women (OR:0.46; 95%CI:0.31,0.69).

Working participants were far less likely to report relatively short (≥6hrs and <7hrs; RRR:0.90; 95%CI: 0.61,1.33), very short (≥5hrs and <6hrs; RRR:0.55; 95%CI:0.32,0.96) and extremely short (<5hrs; RRR: 0.38; 95%CI:0.18,0.79) sleep duration than women who were not working. They were also less likely to report sleeping longer than 9 hours (RRR:0.27; 95%CI:0.13,0.55) and less likely to report bad or very bad sleep quality (OR:0.62; 95%CI:0.44,0.87). Nonetheless, somewhat unsurprisingly, compared to pregnant women with no pre-existing health conditions, those women with one or more such conditions were more likely to report more frequent middle of the night/early morning waking (OR:2.32; 95%CI:1.52,3.53); more trouble sleeping due to coughing/snoring loudly (OR: 1.50; 95%CI:1.03,2.17); greater use of medicine to help them sleep (OR:2.63; 95%CI:1.44, 4.79); and more difficulty staying awake while eating, driving and/or socialising (OR:1.50; 95%CI:1.02,2.26). These women were also more likely to report their sleep quality as being bad or very bad (OR:1.81; 95%CI:1.28,2.56).

Taken together, these results suggest that some of the sociodemographic and health factors that precede pregnancy are potential determinants of (subsequent) sleep *during* pregnancy. While some of these factors (such as education, employment and the absence of a partner or adult cohabitants) appear largely protective against less favourable sleep, others (particularly pre-existing health conditions) are associated with increased odds of less favourable sleep; with parity having both negative (duration and

quality) and positive (difficulty staying awake) associations with sleep.

To a large extent, the relationships observed between self-reported sleep and the pre-pregnant sociodemographic and health factors described above, were still evident in the second and third sets of multivariable analyses. Tables 4.4.1,4.4.2-4.5 show relationships between sociodemographic, economic, lifestyle and health variables and each of the seven self-reported sleep characteristics for pregnant participants (n=286) in Waves 1 and/or 4 of the UKHLS with complete data on BMI. Tables 4.6.1,4.6.2-4.7 present the same relationships between sociodemographic, economic, lifestyle and health variables and each of the seven self-reported sleep characteristics for pregnant participants (n=287) in Waves 1 and/or 4 of the UKHLS with complete data on gestational age. However, most of these relationships were substantially attenuated as a result of the smaller samples of pregnant women with complete data available for inclusion in each of these analyses; as is evident from the smaller number of associations that achieved statistical significance *prior to* adjustment in Tables 4.4.1,4.4.2-4.7 and *following* adjustment in Tables 4.4.1,4.4.2 and 4.5 (since the adjustment sets for these variables were exactly the same as in Tables 4.2.1,4.2.2 and 4.3).

It is also evident, from the further attenuation of these associations in Tables 4.6.1,4.6.2 and 4.7, that the inclusion of gestational age at interview/questionnaire completion as a competing exposure in the adjustment sets for the analyses therein, may have addressed the uneven distribution of gestational age amongst the participants in this sample: over half of the pregnant women were interviewed in trimester two (n=160, 55.7%); around a quarter in trimester three (n=80, 27.8%) and fewer than a fifth in trimester one (n=47; 16.3%). Indeed, gestational age itself was found to be strongly associated with most of the self-reported sleep characteristics.

When compared with participants interviewed in trimester two, those interviewed in trimester one, and particularly in trimester three, were more likely to report shorter sleep duration ≥5hrs and<6 hrs (RRR: 3.08; 95%CI;1.31,7.24); more frequent difficulty falling asleep within 30 minutes (OR: 1.83; 95%CI;1.02,3.26); more frequent waking in the middle of the night/early morning (OR: 2.28; 95%CI;1.13,4.61); less favourable sleep quality(OR: 2.85; 95%CI;1.62,5.02); and more frequent difficulty staying awake while

eating, driving and/or socialising (OR: 1.78; 95%CI;0.83,3.83). Moreover, adjustment for gestational age at interview/questionnaire completion substantially reduced the number of pre-pregnant sociodemographic and health factors displaying statistically significant associations with sleep.

Nonetheless, in the main, and despite attenuation, the direction and relative strength of these associations were still evident for most of the (pre-pregnant) sociodemographic and health factors examined in the analyses of these smaller samples (see Table 4.5) with: educational qualifications and employment remaining protective of short sleep (≤5 hours; RRR: 0.07; 95%CI;0.02,0.63 and RRR: 0.28; 95%CI;0.06,1.32 respectively); and protective of long sleep (>9 hours; RRR: 0.34; 95%CI;0.01,1.02 and RRR: 0.21; 95%CI;0.06,0.73)respectively.

Similar findings are evident in Table 4.7 with educational qualifications and employment remaining protective of short sleep (≤5 hours; RRR: 0.58;95%CI;0.21,1.55 and RRR: 0.61; 95%CI;0.21,1.74, respectively); and protective of long sleep (>9 hrs; RRR: 0.64; 95%CI;0.20,1.99 and RRR: 0.37; 95%CI;0.04,3.42, respectively). Multiparity remained a risk factor for short sleep and less favourable sleep quality; while pre-existing chronic health conditions posed a risk for waking in the middle of the night/early morning (see Tables 4.4.1,4.4.2-4.7). Educational qualifications are protective with the use of sleep medication (OR: 0.38; 95%CI;0.16,0.90) (see Table 4.2.1,4.2.2).

Tables 4.4.1,4.4.2 and 4.5 show multiparity remains a risk factor for short sleep<5 hours (RRR: 2.84; 95%CI;0.50,15.81) and less favourable sleep quality (OR: 1.37; 95%CI;0.75,2.48); pre-existing chronic health conditions posing a risk for shorter sleep duration <5 hours (RRR: 3.07; 95%CI;0.81,11.51), and waking in the middle of the night/early morning (OR: 3.10; 95%CI;1.52,6.33).

Tables 4.6.1,4.6.2 and 4.7 show multiparity remaining a risk factor for short sleep<5 hrs (RRR: 6.52; 95%CI;1.34,31.7) and less favourable sleep quality(OR: 2.71; 95%CI;1.41,5.20)waking in the middle of the night/early morning (OR: 2.18; 95%CI;0.87,5.45).

Table 4.2.1 Logistic regression analyses examining sociodemographic, economic and health-related characteristics associated with the risk of less favourable responses to items on the first four of seven self-reported sleep characteristics amongst n=811 pregnant female participants in UKHLS

Sleep characteristic (referent) Sociodemographic, economic health-related characteristic (referent)	Sleep duration (≥7hrs and ≤9hrs)		Cannot sleep within 30min (Rarely/never:Not during past month)		Wake in night/early morning (Infrequent: Less than once a week or Rarely/never: Not during past month)		Coughing or snore loudly (Rarely/never: Not during past month)	
	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)
Age group (≤30yrs)								
>30yrs	1.16 (0.88,1.54)	1.17 (0.89,1.55)	**0.73 (0.55,0.98)**	**0.73 (0.55,0.97)**	0.92 (0.68,1.26)	0.92 (0.67,1.25)	0.95 (0.68,1.32)	0.95 (0.68,1.32)
Ethnicity-based GDM risk (Low risk)								
High risk	**1.51 (1.08,2.12)**	**1.52(1.08,2.13)**	0.97 (0.69,1.38)	0.97 (0.68,1.37)	0.75 (0.52,1.08)	0.75 (0.52,1.08)	0.97 (0.65,1.46)	0.97 (0.64,1.46)
Education (Less than degree)								
Degree or higher	**0.68 (0.51,0.90)**	**0.61 (0.45,0.82)**	0.80 (0.60,1.06)	0.86 (0.64,1.16)	1.02 (0.75,1.40)	1.06 (0.76,1.47)	0.74 (0.53,1.04)	0.73 (0.51,1.04)
Partnership status (Cohabiting)								
Single	**0.58 (0.40,0.84)**	**0.63 (0.43,0.93)**	**0.57 (0.38,0.86)**	**0.61 (0.40,0.93)**	0.99 (0.66,1.49)	0.98 (0.64,1.49)	1.29 (0.82,2.04)	1.46 (0.91,2.34)
Additional adults in household (None)								
≥1 additional adult(s)	**1.40 (1.02,1.94)**	0.74 (0.41,1.32)	**1.67 (1.17,2.38)**	1.37 (0.75,2.49)	1.15 (0.79,1.67)	1.63 (0.83,3.19)	0.89 (0.59,1.33)	1.13 (0.59,2.16)
Additional couples in household (None)								
≥1 additional couple(s)	**0.56 (0.38,0.83)**	0.78 (0.37,1.62)	0.84 (0.56,1.27)	**4.17 (1.57,11.03)**	0.88 (0.56,1.39)	0.76 (0.33,1.71)	1.30 (0.79,2.15)	1.24 (0.51,2.99)
Parity (Nulliparous)								
Multiparous	**1.57(1.17,2.10)**	**1.49 (1.08,2.05)**	**0.67 (0.50,0.91)**	0.78 (0.57,1.08)	0.81 (0.59,1.12)	0.81 (0.57,1.16)	0.95 (0.67,1.33)	0.89 (0.61,1.29)
Children in household (None)								
≥1 child(ren)	**1.63 (1.20,2.20)**	0.90 (0.41,1.96)	**0.68 (0.50,0.93)**	**0.39 (0.17,0.92)**	0.75 (0.53,1.05)	0.65 (0.28,1.50)	0.89 (0.61,1.29)	0.72 (0.27,1.87)
Pre-existing health conditions (None)								
One or more	1.20 (0.87,1.65)	1.16 (0.83,1.62)	1.12 (0.80,1.57)	1.06 (0.75,1.49)	**2.33 (1.53,3.52)**	**2.32 (1.52,3.53)**	**1.52 (1.05,2.19)**	**1.50 (1.03,2.17)**
Employment status (Not working)								
Working	**0.52 (0.39,0.70)**	**0.62 (0.45,0.85)**	0.76 (0.57,1.02)	0.75 (0.54,1.04)	0.85 (0.62,1.17)	0.79 (0.55,1.12)	0.88 (0.63,1.23)	0.92 (0.63,1.33)

Table 4.2.2: Logistic regression analyses examining sociodemographic, economic and health-related characteristics associated with the risk of less favourable responses to items on the second four of seven self-reported sleep characteristics amongst n=811 pregnant female participants in the UKHLS

Sleep characteristic (referent)	Use of medicine to help sleep (Rarely/never: Not during past month)		Sleep quality overall (Fairly good or Very good)		Trouble staying awake in day (Rarely/never: Not during past month)	
Sociodemographic, economic and health-related characteristic (referent)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)
Age group (≤30yrs)						
>30yrs	0.66 (0.36,1.20)	0.66 (0.36,1.20)	1.27 (0.94,1.71)	1.27 (0.94,1.71)	0.81 (0.56,1.17)	0.81 (0.56,1.17)
Ethnicity-based GDM risk (Low risk)						
High risk	1.36 (0.70,2.64)	1.35 (0.70,2.62)	0.81 (0.56,1.19)	0.82 (0.56,1.19)	0.98 (0.63,1.53)	0.97 (0.63,1.53)
Education (Less than degree)						
Degree or higher	**0.42 (0.22,0.81)**	**0.44 (0.22,0.87)**	0.81 (0.60,1.10)	0.73 (0.53,1.01)	0.90 (0.62,1.30)	0.96 (0.65,1.40)
Partnership status (Cohabiting)						
Single	0.94 (0.44,2.00)	1.26 (0.58,2.73)	0.87 (0.59,1.29)	0.90 (0.60,1.34)	1.29 (0.78,2.14)	1.39 (0.82,2.34)
Additional adults in household (None)						
≥1 additional adult(s)	0.85 (0.41,1.74)	0.41 (0.11,1.58)	1.00 (0.70,1.43)	0.77 (0.41,1.47)	1.00 (0.65,1.55)	1.56 (0.80,3.04)
Additional couples in household (None)						
≥1 additional couple(s)	1.02 (0.44,2.33)	0.92 (0.19,4.39)	0.76 (0.50,1.15)	0.57 (0.25,1.31)	1.13 (0.66,1.92)	0.81 (0.30,2.14)
Parity (Nulliparous)						
Multiparous	0.97 (0.53,1.75)	0.87 (0.45,1.66)	**1.64 (1.19,2.25)**	**1.49 (1.05,2.09)**	**0.50 (0.35,0.72)**	**0.46 (0.31,0.69)**
Children in household (None)						
≥1 child(ren)	0.85 (0.46,1.55)	0.19 (0.02,1.87)	**1.44 (1.03,1.99)**	0.47 (0.17,1.26)	**0.49 (0.34,0.71)**	0.85 (0.32,2.23)
Pre-existing health conditions (None)						
One or more	**2.71 (1.50,4.88)**	**2.63 (1.44, 4.79)**	**1.79 (1.28,2.50)**	**1.81 (1.28,2.56)**	**1.54 (1.03,2.29)**	**1.50 (1.02,2.26)**
Employment status (Not working)						
Working	0.71 (0.40,1.27)	1.01 (0.53,1.94)	**0.61 (0.45,0.83)**	**0.62 (0.44,0.87)**	0.92 (0.64,1.33)	0.82 (0.54,1.24)

[1]**Age** and **ethnicity-based GDM risk** were adjusted for one another; **Education** was adjusted for ethnicity-based GDM risk and age; **Partnership status** was adjusted for education, ethnicity-based GDM risk and age; **Additional adults in the household** was adjusted for partnership status, education, ethnicity-based GDM risk and age; **Additional couples in the household** was adjusted for additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Parity** was adjusted for additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Children in the household** was adjusted for parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Pre-existing health conditions** was adjusted for children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; and **Employment status** was adjusted for pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age.

Table 4.3: Multinomial logistic regression analyses examining sociodemographic, economic and health-related characteristics associated with the risk of reporting less favourable sleep durations (<6hrs or >9hrs) amongst n=811 pregnant female participants in the UKHLS

Sleep duration: (referent)(n=462)	Extremely short (<5hrs) (≥7hrs and ≤9hrs) (n=42)		Very short (≥5hrs and <6hrs) (≥7hrs and ≤9hrs) (n=71)		Short (≥6hrs and <7hrs) (≥7hrs and ≤9hrs) (n=184)		Long (>9hrs) (≥7hrs and ≤9hrs) (n=52)	
Sociodemographic, economic and health-related characteristic (referent)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)
Age group (≤30yrs)								
>30yrs	1.26 (0.67,2.37)	1.26 (0.67,2.38)	**1.66 (1.03,2.76)**	1.65 (0.99,2.75)	1.14 (0.81,1.61)	1.15 (0.82,1.63)	0.71 (0.39,1.29)	0.72 (0.40,1.30)
Ethnicity-based GDM risk (Low risk)								
High risk	1.22 (0.56,2.66)	1.23 (0.56,2.67)	0.73 (0.36,1.49)	0.74 (0.36,1.51)	**1.91 (1.29,2.84)**	**1.92 (1.29,2.85)**	1.65 (0.85,3.19)	1.64 (0.85,3.17)
Education (Less than degree)								
Degree or higher	0.52 (0.27,1.02)	**0.45 (0.22, 0.91)**	0.72 (0.43,1.20)	0.59 (0.34,1.01)	0.81 (0.57,1.14)	0.73 (0.51,1.06)	**0.38 (0.20,0.73)**	**0.38 (0.19,0.75)**
Partnership status (Cohabiting)								
Single	0.61 (0.27,1.33)	0.70 (0.31,1.58)	0.67 (0.35,1.28)	0.68 (0.35,1.34)	0.70 (0.45,1.11)	0.74 (0.46,1.19)	**0.28 (0.15,0.53)**	**0.36 (0.19,0.69)**
Additional adults in household (None)								
≥1 additional adult(s)	1.56 (0.77,3.17)	1.14 (0.35,3.75)	1.23 (0.68,2.22)	0.84 (0.28,2.49)	1.19 (0.79,1.79)	0.67 (0.32,1.38)	**2.44 (1.33,4.47)**	0.59 (0.17,2.07)
Additional couples in household (None)								
≥1 additional couple(s)	0.47 (0.21,1.04)	0.41 (0.07,2.31)	0.57 (0.29,1.12)	0.53 (0.12,2.33)	0.69 (0.42,1.12)	0.85 (0.34,2.14)	**0.35 (0.17,0.69)**	1.08 (0.33,3.48)
Parity (Nulliparous)								
Multiparous	**2.72 (1.27,5.82)**	**2.45 (1.08,5.53)**	**1.89 (1.09,3.28)**	1.60 (0.89,2.87)	**1.65 (1.15,2.38)**	**1.62 (1.08,2.41)**	0.74 (0.41,1.31)	0.73 (0.39,1.39)
Children in household (None)								
≥1 child(ren)	**2.23 (1.04,4.78)**	1.86 (0.84,4.08)	1.55 (0.89,2.69)	1.28 (0.72,2.28)	**1.72 (1.18,2.52)**	1.02 (0.39,2.67)	1.15 (0.63,2.10)	1.65 (0.53,5.11)
Pre-existing health conditions (None)								
One or more	1.86 (0.95,3.63)	1.79 (0.90,3.54)	1.41 (0.81,2.45)	1.38 (0.78,2.44)	1.02 (0.68,1.53)	1.03 (0.68,1.56)	1.11 (0.57,2.17)	0.96 (0.48,1.91)
Employment status (Not working)								
Working	**0.32 (0.16,0.61)**	**0.38 (0.18,0.79)**	**0.56 (0.33,0.92)**	**0.55 (0.32,0.96)**	0.71 (0.50,1.01)	0.90 (0.61,1.33)	**0.23 (0.12,0.43)**	**0.27 (0.13,0.55)**

[1]**Age** and **ethnicity-based GDM risk** were adjusted for one another; **Education** was adjusted for ethnicity-based GDM risk and age; **Partnership status** was adjusted for education, ethnicity-based GDM risk and age; **Additional adults in the household** was adjusted for partnership status, education, ethnicity-based GDM risk and age; **Additional couples in the household** was adjusted for additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Parity** was adjusted for additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Children in the household** was adjusted for parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Pre-existing health conditions** was adjusted for children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; and **Employment status** was adjusted for pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age.

Table 4.4.1: Logistic regression analyses examining sociodemographic, economic, lifestyle and health-related characteristics associated with the risk of less favourable responses to items on the first four of seven self-reported sleep characteristics amongst n=286 pregnant female participants in of the UKHLS with complete data on BMI.156- 157

Sleep characteristic (referent)	Sleep duration (≥7hrs and ≤9hrs)		Cannot sleep within 30min (Rarely/never:Not during past month)		Wake in night/early morning (Infrequent: Less than once a week or Rarely/never: Not during past month)		Coughing or snore loudly (Rarely/never: Not during past month)	
Sociodemographic, economic and health-related characteristic (referent)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)
Age group (≤30yrs)								
>30yrs	1.18 (0.72,1.91)	1.23 (0.75,2.01)	**0.52 (0.32,0.85)**	**0.53 (0.32,0.86)**	0.74 (0.44,1.25)	0.73 (0.43,1.23)	0.87 (0.52,1.48)	0.89 (0.52,1.50)
Ethnicity-based GDM risk (Low risk)								
High risk	**1.80 (1.04,3.10)**	**1.83 (1.06,3.17)**	1.18 (0.68,2.06)	1.12 (0.64,1.97)	0.82 (0.45,1.48)	0.80 (0.44,1.44)	1.21 (0.67,2.17)	1.19 (0.66,2.15)
Education (Less than degree)								
Degree or higher	**0.60 (0.37,0.98)**	**0.53 (0.31,0.89)**	0.68 (0.42,1.09)	0.78 (0.47,1.29)	0.93 (0.55,1.56)	1.01 (0.59,1.74)	0.75 (0.44,1.27)	0.75 (0.44,1.30)
Partnership status (Cohabiting)								
Single	**0.51 (0.27,0.98)**	0.63 (0.32,1.23)	0.56 (0.28,1.12)	0.57 (0.28,1.18)	1.03 (0.51,2.09)	1.00 (0.48,2.08)	0.75 (0.38,1.48)	0.81 (0.40,1.65)
Additional adults in household (None)								
≥1 additional adult(s)	1.67 (0.93,3.00)	0.72 (0.24,2.16)	1.41 (0.76,2.59)	0.79 (0.26,2.32)	1.00 (0.52,1.91)	1.25 (0.38,4.13)	1.50 (0.81,2.79)	1.68 (0.56,5.00)
Additional couples in household (None)								
≥1 additional couple(s)	0.62 (0.32,1.22)	1.95 (0.46,8.33)	0.88 (0.44,1.74)	8.28 (0.80,84.81)	1.25 (0.61,2.57)	2.63 (0.45,15.41)	0.61 (0.30,1.22)	0.46 (0.09,2.22)
Parity (Nulliparous)								
Multiparous	1.21 (0.73,1.99)	1.21 (0.69,2.12)	0.61 (0.37,1.01)	0.77 (0.44,1.32)	0.67 (0.39,1.17)	0.73 (0.40,1.32)	0.86 (0.51,1.47)	0.82 (0.46,1.47)
Children in household (None)								
≥1 child(ren)	1.43 (0.85,2.41)	1.49 (0.36,6.21)	0.68 (0.41,1.14)	0.55 (0.10,2.77)	0.69 (0.39,1.22)	0.71 (0.14,3.56)	0.96 (0.55,1.66)	2.02 (0.46,8.79)
Pre-existing health conditions (None)								
One or more	**1.93 (1.14,3.28)**	**1.95 (1.12,3.38)**	0.92 (0.54,1.57)	0.88 (0.50,1.53)	**3.02 (1.50,6.08)**	**3.10 (1.52,6.33)**	**1.82 (1.04,3.17)**	1.75 (0.99,3.11)
Employment status (Not working)								
Working	**0.39 (0.23,0.64)**	**0.44 (0.24,0.79)**	0.79 (0.48,1.28)	0.94 (0.52,1.69)	0.90 (0.53,1.54)	0.88 (0.46,1.69)	0.95 (0.56,1.61)	1.27 (0.67,2.40)
Usual type of milk consumed (Skimmed or soya)								
Not skimmed or soya	1.38 (0.82,2.33)	0.99 (0.54,1.80)	1.19 (0.70,2.03)	1.00 (0.55,1.81)	0.84 (0.47,1.47)	0.78 (0.41,1.46)	1.29 (0.73,2.25)	1.25 (0.67,2.33)
Type of bread most frequently eaten (Brown or wholemeal)								
Not brown or wholemeal	1.11 (0.68,1.81)	0.94 (0.54,1.63)	1.01 (0.62,1.63)	0.86 (0.51,1.45)	0.76 (0.45,1.30)	0.65 (0.37,1.16)	**1.90 (1.10,3.29)**	**2.02 (1.12,3.65)**

Table 4.4.1 Continued.

Sleep characteristic (referent)	Sleep duration (≥7hrs and ≤9hrs)		Cannot sleep within 30min (Rarely/never:Not during past month)		Wake in night/early morning (Infrequent: Less than once a week or Rarely/never: Not during past month)		Coughing or snore loudly (Rarely/never: Not during past month)	
Sociodemographic, economic and health-related characteristic (referent)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)
Days per week fruit eaten (≥4 days)								
<4 days	1.08 (0.65,1.79)	1.00 (0.58,1.74)	**2.11 (1.25,3.57)**	**2.14 (1.22,3.73)**	1.32 (0.76,2.31)	1.28 (0.71,2.30)	**1.73 (1.02,2.95)**	1.68 (0.95,2.95)
Portions of fruit/vegetables eaten (≥4 portions)								
<4 portions	0.96 (0.59,1.55)	0.92 (0.54,1.55)	**1.65 (1.02,2.67)**	1.58 (0.95,2.61)	1.18 (0.70,1.98)	1.15 (0.66,1.98)	1.61 (0.94,2.74)	1.57 (0.90,2.74)
Habitual sport activity (0=None; 10=Very active; referent≥5 score)								
<5 score	0.83 (0.49,1.40)	0.74 (0.42,1.31)	**1.94 (1.15,3.26)**	**1.89 (1.10,3.22)**	0.64 (0.35,1.17)	0.62 (0.33,1.16)	1.18 (0.66,2.11)	1.19 (0.66,2.17)
Smoking in pregnancy (No)								
Yes	0.45 (0.12,1.66)	0.28 (0.06,1.21)	2.45 (0.66,8.99)	2.27 (0.56,9.17)	2.36 (0.51,10.81)	1.69 (0.33,8.54)	**3.77 (1.26,11.21)**	3.06 (0.93,10.02)
BMI from self-reported height and weight (<25kg·m^{-2})								
≥25kg·m^{-2}	1.48 (0.91,2.41)	1.33 (0.78,2.26)	1.40 (0.87,2.27)	1.46 (0.87,2.44)	**1.72 (1.01,2.91)**	1.59 (0.91,2.77)	**2.08 (1.22,3.54)**	**2.17 (1.23,3.82)**
SF-12PCS Physical health summary (>53 score – healthiest 50%)								
≤53 – least healthy 50%	1.29 (0.79,2.10)	1.05 (0.59,1.86)	1.37 (0.85,2.20)	1.33 (0.76,2.31)	**2.76 (1.60,4.74)**	**2.74 (1.48,5.05)**	1.62 (0.95,2.75)	1.56 (0.85,2.86)
SF-12MCS Mental health summary (>53 score – healthiest 50%)								
≤53 – least healthy 50%	**2.11 (1.27,3.48)**	**1.98 (1.13, 3.45)**	**2.05 (1.26,3.33)**	**1.86 (1.09,3.16)**	1.47 (0.87,2.47)	1.45 (0.81,2.59)	**1.86 (1.08,3.21)**	1.59 (0.88,2.87)

Table 4.4.2: Logistic regression analyses examining sociodemographic, economic, lifestyle and health-related characteristics associated with the risk of less favourable responses to items on the second four of seven self-reported sleep characteristics amongst n=286 pregnant female participants in of the UKHLS with complete data on BMI

Sleep characteristic (referent)	Use of medicine to help sleep (Rarely/never: Not during past month)		Sleep quality overall (Fairly good or Very good)		Trouble staying awake in day (Rarely/never: Not during past month)	
Sociodemographic, economic, lifestyle and health-related characteristic (referent)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)
Age group (≤30yrs)						
>30yrs	0.57 (0.25,1.26)	0.57 (0.26,1.27)	1.13 (0.67,1.90)	1.16 (0.68,1.95)	0.91 (0.49,1.68)	0.93 (0.50,1.72)
Ethnicity-based GDM risk (Low risk)						
High risk	1.24 (0.54,2.84)	1.19 (0.51,2.73)	1.41 (0.79,2.51)	1.42 (0.80,2.55)	1.41 (0.72,2.73)	1.40 (0.72,2.72)
Education (Less than degree)						
Degree or higher	**0.35 (0.15,0.82)**	**0.38 (0.16,0.90)**	0.96 (0.57,1.62)	0.91 (0.53,1.57)	0.59 (0.32,1.10)	0.57 (0.30,1.10)
Partnership status (Cohabiting)						
Single	1.33 (0.44,4.00)	1.78 (0.57,5.51)	0.54 (0.28,1.04)	0.55 (0.27,1.09)	0.89 (0.40,1.99)	1.08 (0.47,2.49)
Additional adults in household (None)						
≥1 additional adult(s)	0.55 (0.18,1.64)	0.22 (0.02,1.84)	1.47 (0.79,2.72)	0.63 (0.18,2.20)	1.22 (0.59,2.52)	1.13 (0.32,3.97)
Additional couples in household (None)						
≥1 additional couple(s)	1.63 (0.47,5.64)	1.15 (0.08,15.21)	**0.48 (0.24,0.96)**	0.37 (0.07,1.90)	1.09 (0.45,2.62)	2.47 (0.48,12.61)
Parity (Nulliparous)						
Multiparous	0.97 (0.38,2.07)	0.89 (0.38,2.07)	1.29 (0.75,2.22)	1.37 (0.75,2.48)	0.73 (0.39,1.34)	0.66 (0.33,1.30)
Children in household (None)						
≥1 child(ren)	0.90 (0.41,1.98)	0.30 (0.01,6.44)	1.36 (0.77,2.38)	1.21 (0.26,5.64)	0.85 (0.45,1.59)	1.63 (0.32,8.20)
Pre-existing health conditions (None)						
One or more	2.06 (0.96,4.45)	1.96 (0.87,4.39)	**2.44 (1.40,4.24)**	**2.63 (1.48,4.68)**	1.50 (0.79,2.85)	1.39 (0.71,2.69)
Employment status (Not working)						
Working	0.95 (0.44,2.03)	1.77 (0.70,4.43)	0.59 (0.35,1.20)	0.62 (0.33,1.17)	0.84 (0.46,1.55)	1.14 (0.55,2.36)
Usual type of milk consumed (Skimmed or soya)						
Not skimmed or soya	**2.99 (1.40,6.38)**	**3.41 (1.40,8.30)**	1.06 (0.60,1.87)	0.86 (0.45,1.63)	1.23 (0.64,2.35)	1.10 (0.53,2.26)
Type of bread most frequently eaten (Brown or wholemeal)						
Not brown or wholemeal	0.89 (0.42,1.88)	0.80 (0.35,1.85)	1.25 (0.73,2.11)	1.18 (0.66,2.12)	0.76 (0.41,1.39)	0.70 (0.36,1.36)

Table 4.4.2 Continued.

Sleep characteristic (referent)	Use of medicine to help sleep (Rarely/never: Not during past month)		Sleep quality overall (Fairly good or Very good)		Trouble staying awake in day (Rarely/never: Not during past month)	
Sociodemographic, economic, lifestyle and health-related characteristic (referent)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)
Days per week fruit eaten (≥4 days)						
<4 days	1.19 (0.55,2.58)	1.01 (0.45,2.30)	0.92 (0.53,1.59)	0.95 (0.53,1.72)	1.32 (0.71,2.46)	1.19 (0.62,2.28)
Portions of fruit/vegetables eaten (≥4 portions)						
<4 portions	0.86 (0.40,1.81)	0.62 (0.27,1.39)	0.61 (0.36,1.03)	0.57 (0.32,1.00)	1.04 (0.57,1.91)	0.96 (0.51,1.81)
Habitual sport activity (0=None; 10=Very active; referent≥5 score)						
<5 score	1.45 (0.60,3.52)	1.62 (0.64,4.09)	0.86 (0.49,1.51)	0.85 (0.47,1.54)	1.13 (0.57,2.22)	1.10 (0.55,2.21)
Smoking in pregnancy (No)						
Yes	1.39 (0.29,6.55)	1.59 (0.28,8.90)	**5.09 (1.65,15.71)**	**5.83 (1.59,21.3)**	1.86 (0.56,6.20)	1.68 (0.44,6.44)
BMI from self-reported height and weight (<25kg·m^{-2})						
≥25kg·m^{-2}	0.72 (0.34,1.54)	0.56 (0.24,1.29)	1.13 (0.67,1.90)	1.08 (0.61,1.91)	1.15 (0.63,2.11)	1.04 (0.55,1.95)
SF-12PCS Physical health summary (>53 score – healthiest 50%)						
≤53 – least healthy 50%	1.13 (0.53,2.39)	0.99 (0.41,2.36)	**2.24 (1.31,3.85)**	**2.60 (1.34,5.01)**	0.90 (0.49,1.64)	0.77 (0.39,1.53)
SF-12MCS Mental health summary (>53 score – healthiest 50%)						
≤53 – least healthy 50%	1.25 (0.58,2.70)	1.31 (0.55,3.12)	**3.72 (2.06,6.72)**	**3.83 (1.97,7.44)**	**3.11 (1.55,6.23)**	**3.12 (1.49,6.53)**

[1]**Age** and **ethnicity-based GDM risk** were adjusted for one another; **Education** was adjusted for ethnicity-based GDM risk and age; **Partnership status** was adjusted for education, ethnicity-based GDM risk and age; **Additional adults in the household** was adjusted for partnership status, education, ethnicity-based GDM risk and age; **Additional couples in the household** was adjusted for additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Parity** was adjusted for additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Children in the household** was adjusted for parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Pre-existing health conditions** was adjusted for children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Employment status** was adjusted for pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Usual type of milk consumed** was adjusted for employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Type of bread most frequently eaten** was adjusted for employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Days per week fruit eaten** was adjusted for employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Portions of fruit/vegetables eaten** was adjusted for employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Habitual sport activity** was adjusted for employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Smoking in pregnancy** was adjusted for employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **BMI** was adjusted for smoking in pregnancy, habitual sporting activity, portions of fruit/vegetables eaten (as a marker for dietary behaviour), employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **SF-12PCS** was adjusted for SF-12MCS, smoking in pregnancy, habitual sporting activity, portions of fruit/vegetables eaten (as a marker for dietary behaviour), BMI, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **SF-12MCS** was adjusted for SF-12PCS, smoking in pregnancy, habitual sporting activity, portions of fruit/vegetables eaten (as a marker for dietary behaviour), BMI, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age.

Table 4.5: Multinomial logistic regression analyses examining sociodemographic, economic, lifestyle and health-related characteristics associated with the risk of reporting less favourable sleep durations (<6hrs or >9hrs) amongst n=286 pregnant female participants in UKHLS with complete data on BMI

Sleep duration: (referent)(n=181)	Extremely short (<5hrs) (≥7hrs and ≤9hrs) (n=11)		Very short (≥5hrs and <6hrs) (≥7hrs and ≤9hrs) (n=15)		Short (≥6hrs and <7hrs) (≥7hrs and ≤9hrs) (n=60)		Long (>9hrs) (≥7hrs and ≤9hrs) (n=19)	
Sociodemographic, economic, lifestyle and health-related characteristic (referent)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)
Age group (≤30yrs)								
>30yrs	1.12 (0.33,3.82)	1.20 (0.35,4.14)	0.67 (0.22,2.01)	0.65 (0.21,1.99)	1.65 (0.91,2.97)	1.78 (0.97,3.24)	0.62 (0.22,1.71)	0.65 (0.23,1.79)
Ethnicity-based GDM risk (Low risk)								
High risk	2.15 (0.59,7.73)	2.19 (0.60,7.95)	0.57 (0.12,2.67)	0.55 (0.11,2.57)	**2.17 (1.15,4.11)**	**2.32 (1.21,4.42)**	1.73 (0.61,4.87)	1.66 (0.58, 4.68)
Education (Less than degree)								
Degree or higher	**0.09 (0.01,0.75)**	**0.07 (0.02,0.63)**	0.82 (0.28,2.37)	0.95 (0.31,2.91)	0.82 (0.46,1.48)	0.67 (0.36,1.25)	**0.33 (0.11,0.97)**	0.34 (0.11,1.02)
Partnership status (Cohabiting)								
Single	0.38 (0.09,1.56)	0.66 (0.15,2.79)	0.94 (0.20,4.46)	0.90 (0.18,4.50)	0.58 (0.26,1.25)	0.68 (0.30,1.52)	**0.31 (0.10,0.91)**	0.41 (0.13,1.23)
Additional adults in household (None)								
≥1 additional adult(s)	2.76 (0.76,10.10)	1.22 (0.13,10.71)	0.74 (0.15,3.46)	0.37 (0.01,8.18)	1.61 (0.80,3.25)	0.80 (0.21,2.97)	2.23 (0.78,6.32)	0.44 (0.04,4.42)
Additional couples in household (None)								
≥1 additional couple(s)	0.36 (0.09,1.49)	1.11 (0.04,27.71)	0.89 (0.19,4.25)	0.66 (0.02,17.10)	0.69 (0.30,1.55)	2.36 (0.41,13.39)	0.51 (0.15,1.70)	3.09 (0.35,26.83)
Parity (Nulliparous)								
Multiparous	2.97 (0.62,14.11)	2.84 (0.50,15.81)	0.99 (0.33,2.90)	1.06 (0.33,3.35)	1.42 (0.76,2.64)	1.37 (0.68,2.73)	0.59 (0.23,1.53)	0.69 (0.23,2.02)
Children in household (None)								
≥1 child(ren)	2.58 (0.54,12.3)	1.96 (0.39,9.91)	0.86 (0.29,2.52)	0.91 (0.29,2.81)	1.72 (0.89,3.32)	2.29 (0.42,12.5)	0.98 (0.36,2.62)	1.96 (0.24,15.53)
Pre-existing health conditions (None)								
One or more	2.84 (0.82,9.80)	3.07 (0.81,11.51)	1.70 (0.55,5.27)	1.63 (0.51,5.19)	1.70 (0.90,3.23)	1.77 (0.91,3.46)	2.48 (0.93,6.58)	2.42 (0.86,6.78)
Employment status (Not working)								
Working	**0.18 (0.04,0.70)**	0.28 (0.06,1.32)	0.55 (0.19,1.59)	0.44 (0.13,1.49)	**0.51 (0.28,0.93)**	0.56 (0.27,1.15)	**0.17 (0.05,0.50)**	**0.21 (0.06,0.73)**
Usual type of milk consumed (Skimmed)								
Not skimmed	3.32 (0.97,11.39)	2.08 (0.49,8.82)	1.84 (0.62, 5.46)	1.72 (0.52,5.70)	1.09 (0.57,2.10)	0.85 (0.41,1.78)	1.27 (0.46,3.55)	0.63 (0.20,2.00)
Type of bread most frequently eaten (Brown or wholemeal)								
Not brown or wholemeal	2.06 (0.53,8.03)	1.23 (0.26, 5.71)	0.67 (0.23,1.94)	0.48 (0.14,1.59)	1.01 (0.56,1.82)	1.00 (0.52,1.92)	1.67 (0.61,4.61)	1.14 (0.35,3.68)

Table 4.5 Continued.

Sleep duration: (referent)(n=181)	Extremely short (<5hrs) (≥7hrs and ≤9hrs) (n=11)		Very short (≥5hrs and <6hrs) (≥7hrs and ≤9hrs) (n=15)		Short (≥6hrs and <7hrs) (≥7hrs and ≤9hrs) (n=60)		Long (>9hrs) (≥7hrs and ≤9hrs) (n=19)	
Sociodemographic, economic, lifestyle and health-related characteristic (referent)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)
Days per week fruit eaten (≥4 days)								
<4 days	0.19 (0.02,1.53)	**0.09 (0.01,0.79)**	**3.83 (1.25,11.71)**	**4.28 (1.29,14.11)**	1.03 (0.55,1.90)	1.00 (0.51,1.96)	0.88 (0.32,2.44)	0.57 (0.18,1.79)
Portions of fruit/vegetables eaten (≥4 portions)								
<4 portions	0.46 (0.13,1.63)	0.32 (0.08,1.32)	2.2 (0.68,7.25)	2.17 (0.63,7.40)	0.99 (0.55,1.78)	1.01 (0.54,1.90)	0.72 (0.28,1.87)	0.47 (0.16,1.40)
Habitual sport activity (0=None; 10=Very active; referent≥5 score)								
<5 score	0.66 (0.18,2.38)	0.61 (0.15,2.38)	0.76 (0.24,2.34)	0.72 (0.23,2.28)	0.76 (0.40,1.43)	0.70 (0.36,1.35)	1.43 (0.45, 4.52)	1.04 (0.31, 3.50)
Smoking in pregnancy (No)								
Yes	1.54 (0.18,13.11)	0.90 (0.76,10.6)	1.10 (0.13,9.18)	0.78 (0.07,7.95)	0.26 (0.03,2.07)	0.20 (0.02,1.86)	0	0
BMI from self-reported height and weight (<25kg·m^{-2})								
≥25kg·m^{-2}	0.45 (0.11,1.76)	0.24 (0.05,1.14)	2.41 (0.79,7.34)	2.49 (0.75,8.26)	1.69 (0.93,3.05)	1.59 (0.84,3.01)	1.34 (0.52,3.45)	0.96 (0.31,2.95)
SF-12PCS Physical health summary (>53 score – healthiest 50%)								
≤53 – least healthy 50%	1.21 (0.35,4.11)	1.43 (0.28,7.17)	2.78 (0.85, 9.05)	2.92 (0.76,11.1)	1.08 (0.60,1.93)	0.85 (0.42,1.70)	1.39 (0.53,3.61)	0.59 (0.17,2.00)
SF-12MCS Mental health summary (>53 score – healthiest 50%)								
≤53 – least healthy 50%	1.76 (0.50,6.25)	1.65 (0.32,8.48)	**4.04 (1.10,14.81)**	**5.48 (1.34,22.22)**	**2.55 (1.35,4.81)**	**2.47 (1.24,4.94)**	0.91 (0.35,2.34)	0.58 (0.19,1.74)

[1]**Age** and **ethnicity-based GDM risk** were adjusted for one another; **Education** was adjusted for ethnicity-based GDM risk and age; **Partnership status** was adjusted for education, ethnicity-based GDM risk and age; **Additional adults in the household** was adjusted for partnership status, education, ethnicity-based GDM risk and age; **Additional couples in the household** was adjusted for additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Parity** was adjusted for additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Children in the household** was adjusted for parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Pre-existing health conditions** was adjusted for children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Employment status** was adjusted for pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Usual type of milk consumed** was adjusted for employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Type of bread most frequently eaten** was adjusted for employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Days per week fruit eaten** was adjusted for employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Portions of fruit/vegetables eaten** was adjusted for employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Habitual sport activity** was adjusted foremployment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Smoking in pregnancy** was adjusted for employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **BMI** was adjusted for smoking in pregnancy, habitual sporting activity, portions of fruit/vegetables eaten (as a marker for dietary behaviour), employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **SF-12PCS** was adjusted for SF-12MCS, smoking in pregnancy, habitual sporting activity, portions of fruit/vegetables eaten (as a marker for dietary behaviour), BMI, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **SF-12MCS** was adjusted for SF-12PCS, smoking in pregnancy, habitual sporting activity, portions of fruit/vegetables eaten (as a marker for dietary behaviour), BMI, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age.

Table 4.6.1: Logistic regression analyses examining sociodemographic, economic, lifestyle and health-related characteristics associated with the risk of less favourable responses to items on the first four of seven self-reported sleep characteristics amongst n=287 pregnant female participants in UKHLS with complete data on gestational age

Sleep characteristic (referent) Sociodemographic, economic health-related characteristic (referent)	Sleep duration (≥7hrs and ≤9hrs)		Cannot sleep within 30min (Rarely/never:Not during past month)		Wake in night/early morning (Infrequent: Less than once a week or Rarely/never: Not during past month)		Coughing or snore loudly (Rarely/never: Not during past month)	
	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)
Age group (≤30yrs)								
>30yrs	1.33 (0.83,2.13)	1.37 (0.85,2.20)	0.94 (0.58,1.52)	0.97 (0.59,1.58)	1.43 (0.84,2.46)	1.50 (0.86,2.58)	0.63 (0.35,1.13)	0.63 (0.35,1.13)
Ethnicity-based GDM risk (Low risk)								
High risk	1.41 (0.75,2.67)	1.47 (0.77,2.78)	0.99 (0.51,1.91)	1.03 (0.53,1.99)	1.05 (0.50,2.20)	1.10 (0.52,2.33)	0.82 (0.36,1.88)	0.82 (0.35,1.88)
Education (Less than degree)								
Degree or higher	0.75 (0.47,1.20)	0.66 (0.40,1.08)	0.95 (0.59,1.54)	0.96 (0.58,1.59)	0.97 (0.56,1.66)	0.87 (0.49,1.54)	0.63 (0.35,1.15)	0.71 (0.38,1.33)
Partnership status (Cohabiting)								
Single	0.63 (0.33,1.19)	0.61 (0.31,1.21)	0.89 (0.46,1.73)	0.91 (0.45,1.83)	1.24 (0.61,2.51)	1.19 (0.55,2.53)	2.25 (0.84,5.99)	**3.13 (1.13,8.65)**
Additional adults in household (None)								
≥1 additional adult(s)	1.45 (0.80,2.61)	1.11 (0.34,3.55)	1.25 (0.67,2.34)	1.54 (0.44,5.37)	1.07 (0.54,2.14)	3.15 (0.63,15.71)	0.63 (0.28,1.43)	1.23 (0.32,4.67)
Additional couples in household (None)								
≥1 additional couple(s)	**0.46 (0.21,0.98)**	0.50 (0.13,1.86)	1.49 (0.71,3.10)	**10.7 (1.75,65.91)**	0.97 (0.41,2.25)	0.88 (0.20,3.79)	4.28 (0.99,18.41)	4.70 (0.69,31.71)
Parity (Nulliparous)								
Multiparous	**2.07 (1.24,3.44)**	**1.99 (1.14,3.47)**	0.88 (0.53,1.48)	1.08 (0.61,1.90)	1.06 (0.60,1.88)	1.03 (0.55,1.94)	1.18 (0.63,2.22)	1.50 (0.74,3.01)
Children in household (None)								
≥1 child(ren)	**2.07 (1.22,3.51)**	0.13 (0.16,3.56)	0.80 (0.46,1.36)	**0.15 (0.02,0.97)**	0.84 (0.46,1.54)	0.24 (0.04,1.21)	0.96 (0.51,1.82)	1.13 (0.58,2.23)
Pre-existing health conditions (None)								
One or more	0.89 (0.47,1.67)	0.67 (0.33,1.33)	1.04 (0.54,1.99)	0.82 (0.40,1.67)	2.07 (0.88,4.87)	2.18 (0.87,5.45)	1.28 (0.61,2.72)	1.19 (0.52,2.71)
Employment status (Not working)								
Working	0.66 (0.41,1.06)	0.91 (0.53,1.57)	0.88 (0.54,1.44)	0.90 (0.51,1.58)	0.89 (0.51,1.54)	0.90 (0.48,1.68)	0.88 (0.49,1.58)	0.92 (0.47,1.81)
Gestational age at interview/questionnaire completion (Trimester 2)								
Trimester 1	0.92 (0.48,1.79)	n/a	1.57 (0.79,3.13)	n/a	1.05 (0.51,2.17)	n/a	1.06 (0.46,2.45)	n/a
Trimester 3	1.53 (0.89,2.62)	n/a	**1.83 (1.02,3.26)**	n/a	**2.28 (1.13,4.61)**	n/a	1.40 (0.73,2.70)	n/a
Usual type of milk consumed (Skimmed or soya)								
Not skimmed or soya	0.73 (0.43,1.25)	0.56 (0.31,1.02)	0.82 (0.48,1.40)	0.85 (0.46,1.56)	0.76 (0.42,1.37)	0.80 (0.41,1.57)	0.86 (0.44,1.68)	0.77 (0.36,1.64)

Table 4.6.1. Continued.

Sleep characteristic (referent) Sociodemographic, economic health-related characteristic (referent)	Sleep duration (≥7hrs and ≤9hrs)		Cannot sleep within 30min (Rarely/never:Not during past month)		Wake in night/early morning (Infrequent: Less than once a week or Rarely/never: Not during past month)		Coughing or snore loudly (Rarely/never: Not during past month)	
	Unadjusted OR (95%CI)	Adjusted1 OR (95%CI)	Unadjusted OR (95%CI)	Adjusted1 OR (95%CI)	Unadjusted OR (95%CI)	Adjusted1 OR (95%CI)	Unadjusted OR (95%CI)	Adjusted1 OR (95%CI)
Type of bread most frequently eaten (Brown or wholemeal)								
Not brown or wholemeal	0.91 (0.56,1.49)	0.78 (0.46,1.33)	0.73 (0.44,1.22)	0.67 (0.38,1.16)	**0.51 (0.27,0.94)**	**0.48 (0.25,0.93)**	0.72 (0.40,1.32)	0.63 (0.33,1.20)
Days per week fruit eaten (≥4 days)								
<4 days	0.69 (0.42,1.12)	0.62 (0.35,1.08)	1.11 (0.67,1.84)	1.07 (0.60,1.88)	0.86 (0.49,1.50)	0.85 (0.45,1.59)	1.41 (0.78,2.56)	1.34 (0.68,2.65)
Portions of fruit/vegetables eaten (≥4 portions)								
<4 portions	1.06 (0.66,1.71)	0.94 (0.55,1.58)	0.91 (0.55,1.48)	0.94 (0.55,1.61)	1.12 (0.65,1.94)	1.27 (0.70,2.32)	0.75 (0.41,1.35)	0.68 (0.35,1.29)
Habitual sport activity (0=None; 10=Very active; referent≥5 score)								
<5 score	1.01 (0.60,1.69)	0.97 (0.56,1.68)	0.91 (0.53,1.56)	0.89 (0.50,1.57)	0.78 (0.42,1.45)	0.73 (0.38,1.40)	1.36 (0.68,2.69)	1.46 (0.71,3.01)
Smoking in pregnancy (No)								
Yes	0.79 (0.39,1.58)	0.66 (0.30,1.46)	1.00 (0.49,2.03)	0.89 (0.39,2.02)	1.06 (0.47,2.38)	1.03 (0.41,2.60)	1.29 (0.57,2.92)	1.16 (0.45,2.97)
SF-12PCS Physical health summary (>53 score – healthiest 50%)								
≤53 – least healthy 50%	1.15 (0.71,1.84)	1.17 (0.70,1.97)	1.05 (0.64,1.71)	1.09 (0.64,1.86)	1.57 (0.89,2.77)	1.56 (0.84,2.88)	1.19 (0.66,2.14)	0.96 (0.50,1.83)
SF-12MCS Mental health summary >53 score – healthiest 50%)								
≤53 – least healthy 50%	0.91 (0.57,1.45)	0.88 (0.53,1.46)	0.88 (0.54,1.43)	0.86 (0.51,1.45)	1.14 (0.66,1.97)	1.06 (0.59,1.91)	1.22 (0.67,2.21)	1.10 (0.58,2.09)

Table 4.6.2: Logistic regression analyses examining sociodemographic, economic, lifestyle and health-related characteristics associated with the risk of less favourable responses to items on the second four of seven self-reported sleep characteristics amongst n=287 pregnant female participants in UKHLS with complete data on gestational age.

Sleep characteristic (referent)	Use of medicine to help sleep (Rarely/never: Not during past month)		Sleep quality overall (Fairly good or Very good)		Trouble staying awake in day (Rarely/never: Not during past month)	
Sociodemographic, economic and health-related characteristic (referent)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)
Age group (≤30yrs)						
>30yrs	1.66 (0.14,18.51)	1.85 (0.16,21.41)	1.35 (0.81,2.24)	1.44 (0.85,2.42)	0.66 (0.33,1.33)	0.69 (0.34,1.39)
Ethnicity-based GDM risk (Low risk)						
High risk	0	0	0.80 (0.40,1.62)	0.85 (0.42,1.75)	1.85 (0.80,4.23)	1.89 (0.82,4.38)
Education (Less than degree)						
Degree or higher	0	0	0.79 (0.48,1.30)	0.70 (0.40,1.20)	0.93 (0.46,1.87)	1.03 (0.49,2.15)
Partnership status (Cohabiting)						
Single	0.37 (0.03,4.24)	0.54 (0.04,7.17)	1.40 (0.69,2.86)	1.51 (0.70,3.27)	2.35 (0.69,8.01)	2.98 (0.83,10.61)
Additional adults in household (None)						
≥1 additional adult(s)	2.12 (0.18,23.91)	0.29 (0.02, 885.12)	0.84 (0.44,1.60)	1.50 (0.41,5.46)	0.47 (0.16,1.39)	0.52 (0.08,3.36)
Additional couples in household (None)						
≥1 additional couple(s)	0.25 (0.02,2.88)	0.38 (0.02,88.21)	1.09 (0.49,2.41)	0.80 (0.17,3.77)	1.08 (0.35,3.27)	1.23 (0.38,3.95)
Parity (Nulliparous)						
Multiparous	0	0	**2.40 (1.34,4.29)**	**2.71 (1.41,5.20)**	0.59 (0.29,1.20)	0.49 (0.22,1.07)
Children in household (None)						
≥1 child(ren)	0	0	**2.10 (1.16,3.81)**	0.36 (0.03,3.61)	0.55 (0.27,1.14)	0.59 (0.04,7.16)
Pre-existing health conditions (None)						
One or more	2.58 (0.22,29.11)	0.39 (0.01,9.45)	1.11 (0.57,2.15)	0.88 (0.42,1.84)	0.98 (0.38,2.51)	1.23 (0.43,3.51)
Employment status (Not working)						
Working	0	0	0.63 (0.38,1.05)	0.81 (0.45,1.44)	0.81 (0.40,1.62)	0.85 (0.37,1.93)
Gestational age at interview/questionnaire completion (Trimester 2)						
Trimester 1	7.06 (0.62,79.71)	n/a	1.14 (0.55,2.38)	n/a	1.23 (0.45,3.32)	n/a
Trimester 3	0	n/a	**2.85 (1.62,5.02)**	n/a	1.78 (0.83,3.83)	n/a
Usual type of milk consumed (Skimmed or soya)						
Not skimmed or soya	5.57 (0.49,62.35)	5 (0.16,157.10)	0.87 (0.49,1.53)	0.79 (0.42,1.50)	0.72 (0.31,1.66)	0.60 (0.23,1.54)

Table 4.6.2 Continued.

Sleep characteristic (referent)	Use of medicine to help sleep (Rarely/never: Not during past month)		Sleep quality overall (Fairly good or Very good)		Trouble staying awake in day (Rarely/never: Not during past month)	
Sociodemographic, economic and health-related characteristic (referent)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)
Type of bread most frequently eaten (Brown or wholemeal)						
Not brown or wholemeal	1.05 (0.09,11.71)	0.40 (0.01,9.80)	0.64 (0.38,1.08)	**0.54 (0.30,0.96)**	0.74 (0.36,1.50)	0.76 (0.35,1.66)
Days per week fruit eaten (≥4 days)						
<4 days	3.68 (0.32,41.08)	7.43 (0.15,363.12)	0.88 (0.52,1.49)	0.89 (0.48,1.65)	0.45 (0.20,1.04)	**0.32 (0.12,0.85)**
Portions of fruit/vegetables eaten (≥4 portions)						
<4 portions	1.34 (0.12,14.94)	0.23 (0.02,12.31)	0.71 (0.43,1.17)	0.66 (0.37,1.18)	0.52 (0.25,1.04)	0.47 (0.21,1.02)
Habitual sport activity (0=None; 10=Very active; referent≥5 score)						
<5 score	0	0	1.02 (0.58,1.79)	0.92 (0.50,1.68)	0.76 (0.36,1.60)	0.77 (0.34,1.70)
Smoking in pregnancy (No)						
Yes	**13.77 (1.21,16)**	8.83 (0.60,128.31)	0.97 (0.46,2.03)	0.80 (0.34,1.86)	0.77 (0.25,2.31)	1.19 (0.34,4.07)
SF-12PCS Physical health summary (>53 score – healthiest 50%)						
≤53 – least healthy 50%	2.98 (0.26,33.27)	2.41 (0.15,37.41)	1.37 (0.83,2.26)	1.35 (0.77,2.36)	1.14 (0.56,2.29)	0.85 (0.39,1.85)
SF-12MCS Mental health summary (>53 score – healthiest 50%)						
≤53 – least healthy 50%	1.48 (0.13,16.51)	5.39 (0.1,222.32)	1.07 (0.65,1.77)	1.03 (0.59,1.78)	1.24 (0.61,2.54)	1.06 (0.48,2.30)

[1]**Age** and **ethnicity-based GDM risk** were adjusted for one another, and for gestational age acting as a competing exposure; **Education** was adjusted for ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Partnership status** was adjusted for education, ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Additional adults in the household** was adjusted for partnership status, education, ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Additional couples in the household** was adjusted for additional adults in the household, partnership status, education, ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Parity** was adjusted for additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Children in the household** was adjusted for parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Pre-existing health conditions** was adjusted for children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Employment status** was adjusted for pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Gestational age** was not adjusted for any preceding covariates; **Usual type of milk consumed** was adjusted for gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Type of bread most frequently eaten** was adjusted for gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Days per week fruit eaten** was adjusted for gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Portions of fruit/vegetables eaten** was adjusted for gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Habitual sport activity** was adjusted for gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Smoking in pregnancy** was adjusted for, gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **SF-12PCS** was adjusted for SF-12MCS, smoking in pregnancy, habitual sporting activity, portions of fruit/vegetables eaten (as a marker for dietary behaviour), gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **SF-12MCS** was adjusted for SF-12PCS, smoking in pregnancy, habitual sporting activity, habitual daily vegetable portions (as a marker for dietary behaviour), gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age.

Table 4.7: Multinomial logistic regression analyses examining sociodemographic, economic, lifestyle and health-related characteristics associated with the risk of reporting less favourable sleep durations (<6hrs or >9hrs) amongst n=287 pregnant female participants in UKHLS with complete data on gestational age

Sleep duration: (referent) (n=152)	Extremely short (<5hrs) (≥7hrs and ≤9hrs) (n=21)		Very short (≥5hrs and <6hrs) (≥7hrs and ≤9hrs) (n=35)		Short (≥6hrs and <7hrs) (≥7hrs and ≤9hrs) (n=64)		Long (>9hrs) (≥7hrs and ≤9hrs) (n=15)	
Sociodemographic, economic, lifestyle and health-related characteristic (referent)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)
Age group (≤30yrs)								
>30yrs	1.54 (0.60,3.93)	1.68 (0.65,4.35)	1.60 (0.75,3.41)	1.75 (0.81,3.78)	1.30 (0.72,2.34)	1.31 (0.72,2.39)	0.83 (0.28,2.40)	0.78 (0.26,2.29)
Ethnicity-based GDM risk (Low risk)								
High risk	1.46 (0.44,4.78)	1.60 (0.48,5.32)	1.03 (0.36,2.97)	1.14 (0.39,3.33)	1.74 (0.82,3.70)	1.78 (0.83,3.82)	0.95 (0.20,4.55)	0.91 (0.18,4.36)
Education (Less than degree)								
Degree or higher	0.73 (0.29,1.83)	0.58 (0.21,1.55)	0.64 (0.30,1.37)	0.50 (0.22,1.13)	0.85 (0.47,1.54)	0.78 (0.42,1.46)	0.64 (0.22,1.91)	0.64 (0.20,1.99)
Partnership status (Cohabiting)								
Single	0.48 (0.15,1.46)	0.44 (0.13,1.50)	0.60 (0.23,1.57)	0.59 (0.20,1.67)	0.92 (0.39,2.16)	0.93 (0.37,2.29)	**0.30 (0.09,0.97)**	0.30 (0.08,1.06)
Additional adults in household (None)								
≥1 additional adult(s)	2.03 (0.71,5.74)	1.87 (0.21,16.31)	1.75 (0.73,4.20)	2.02 (0.36,11.31)	0.94 (0.42,2.09)	0.68 (0.13,3.57)	2.54 (0.79,8.07)	0.78 (0.06,10.13)
Additional couples in household (None)								
≥1 additional couple(s)	**0.27 (0.08,0.87)**	0.18 (0.03,3.70)	0.41 (0.14,1.19)	0.66 (0.08,5.18)	0.82 (0.29,2.31)	0.75 (0.13,4.07)	**0.23 (0.06,0.85)**	0.32 (0.02,4.60)
Parity (Nulliparous)								
Multiparous	**6.36 (1.43,28.31)**	**6.52 (1.34,31.7)**	2.26 (0.96,5.30)	2.20 (0.85,5.67)	**2.18 (1.12,4.24)**	**2.43 (1.17,5.06)**	0.58 (0.20,1.70)	0.36 (0.11,1.22)
Children in household (None)								
≥1 child(ren)	**5.38 (1.20,23.91)**	4.56 (0.97,21.4)	1.91 (0.81,4.50)	1.55 (0.62,3.87)	**2.22 (1.11,4.44)**	**2.26 (1.08,4.69)**	0.85 (0.28,2.51)	0.62 (0.18,2.05)
Pre-existing health conditions (None)								
One or more	1.51 (0.50,4.50)	0.87 (0.26,2.91)	1.21 (0.47,3.06)	0.76 (0.27,2.14)	0.69 (0.29,1.62)	0.59 (0.23,1.47)	0.34 (0.04,2.74)	0.37 (0.04,3.42)
Employment status (Not working)								
Working	**0.35 (0.14,0.91)**	0.61 (0.21,1.74)	0.49 (0.23,1.03)	0.67 (0.28,1.56)	1.03 (0.56,1.90)	1.55 (0.78,3.09)	0.51 (0.17,1.48)	0.42 (0.09,1.78)
Gestational age at interview/questionnaire completion (Trimester 2)								
Trimester 1	1.64 (0.46,5.89)	n/a	2.19 (0.81,5.93)	n/a	0.32 (0.10,1.03)	n/a	1.19 (0.35,4.07)	n/a
Trimester 3	2.78 (0.99,7.77)	n/a	**3.08 (1.31,7.24)**	n/a	1.23 (0.63,2.39)	n/a	0	n/a
Usual type of milk consumed (Skimmed or soya)								
Not skimmed or soya	0.95 (0.34, 2.60)	0.75 (0.24, 2.33)	0.82 (0.35,1.89)	0.76 (0.30,1.94)	0.66 (0.33,1.32)	0.47 (0.21,1.03)	0.59 (0.16,2.20)	0.26 (0.04,1.53)

Table 4.7. Continued.

Sleep duration: (referent) (n=152)	Extremely short (<5hrs) (≥7hrs and ≤9hrs) (n=21)		Very short (≥5hrs and <6hrs) (≥7hrs and ≤9hrs) (n=35)		Short (≥6hrs and <7hrs) (≥7hrs and ≤9hrs) (n=64)		Long (>9hrs) (≥7hrs and ≤9hrs) (n=15)	
Sociodemographic, economic, lifestyle and health-related characteristic (referent)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)
Type of bread most frequently eaten (Brown or wholemeal)								
Not brown or wholemeal	1.26 (0.46,3.44)	1.02 (0.35,2.97)	0.59 (0.28,1.26)	0.49 (0.21,1.10)	1.11 (0.59,2.07)	0.95 (0.48,1.87)	0.75 (0.25,2.24)	0.60 (0.17,2.09)
Days per week fruit eaten (≥4 days)								
<4 days	0.76 (0.29,2.00)	0.72 (0.23,2.27)	0.90 (0.42,1.93)	0.79 (0.32,1.94)	0.6 (0.31,1.13)	**0.54 (2.93,1.12)**	0.55 (0.16,1.83)	0.33 (0.07,1.46)
Portions of fruit/vegetables eaten (≥4 portions)								
<4 portions	1.11 (0.43,2.86)	0.98 (0.34,2.83)	0.91 (0.43,1.93)	0.80 (0.34,1.86)	1.00 (0.55,1.82)	0.89 (0.46,1.73)	1.89 (0.57,6.22)	1.45 (0.38,5.46)
Habitual sport activity (0=None; 10=Very active; referent≥5 score)								
<5 score	2.29 (0.64,8.18)	2.06 (0.53,7.90)	0.83 (0.37,1.84)	0.77 (0.32,1.84)	0.97 (0.50,1.87)	1.00 (0.50,1.99)	0.76 (0.24,2.36)	0.76 (0.21,2.67)
Smoking in pregnancy (No)								
Yes	1.84 (0.61,5.55)	1.68 (0.45,6.31)	1.22 (0.45,3.28)	0.99 (0.31,3.11)	0.39 (0.13,1.19)	0.34 (0.10,1.15)	0.42 (0.05,3.37)	0.25 (0.02,2.63)
SF-12PCS Physical health summary (>53 score – healthiest 50%)								
≤53 – least healthy 50%	1.73 (0.69,4.33)	1.66 (0.60,4.58)	1.66 (0.79,3.49)	1.83 (0.81,4.14)	0.94 (0.51,1.72)	1.02 (0.53,1.98)	0.57 (0.17,1.88)	0.47 (0.10,2.07)
SF-12MCS Mental health summary (>53 score – healthiest 50%)								
≤53 – least healthy 50%	1.41 (0.54,3.70)	1.40 (0.49,3.97)	1.19 (0.56,2.55)	1.12 (0.49,2.56)	0.75 (0.41,1.35)	0.79 (0.42,1.49)	0.61 (0.21,1.79)	0.70 (0.19,2.48)

[1]**Age** and **ethnicity-based GDM risk** were adjusted for one another, and for gestational age acting as a competing exposure; **Education** was adjusted for ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Partnership status** was adjusted for education, ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Additional adults in the household** was adjusted for partnership status, education, ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Additional couples in the household** was adjusted for additional adults in the household, partnership status, education, ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Parity** was adjusted for additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Children in the household** was adjusted for parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Pre-existing health conditions** was adjusted for children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Employment status** was adjusted for pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age, and for gestational age acting as a competing exposure; **Gestational age** was not adjusted for any preceding covariates; **Usual type of milk consumed** was adjusted for gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Type of bread most frequently eaten** was adjusted for gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Days per week fruit eaten** was adjusted for gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Portions of fruit/vegetables eaten** was adjusted for gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Habitual sport activity** was adjusted for gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **Smoking in pregnancy** was adjusted for, gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **SF-12PCS** was adjusted for SF-12MCS, smoking in pregnancy, habitual sporting activity, portions of fruit/vegetables eaten (as a marker for dietary behaviour), gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age; **SF-12MCS** was adjusted for SF-12PCS, smoking in pregnancy, habitual sporting activity, portions of fruit/vegetables eaten (as a marker for dietary behaviour), gestational age, employment status, pre-existing health conditions, children in the household, parity, additional couples in the household, additional adults in the household, partnership status, education, ethnicity-based GDM risk and age.

4.7.4 Concurrent lifestyle, behavioural and health factors as potential determinants of sleep in pregnancy

Although the impact of the smaller sample sizes of participants with complete data on the additional variables examined in Tables 4.4.1,4.4.2-4.7 is evident in the limited precision of even the stronger relationships between these and sleep, the analyses summarised in these Tables still provide important insights into the potential importance of lifestyle, behaviour and health during pregnancy for the self-reported sleep of pregnant women. For the analyses presented in Tables 4.4.1,4.4.2 and 4.5 (which used a sample of participants with complete data on a range of lifestyle and behaviour variables, including BMI but not gestational age at interview/questionnaire completion), there was substantial evidence that dietary habits, sporting activity, smoking, BMI and current health (both physical and mental) were associated with one or more of the self-reported sleep characteristics. Indeed, the only sleep characteristic that displayed an unambiguous relationship with these variables was the use of medication to help with sleep. This was more frequently reported by those participants who usually drank whole milk (or milk other than skimmed or soya; OR:3.41; 95%CI:1.40,8.30).

Elsewhere, those lifestyle and behaviour characteristics considered least healthy were consistently associated with less favourable sleep, and this was also evident in the associations observed between SF12 physical and mental health scores and sleep. Thus, participants who were obese (BMI>30kg·m-2), and those who usually ate white or other more refined bread, were more likely to frequently report trouble sleeping because they coughed or snored loudly (BMI OR:2.17; 95%CI:1.23,3.82; Bread OR:2.02; 95%CI:1.12,3.65); participants eating fruit less regularly and those with lower habitual sporting activity were more likely to report more frequent 'trouble getting to sleep within 30 minutes' (Fruit OR: 2.14; 95%CI:1.22,3.73; Sport OR:1.89; 95%CI:1.10,3.22). Those eating fruit less regularly were also more likely to report sleeping <6 hours (RRR:4.28; 95%CI:1.29,14.11).

Although very few of the participants in this sample reported smoking during pregnancy (n=14/286; 4.9%), those that did displayed less favourable sleep on all of the self-reported criteria except duration, and they had almost six times the odds of reporting

less than good sleep quality (OR:5.83; 95%CI:1.59,21.3). Finally, and somewhat unsurprisingly, women with lower scores on both the SF12-PCS and SF12-MCS (for physical and mental health, respectively) reported less favourable sleep across the widest range of sleep characteristics. Those with worse physical health being more likely to report frequent trouble sleeping due to waking in the middle of the night/early morning (OR:2.74; 95%CI:1.48,5.05), and less than good sleep quality overall (OR:2.60; 95%CI:1.34,5.01).

Similarly, participants reporting worse mental health were more likely to report sleeping both ≥6 hours to<7 hours (RRR:2.47; 95%CI:1.24,4.94) and ≥5 hours to <6 hours (RRR:5.48; 95%CI:1.34,22.22), and were more likely to report frequent trouble getting to sleep within 30 minutes (OR:1.86; 95%CI:1.09,3.16). This may explain why these participants were also more likely to report less than good sleep quality overall (OR:3.83; 95%CI:1.97,7.44), and more frequent trouble staying awake while eating, driving and/or socialising (OR:3.12; 95%CI:1.49,6.53).

Indeed, what is particularly striking about these elevated odds of less favourable sleep amongst participants with worse physical and mental health across so many of the self-reported sleep characteristics examined, is that these remained statistically significant despite the limited power of the smaller sample size of participants with complete data on the variables included in these analyses; and even after adjustment for one another (i.e. SF12-PCS adjusted for SF12-MCS, and SF12-MCS for SF12-PCS) and for all preceding variables (including pre-existing chronic health conditions).

Clearly, the self-reported sleep of pregnant women is not only patterned according to sociodemographic and health factors that are established prior to pregnancy, but also by lifestyle and behavioural factors occurring during pregnancy, and the roles that all of these variables have on each woman's physical and psychological health.

While the analyses presented in Tables 4.2.1,4.2.2-4.5 appear convincing, they are based on samples which lack complete data on gestational age at interview/questionnaire completion, and as such are insensitive to the potential for sampling bias when analysed without adjustment for this variable (as described earlier). This is because there is substantial evidence that lifestyle, behaviour- and health-related potential risks for less favourable sleep are subject to change during the

course of pregnancy (e.g. Leppänen et al., 2014; McGowan and McAuliffe, 2013), particularly in response to what are considered the 'normal' physiological, hormonal and anatomical changes that women experience as pregnancy progresses (e.g. Empson and Purdie, 1999; Lee, 1998). For this reason, variation in sociodemographic, lifestyle and health factors amongst pregnant women is likely to assume lesser or greater significance for their sleep at different stages of pregnancy (i.e. where these factors affect sleep in the absence of, or in combination with, other pregnancy-related factors that are themselves likely to influence sleep).

Given that in the present study it was only possible to estimate gestational age at interview/questionnaire completion for 29.6% of the participants (n=295/995), and that only 28.8% (n=287/995) of these had complete data on all of the other variables of interest acting as potential determinants of sleep in pregnancy, there is substantial potential for bias given the uneven distribution of gestational age at interview/questionnaire completion across all of the samples in the present study (as described earlier).

To address this problem, the analyses conducted in Tables 4.4.1,4.4.2 and 4.5 were repeated in Tables 4.6.1,4.6.2 and 4.7 with additional adjustment for gestational age at interview/questionnaire completion for all potential determinants of sleep (with the exception of BMI, because this relied on data from items requesting self-reported height and weight that were only available in UKHLS questionnaires at Wave 1 – the same wave for which there was a shortage of information on date of conception and date of birth which was required to estimate gestational age at interview/questionnaire completion). The rationale for these additional analyses was that gestational age acts as a competing exposure for factors that precede pregnancy, and as a confounder for factors occurring following conception (see Figure 4.1).

The results of these final analyses are striking since the associations observed between sleep and all of the potential determinants examined in Tables 4.4.1,4.4.2 and 4.5 are substantially attenuated, and the only associations with any degree of precision are somewhat different to those observed in the analyses summarised in Tables 4.6.1,4.6.2 and 4.7: participants who usually ate white or refined bread having lower odds of waking up in the middle of the night/early morning (OR:0.48; 95%CI:0.25,0.93)

and lower odds of reporting the quality of their sleep as less than good (OR:0.54; 95%CI:0.30,0.96). Likewise, participants who reported that they ate fruit less frequently had lower odds of sleeping ≥6 hours and <7 hours (RRR:0.54; 95%CI:1.12,2.93) and lower odds of trouble staying awake while eating, driving and/or socialising (OR:0.32; 95%CI:0.12,0.85).

These results appear at odds with those in Tables 4.6.1,4.6.2 and 4.7, but are likely to be explained by the defining role that the physiological, hormonal and anatomical changes that occur during the course of pregnancy appear to play, not only in the behaviour and lifestyle of pregnant women but also on their self-reported sleep. If this interpretation is correct, then much of the variation in sleep found to be associated with lifestyle, behaviour, BMI and self-reported health in Tables 4.4.1,4.4.2 and 4.5 is directly influenced by pregnancy itself (as evident in studies by Leppänen et al., 2014; McGowan and McAuliffe, 2013; amongst others). What little variation remains associated with these factors after adjustment for gestational age at interview/questionnaire completion (i.e. the less unfavourable sleep experienced by participants reporting less healthy diets) therefore requires careful interpretation.

4.8 Discussion

4.8.1 Study limitations

While the limited sample sizes of pregnant women with self-reported sleep data generally poses a substantive limitation for the present study, this becomes increasingly important for analyses requiring complete data on lifestyle, behaviour, health, BMI and/or gestational age at interview/questionnaire completion (given that neither the second nor the third of the three samples analysed in the present study exceeded n=290); and particularly so for low prevalence outcomes, such as the use of medication to help with sleep, where it was often not possible to generate coefficient estimates. Similarly low sample sizes are commonplace in studies examining sleep in pregnancy, while reliance on recruitment within clinical contexts (probably to facilitate recruitment

and enhance the precision and completeness of measurement) is likely to undermine the external validity of many such studies (see Chapter 2).

Although the present study sought to avoid both of these issues by using data from a sample of pregnant women participating in a large, nationally representative survey, the numbers of participants involved remained modest, particularly given the numbers of households surveyed and the inclusion of data from two waves; and these analyses relied exclusively on self-reported data from items on which there was substantial missingness. Such items can suffer from systematic and non-systematic response biases. These can be caused by participants unintentionally or deliberately providing the answers they think are 'best' or 'expected' rather than those that accurately reflect their status or experience. In addition, there are reporting errors associated with poorly worded items or item answer categories; and there is also the risk of poorly recalled past events.

By drawing on the large numbers of participants available from a non-clinical setting afforded by the UKHLS, a large, nationally representative survey, the analyses presented in the present Chapter offer the largest in-depth exploration to date of potential sociodemographic, health and lifestyle determinants of sleep in pregnancy – many of which are not routinely available within clinical datasets – though at the expense of relying exclusively on self-reported data. Indeed, the present study's reliance on data from the UKHLS derived from the survey's use of custom sleep item sets to capture different characteristics of self-reported sleep might also be considered an additional disadvantage. This is because data generated using these items do not strictly lend themselves to direct comparison with findings from previous studies except, perhaps, those that have used the PSQI (from which the UKHLS sleep module items were derived).

The Odds Ratios (and 95%CIs) for each of these sample size calculations has been included in the text to indicate the allocation ratio, and to facilitate interpretation by the reader.

Leaving these concerns aside, A *post hoc* examination of the sample sizes in the final two sets of analyses conducted by the present study (i.e. n=286 and n=287 in Tables 4.4.1, 4.4.2 and 4.5, and in Tables 4.6.1, 4.6.2 and 4.7, respectively) confirmed that,

assuming an equal number (i.e. 50%) were exposed/unexposed, these sample sizes were sufficient to detect, at 80% power, a 16% difference in sleep characteristics prevalent at around 50% (i.e. 58% vs. 42%; equivalent to an Odds Ratio of 1.91) of each sample (Kane, 2016); and a 7% difference in sleep characteristics that was common in most participants (i.e. 99% vs. 92%; equivalent to an odds ratio of 11.83) of each sample (Kane, 2016). As such, the present study is likely to be sufficiently powered to detect differences at or above these levels.

Given the limited power of these analyses, there is an increased risk that multiple testing might have generated 'false positive' findings – a 'type 1 error'. Multiple testing refers to any instance that involves the simultaneous testing of more than one hypothesis within a single set of analyses on the same dataset. If decisions about these individual hypotheses are based on the p-values generated, then there is typically an increased probability that some of the (true) null hypotheses will be rejected. It is therefore important to interpret the results of the analyses presented in this Chapter with a degree of circumspection (i.e. as suggestive rather than definitive evidence of any 'significant' associations observed).

4.8.2 Sociodemographic, lifestyle and health-related factors as potential determinants of sleep in pregnancy

In spite of the limitations of the sample sizes, data and analyses on which the present study relied, its analyses nonetheless found convincing evidence that most of the sleep characteristics reported by pregnant women were affected both by factors established prior to pregnancy and those subject to change during the course of pregnancy. This evidence was generated using a causal framework (in the form of a directed acyclic graph, or DAG; see Figure 4.1), to guide the multivariable analyses undertaken and generate estimates of association between each potential determinant and each self-reported sleep characteristic that were adjusted for other covariates robustly specified as potential confounders or competing exposures. Thus, the present study's findings offer perhaps the most comprehensive statistical analysis yet of the potential role of these factors in the self-reported sleep of pregnant women.

After adjusting for potential confounders, these analyses identified: three sociodemographic variables that appear protective against less favourable sleep,

namely, the absence of a partner, higher educational qualfications and employment. One variable, multiparity, appeared protective against daytime sleepiness, but was otherwise associated with less favourable sleep; and a combined variable which aimed to capture pre-existing chronic health conditions (including cardiovascular, respiratory and psychological conditions) was associated with less favourable responses to items on all but two of the self-reported sleep charateristics, namely, duration and frequent awakening.

To a large extent, the patterning of these associations by markers of social position (i.e. education and employment), household composition (childcare responsibilities, for previous children) and longstanding health conditions appear entirely consistent with family responsibilities and health-related behaviours in which maternal education and engagement in the workforce appear beneficial to sleep (Okun et al., 2014). However, women's sleep is still dependent on their roles within most contemporary families (Dzaja et al., 2005); and this may explain the better self-reported sleep of pregnant UKHLS participants who were neither married nor cohabiting. This, apparently unconventional finding might indicate the net benefits of sleeping alone in households where women have neither the care-related responsibilities for, nor the potential social, emotional and economic benefits of, a partner (Prigerso et al.,1999).

Clearly then, contemporary variation in self-reported sleep amongst pregnant women in the UK is partly explained by pre-existing sociodemographic and health factors that have little to do with pregnancy itself (though possibly with the risk of conception), and instead create a background of characteristics that appear capable of increasing or decreasing the impact of pregnancy-related hormonal, physiological and anatomical changes often viewed as likely to have unavoidable consequences for sleep. Whilst many of these sociodemographic characteristics may not be amenable to modification, knowing that these pose risks to sleep might help expectant mothers, and the clinicians who care for them, better prepare for (and more effectively intervene to reduce) the impact of pregnancy on sleep, and on any concerns that arise from less favourable sleep experiences (see also Chapter 6 in this thesis). Indeed, Osaikhuwuomwan et al. (2014, pp. 158-9) suggested that: "Improved knowledge of sleep disorders among health care givers is desirable and recommended as this will enable them to offer the

counselling and reassurance expectant women need concerning sleep and pregnancy." This view is supported by the present study's finding that higher education appeared protective of less favourable (shorter and longer) sleep duration, and reliance on sleep medication.

Sociodemographic patterning of self-reported sleep in pregnancy was also evident in the less favourable sleep characteristics reported by women considered to have less healthy dietary, exercise and smoking habits, and a self-reported BMI>30kg·m-2, many of whom displayed significantly increased risks of less favourable sleep. For many of these women, the fact that their relationship with sleep remained stable following adjustment for preceding sociodemographic and health factors indicates that irrespective of education, social position and pre-existing health, residual variation in less healthy lifestyles remained an important potential determinant of less favourable sleep in pregnancy. Again, this provides strong support for Osaikhuwuomwan et al.'s (2014) suggestion that there is a potential role for healthcare professionals in delivering advice and support regarding the likely role that healthier lifestyles might play in lessening any effects of pregnancy on sleep. Three comparatively recent trials designed to test the impact of such interventions (Malekzadegan et al., 2010; Kempler et al., 2012; Hassanpour et al., 2014) have all reported encouraging findings (Bartlett and Kempler, personal communication, 2016).

However, the defining role that pregnancy-related hormonal, physiological and anatomical changes play in the self-reported sleep characteristics of pregnant women is clear from the less favourable sleep reported by those UKHLS participants interviewed during the first, and particularly the third, trimester of their pregnancy (as compared to those surveyed in the second trimester). In the analyses presented here, gestational age at interview/questionnaire completion was considered a competing exposure for the relationship between preceding sociodemographic and health factors and sleep, but a likely confounder of the relationship between contemporaneous behavioural factors, self-reported health and sleep. This interpretation of the likely temporal and causal position of gestational age at interview/questionnaire completion in the causal framework adopted here means that it was not considered appropriate to adjust for any of the other covariates when examining the 'total statistical effect' of gestational

age on sleep.

Thus, this model (i.e. Figure 4.1) assumes that the relationships observed between contemporaneous measures of lifestyle, behaviour, self-reported health and sleep are themselves in large part determined by the hormonal, physiological and anatomical changes at that point in pregnancy. This would explain why most of the relationships between these lifestyle and health factors and sleep are removed or reversed following adjustment for gestational age at interview/questionnaire completion, in addition to preceding sociodemographic and health conditions, indicating that these lifestyle and health factors change in response to or are determined by the hormonal, physiological and hormonal changes occurring during successive stages of pregnancy.

The fact that residual variation in two dietary characteristics considered indicative of healthier lifestyles –a diet normally containing brown/wholemeal bread and more frequent consumption of fruit– were associated with increased odds of less favourable sleep (brown/wholemeal bread consumption: sleep quality and nocturnal/early morning waking; frequency of fruit consumption: short sleep duration and daytime sleepiness) requires further investigation, since these relationships were evident after adjustment for gestational age but without adjustment for obesity or other contemporaneous lifestyle and health factors. As such they are likely to reflect patterns within and amongst the dietary behaviours of pregnant women, irrespective of any changes associated with/caused by the progression of pregnancy that capture residual variation in the risk of less favourable sleep. If, for example, ostensibly healthy diets were most common amongst obese participants and/or those diagnosed with GDM (irrespective of gestational age and preceding sociodemographic and health characteristics), then these residual statistical associations might simply indicate the extent to which 'healthier' diets might act as markers of the need for these amongst women who were obese and/or had developed gestational diabetes.

4.9 Key findings

In conclusion, the present study offers perhaps the most comprehensive insight to-date of the relevant importance of sociodemographic, health and lifestyle factors to the self-reported sleep of pregnant women. Within the constraints of the sample sizes

available, the findings indicate that sleep is associated with variation in sociodemographic and health characteristics that precede pregnancy, and with lifestyle, behaviour and health factors during pregnancy, many of which appear to be determined by (or inextricably tied up with) the hormonal, physiological and anatomical changes that occur during the course of pregnancy. When these preceding characteristics are protective of sleep they appear capable of attenuating the impact of pregnancy on sleep; conversely, when they operate as risks to sleep, they exacerbate this impact. This indicates the need to pay greater attention to sleep practices amongst women (and their partners/cohabitants) that might exacerbate any subsequent impact of pregnancy on sleep by increasing the sensitivity of pregnant women to pregnancy-related factors that militate against sleep, or act together with these factors in a multiplicative fashion.

The present study also offers some evidence that less healthy lifestyles and poor self-reported health during pregnancy are strong predictors of self-reported sleep characteristics, although these appear dependent upon, and/or are caused by, the hormonal, physiological and anatomical changes that occur during the course of pregnancy, and as such it remains unclear whether there is much scope to address these with interventions that improve lifestyle and/or health. The results of three modest trials which aimed to prepare women for the impact of pregnancy-related changes on their sleep (Malekzadegan et al., 2010; Kempler et al., 2012; Hassanpour et al., 2014) have generated results worth exploring further.

Chapter 5

Is a risk or diagnosis of gestational diabetes associated with variation in self-reported sleep amongst pregnant women?

5.1 Summary

Using data from a large, nationally representative sample of pregnant women (the UKHLS) and a dedicated clinical sample (of pregnant women considered 'at risk' of gestational diabetes; GDM), the present Chapter explored the potential role of a commonly occurring physiological phenomenon (glucose intolerance) on the sleep of pregnant women. Careful harmonisation of sociodemographic, behavioural, health and sleep data from these two sources generated a sample comprising women considered at little and high risk of GDM, some of whom had received a formal diagnosis of GDM at the time data on self-reported sleep were collected. Multivariable analyses of this variable, both before and after adjustment for available/measured confounders and competing exposures, confirmed that GDM was associated with a range of less favourable sleep characteristics; and that the relationship between sleep and GDM risk/diagnosis appeared to reflect a 'dose-response' relationship. As such, the findings of this Chapter confirm that (at least one, important) pregnancy-specific change (amongst the many other hormonal, physiological and anatomical changes that accompany pregnancy) displays a strong relationship with sleep – evidence of the important contribution that such changes make to self-reported sleep in pregnancy.

5.2 Introduction

The aim of the present study was to compare the self-reported sleep characteristics of pregnant women considered to be at 'low' and 'high' risk of gestational diabetes mellitus (GDM) and those of pregnant women who had been diagnosed with GDM, to assess whether one of the many physiological changes that accompany pregnancy, glucose intolerance (American Diabetic Association, 2013) might be associated with measureable differences in sleep.

5.3 Methods

5.3.1 Sample specification and the assessment of GDM risk/diagnosis and sleep

The analyses undertaken for the present study drew on data collected from two sources: first, from participants enrolled in the UK Household Longitudinal Study (UKHLS), a large, nationally representative sample of households with whom detailed questionnaire-based surveys have been conducted every two years since 2009 (Buck and McFall, 2011; see also Chapters 3 and 4 in this thesis); and second, from participants recruited to a GDM 'at risk' sample from patients receiving routine and specialist diabetes care at Leeds Teaching Hospitals NHS Foundation Trust.

UKHLS – Questionnaires administered during Wave 1 and 4 of the UKHLS contained a dedicated 'sleep module' comprising seven bespoke items adapted from the Pittsburgh Sleep Quality Index (Buysse et al., 1989). These items generated data on sleep: duration; latency; disturbance; coughing/snoring; medication; quality; and daytime sleepiness. Careful examination of questionnaires used in these and subsequent waves of the UKHLS (i.e. in Waves 2 and 5, respectively) identified a number of variables capable of identifying which of the adult female participants were/had been pregnant at the time of interview/questionnaire completion. The most important of these items asked the key household informant: "Do you think you will have [any more/any] children?" (in Wave 1), one response to which was: "Self/partner currently pregnant". Items included in questionnaires from Wave 2 onwards helped to identify female participants in preceding waves who may have been unaware or unwilling to disclose that they were pregnant: "Since last wave, have you been pregnant at all, even if this did not result in a live birth?", one response to which was: "Pregnant at last interview". Related follow-up questions also generated contemporaneous self-reports of pregnancy which proved useful for identifying pregnant participants (though only in Wave 4), including a question which asked: "Last time we interviewed you, you were pregnant. Did this/your next pregnancy result in a live birth with a normal delivery or by caesarean section?", for which one of the possible responses was: "Current pregnancy" (for further information on the identification of pregnant women within the UKHLS, and the

Identification of pregnant women with singleton and multiple pregnancies, please see Chapters 3 and 4 in this thesis).

A review of questionnaires used in Waves 1 and 4, and in any preceding waves, sought to find questions capable of identifying women who had: pre-existing Type 1 or 2 diabetes; experienced GDM during a previous pregnancy; newly diagnosed diabetes at the time the interview took place; or an ethnic origin with a high prevalence of diabetes (Mugglestone, 2008). The most important of these items was a question asking participants: "Has a doctor or other health professional ever told you that you have diabetes?", for which a follow-up question to those responding "Yes" was: "Do you still have diabetes?". Those participants identified as pregnant in Wave 1 who answered "Yes" to both of these questions were considered to have pre-existing Type 1 or 2 diabetes; while those who answered "Yes" to the first ("ever") and "No" to the second ("still") question, and who were multiparous, were considered likely to have experienced GDM in a previous pregnancy. For participants identified as pregnant in Wave 4, all available answers provided to each of these questions in previous Waves of the UKHLS were used to identify, amongst those who answered "Yes" to both ("Ever" and "Still") questions in Wave 4: those who had answered "No" to both questions ("Ever" and "Still") in preceding Waves, who were considered to have a current diagnosis of GDM but not to have experienced GDM in any previous pregnancy; and those who had answered "Yes" to the first ("Ever") and "No" to the second ("Still") question in preceding Waves, who were considered to have a current diagnosis of GDM and to have experienced GDM in a previous pregnancy.

GDM 'at risk' sample – Following ethical approval and informed consent, women attending for antenatal care at St James' Hospital in Leeds during 2012-2014 were approached for inclusion in the GDM 'at risk' sample if they were diagnosed with GDM (following an oral glucose tolerance test) or if they had one or more of the five risk factors for GDM identified by the UK National Institute for Clinical Excellence (NICE, 2008) namely: a body mass index (BMI) above 30kg·m-2; a previous macrosomic baby (weighing 4.5kg or above); previous gestational diabetes; a first-degree relative with diabetes; or a minority ethnic family origin with a high prevalence of diabetes. (This

guidance was updated in 2015). Participants who consented to take part in the study were asked to complete the Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989) and to give their permission for sociodemographic, health and lifestyle data from their antenatal and obstetric medical records to be accessed following delivery.

The variables derived from patients' medical notes were tabulated in spreadsheet proforma to facilitate data entry, so that medical notes could be retrospectively reviewed and data entered as these were identified therein. Duplicate data collection by two research fellows (the candidate and her colleague, Amal Alghamdi [whose doctoral thesis also uses these data] helped to ensure transcription validity and thereby minimise (through the identification and resolution of any differences observed) the risk of error. The precise definition of each of the original and derived variables generated for the 'at risk' sample have been summarised in (Appendix 5.1).

GDM 'at risk' sample (Data collection) Sociodemographic, health and lifestyle factors for pregnant women were identified through systematic review of the literature (chapter 2), As soon as ethical approval has been obtained. A mechanism was established to request the medical notes for diabetes patients at Leeds Teaching Hospitals, using the available administrative channels to ensure continuity and time efficiency. These medical notes were checked to derive the related variables.

Pregnant women who had been diagnosed as having GDM or being at risk of developing GDM were referred by their GP to Leeds Teaching Hospitals. Data were initially extracted from the notes of 64 participants either from St James University Hospital or Leeds General Infirmary, based on the place of delivery. Data from a further 129 patients was later added, making a total sample of 193 pregnant women to participate in the study, each being allocated a serial number. All participants then had to fill in self-reported sleep data, the Pittsburgh Sleep Quality Index PSQI.

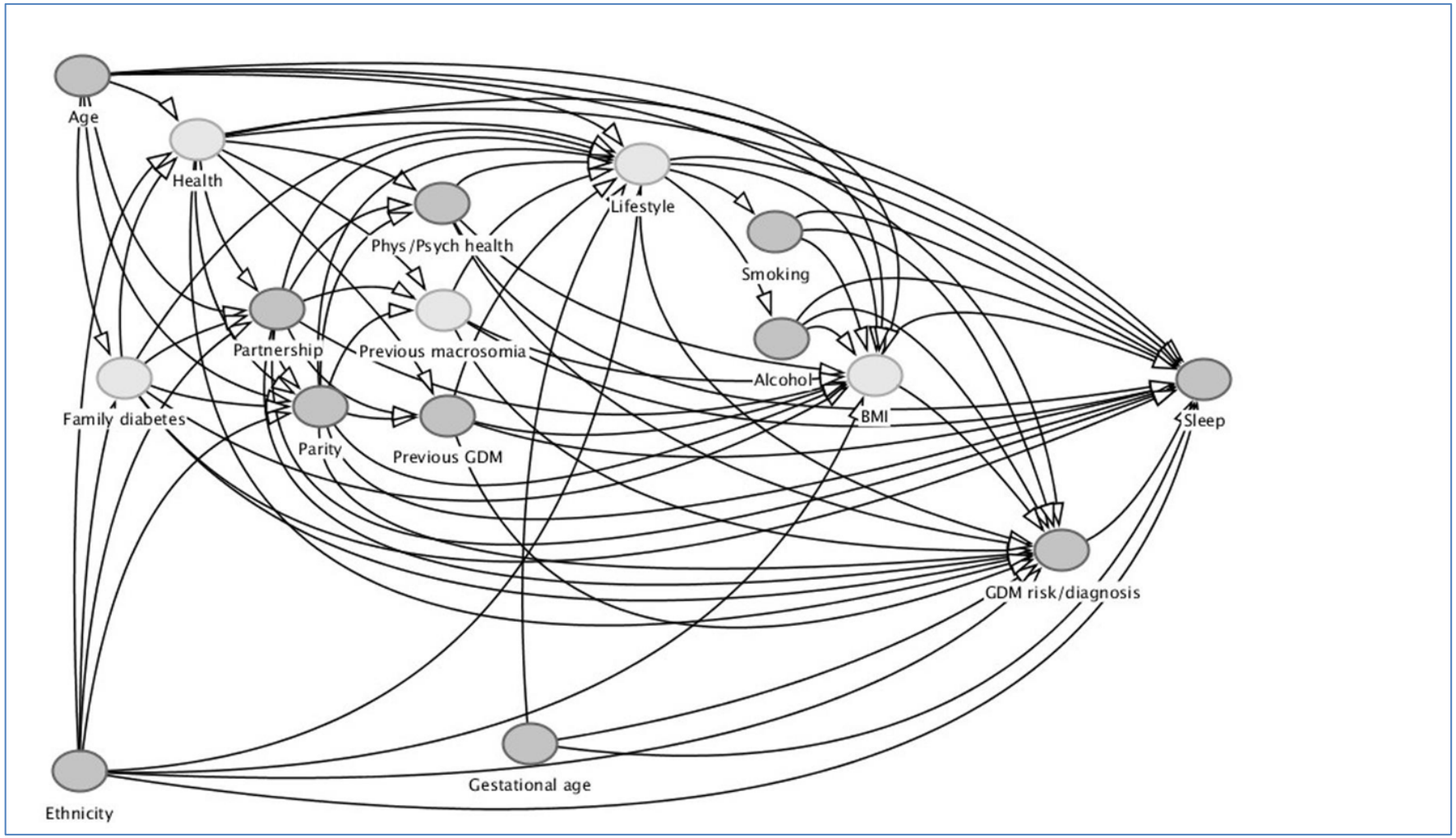
The variables derived from patients' medical notes were tabulated in spreadsheet to start data entry (medical notes were retrospectively reviewed and data entered on the spot). Data collected from each patient's notes were immediately entered by two research follows to double checked in order to minimise errors. This spreadsheet

included sociodemographic, health and lifestyle factors (see Precise wording for the derived variables used in UKHLS/GDM 'at risk' sample Appendix 5.1).

5.4 Statistical analyses

Summary descriptive statistics were used to compare the sociodemographic, health, lifestyle and self-reported sleep characteristics of study participants with complete and incomplete data on potential determinants, confounders and outcome variables; with the results of these summaries presented as frequencies with percentages in parentheses (%). Separate multivariable logistic regression analyses were then conducted for each of the seven sleep characteristics to establish the direction and strength of any differences observed between pregnant and non-pregnant women before and after adjustment for potential confounding. These analyses were informed by a causal path diagram in which the harmonisable covariates and estimated gestational age at interview/questionnaire completion were arranged in a hypothesised temporal sequence using a saturated directed acyclic graph (DAG) to identify those acting as potential confounders or competing exposures in any relationship between GDM risk/diagnosis and sleep (see Figure 5.1). The results of these analyses were presented as odds ratios (ORs See Glossary of Terminology) with 95% confidence intervals (95%CIs) in parentheses. All analyses were conducted using Stata-IC 14 (StataCorp LP, TX).

Figure 5.1: Causal path diagram in the form of a directed acyclic graph (DAG) summarising the theorised temporal relationships between the risk of GDM/GDM diagnosis, sleep and all covariates from the UKHLS and 'at risk' clinical samples that were amenable to harmonisation. Filled nodes indicate observed variables for which data were available; clear nodes indicate hypothesised (latent) variables for which no data were available. Drawn using *http://dagitty.net* (see Appendix for Model Code).



5.5 Ethical approval

Most of the data for the UKHLS sample was obtained from publicly available datasets (available at: https://www.understandingsociety.ac.uk/), although a 'Special License Access' was required and granted by the UK Data Archive, for date of birth data to facilitate the estimation of gestational age at interview/questionnaire completion (UKDA Usage Number: 84718; see Appendix 3.4). Ethical approval for the GDA 'at risk' sample was obtained from Yorkshire and the Humber Research National Health Service Research Ethics Committee (Reference: 12/YH/0156) See ethical approval letters (Appendix 5.3).

5.6 Data security

All data derived from the UKHLS are pseudo-anonymised (with no possibility that users can link these data to personal identifiers held securely by the UKHLS team). Once each of the UKHLS datasets had been downloaded, it was saved on the University of Leeds servers, and secured using password-only access – the data being held within a dedicated (password-protected) account on the N-drive (the Division of Epidemiology and Biostatistics server). Access to these data was restricted to the present study's research team alone. In a similar fashion, data from the GDM 'at risk' sample were pseudo-anonymised following data collection, so that no personal identifiers were included in datasets during analysis and/or reporting.

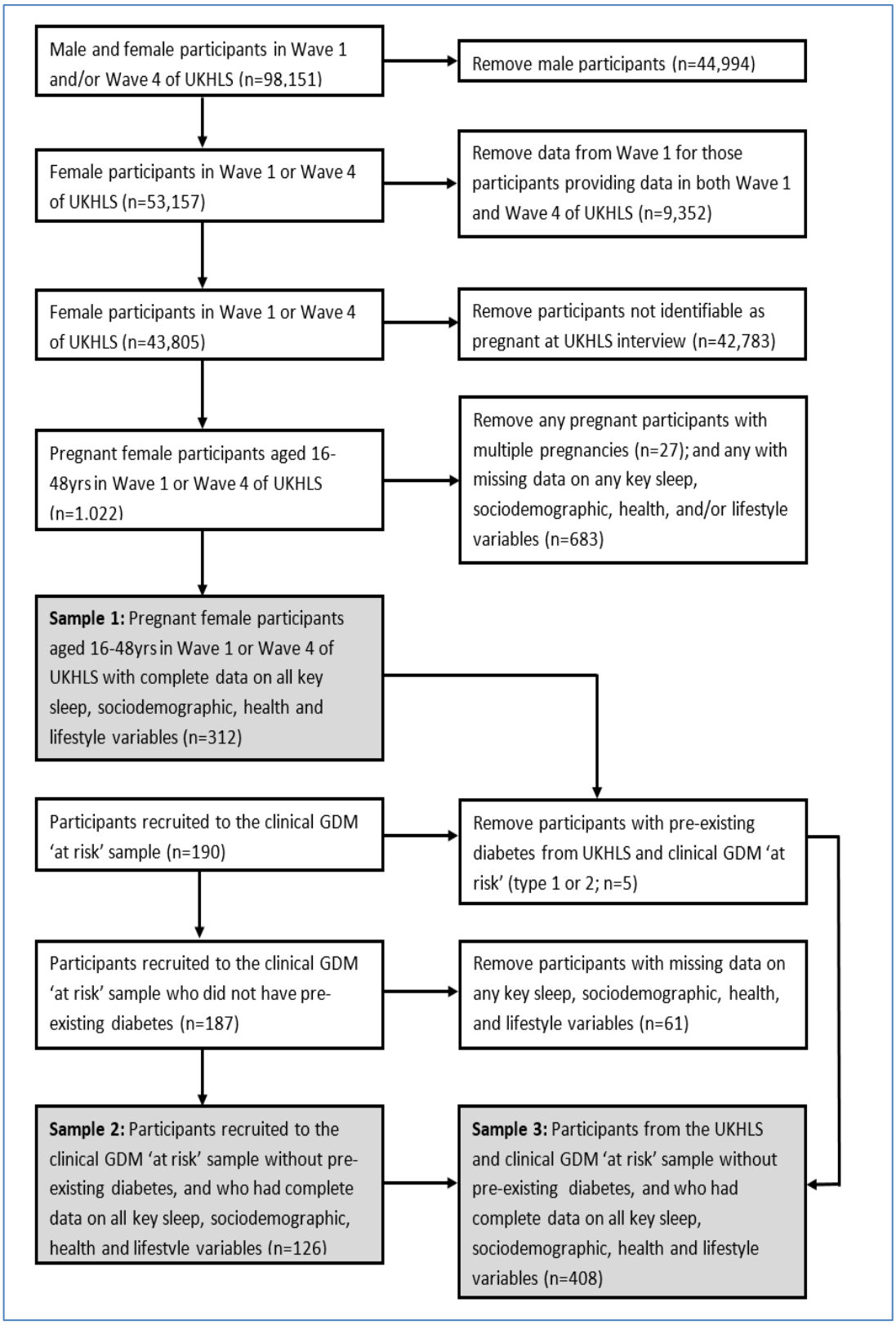
5.7 Results

5.7.1 Sampling

The sampling procedures outlined in Figure 5.2 identified a total of n=43,805 individual female participants in Waves 1 and 4 of the UKHLS, n=1,022 of whom were identified as pregnant at interview/questionnaire completion. Of these, a large number were found to have missing data for one or more of the variables necessary for inclusion in the analyses that follow, and a further two participants were excluded after the assessment of GDM risk indicated they were likely to have pre-pregnancy Type 1 or Type 2 diabetes.

Of the n=190 women succesfully recruited for the GDM 'at risk' sample, three were also

Figure 5.2 Sampling flowchart summarising the two sub-samples of pregnant women identified within Waves 1 and 4 of the UKHLS and the clinical GDM 'at risk' sample on which the multivariable analyses that follow are based.



found to have pre-existing/pre-pregnancy diabetes, whilst n=61 (32.6%) were found to have missing data for one or more of the sociodemographic, health, lifestyle and sleep variables required.

The combined sample therefore comprised n=408 women, n=242 of whom were considered to be at 'low' risk of GDM (on the basis of their ethnicity and/or GDM in a previous pregnancy) while n=101 were classified as at 'high' risk of GDM, on the same basis. Some n=65 had been diagnosed with GDM at the time of interview/questionnaire completion.

5.7.2 Sample characteristics

Given the relatively high proportion of participants from both the UKHLS and GDM 'at risk' samples with incomplete data on one or more of the required variables, the distribution of data on each of these variables was compared between the original source and complete datasets (see Table 5.1). Table 5.1 contains a summary of the sociodemographic, health, behaviour and sleep characteristics of each of the (sub)samples of pregnant women (UKHLS and GDM 'at risk') participants (i.e. those with complete or missing data on one or more variable; and those with complete data on all variables). By comparing the distribution of these characteristics amongst these (sub)samples of women (particularly those in columns 3 and 4 of Table 5.1) it is evident that, in the broadest sense, the final (sub)sample appears largely comparable, and representative of the original samples of pregnant women from which they were drawn. However, there were a number of subtle differences in health and sleep characteristics (such as the lower frequency of women with pre-existing physical and mental health conditions; and the fewer women reporting using sleep medication during the month preceding interview/questionnaire completion amongst the [sub]samples with complete data) that indicate a modest potential for selection bias that needs to be taken into account in the interpretation and extrapolation of the analyses that follow.

Table 5.1: A comparison of sociodemographic, health, lifestyle and sleep characteristics amongst: all female participants in Waves 1 and/or 4 (W1/4) of the UKHLS who were identified as pregnant (n=995); all participants recruited to the clinical GDM 'at risk/diagnosed ' sample (n=190); and those from both samples with and without complete data on all variables

	All pregnant female UKHLS participants in W1 and/or W4: **Sample 1 (n=995)**	All participants in the clinical GDM 'at risk/diagnosed' sample: **Sample 2 (n=190)**	All pregnant female UKHLS participants in W1 and/or W4 and all participants in the clinical GDM 'at risk/ diagnosed' sample: **Sample 1+2 (n=1,185)**	All participants in Sample 1 and 2 with complete data on sociodemographic, health, lifestyle and sleep variables: **Sample 3 (n=408)**
	n (%)	n (%)	n (%)	n (%)
Age group				
16-23yrs	164 (16.4)	18 (9.4)	182 (15.3)	57 (13.9)
24-31yrs	403 (40.5)	82 (43.1)	485 (40.9)	161 (39.4)
32-39yrs	373 (37.4)	79 (41.5)	452 (38.1)	178 (43.6)
40-48yrs	55 (5.5)	3 (1.5)	58 (4.8)	12 (2.9)
Missing	0 (0.0)	8 (4.2)	8 (0.6)	n/a
Ethnicity-based GDM risk				
Low risk	751 (75.4)	107 (56.3)	858 (72.4)	321 (78.6)
High risk	243 (24.4)	63 (33.1)	306 (25.8)	87 (21.3)
Missing	1 (0.1)	20 (10.5)	21 (1.7)	n/a
Partnership status				
Partner	812 (81.6)	160 (84.2)	972 (82.0)	351 (86.0)
No Partner	182 (18.2)	14 (7.3)	196 (16.5)	57 (13.9)
Missing	1 (0.1)	16 (8.4)	17 (1.4)	n/a
Parity				
Nulliparous	421 (42.3)	75 (39.4)	496 (41.8)	156 (38.2)
Multiparous	574 (57.6)	102 (53.6)	676 (57.0)	252 (61.7)
Missing	0 (0.0)	13 (6.8)	13 (1.0)	n/a
Pre-existing physical health conditions				
None	758 (76.1)	160 (84.2)	918 (77.4)	347 (85.0)
One or more	237 (23.8)	29 (15.2)	266 (22.4)	61 (14.9)
Missing	0 (0.0)	1 (0.5)	1 (0.1)	n/a

Table 5.1. Continued.

	All pregnant female UKHLS participants in W1 and/or W4: **Sample 1 (n=995)**	All participants in the clinical GDM 'at risk/diagnosed' sample: **Sample 2 (n=190)**	All pregnant female UKHLS participants in W1 and/or W4 and all participants in the clinical GDM 'at risk/ diagnosed' sample: **Sample 1+2 (n=1,185)**	All participants in Sample 1 and 2 with complete data on sociodemographic, health, lifestyle and sleep variables: **Sample 3 (n=408)**
	n (%)	n (%)	n (%)	n (%)
Pre- existing psychological health conditions				
None	761 (76.4)	167 (87.8)	928 (78.3)	375 (91.9)
One or more	234 (23.5)	23 (12.2)	257 (21.6)	33 (8.0)
Missing	0 (0.0)	0 (0.0)	0 (0.0)	n/a
Gestational age at sleep interview/questionnaire completion				
First trimester	58 (5.8)	0 (0.0)	58 (12.0)	43 (10.5)
Second trimester	147 (14.7)	155 (81.5)	302 (62.2)	266 (65.2)
Third trimester	90 (9.0)	35 (18.4)	125 (25.8)	99 (24.2)
Missing	0 (0.0)	0 (0.0)	0 (0.0)	n/a
Smoking				
No	800 (80.4)	143 (75.2)	943 (79.5)	352 (86.2)
Yes	125 (12.5)	22 (11.5)	147 (12.4)	56 (13.7)
Missing	70 (7.0)	25 (13.1)	95 (8.0)	n/a
Alcohol consumption				
No	621 (62.4)	135 (71.0)	756 (63.7)	315 (77.2)
Yes	181 (18.1)	25 (13.1)	206 (17.3)	93 (22.7)
Missing	193 (19.3)	30 (15.7)	223 (18.8)	n/a
GDM risk				
No risk	724 (72.7)	58 (30.5)	782 (65.9)	242 (59.3)
Risk but GDM-free	258 (25.9)	68 (35.7)	326 (27.5)	101 (24.7)
GDM diagnosed	13 (1.3)	64 (33.6)	77 (6.4)	65 (15.9)
Missing	0 (0.0)	0 (0.0)	0 (0.0)	n/a

Table 5.1. Continued.

	All pregnant female UKHLS participants in W1 and/or W4: **Sample 1 (n=995)**	All participants in the clinical GDM 'at risk/diagnosed' sample: **Sample 2 (n=190)**	All pregnant female UKHLS participants in W1 and/or W4 and all participants in the clinical GDM 'at risk/ diagnosed' sample: **Sample 1+2 (n=1,185)**	All participants in Sample 1 and 2 with complete data on sociodemographic, health, lifestyle and sleep variables: **Sample 3 (n=408)**
	n (%)	n (%)	n (%)	n (%)
Cough or snore loudly				
Rarely/never: Not during past month	671 (67.4)	117 (61.5)	788 (66.4)	311 (76.2)
Infrequent: Less than once a week	83 (8.3)	23 (12.1)	106 (8.9)	37 (9.0)
Regular: Once or twice a week	54 (5.4)	14 (7.3)	68 (5.7)	29 (7.1)
Frequent: Three or more times a week	29 (2.9)	22 (11.5)	51 (4.3)	21 (5.1)
Always: More than once most nights	36 (3.6)	0 (0.0)	36 (3.0)	10 (2.4)
Missing	122 (12.2)	14 (7.3)	136 (11.4)	n/a
Use of medicine to help sleep				
Rarely/never: Not during past month	848 (85.2)	170 (89.4)	101 (85.9)	402 (98.0)
Infrequent: Less than once a week	20 (2.0)	3 (1.5)	23 (1.9)	4 (0.9)
Regular: Once or twice a week	12 (1.2)	1 (0.5)	13 (1.0)	0 (0.0)
Frequent: Three or more times a week	25 (2.5)	1 (0.5)	26 (2.1)	2 (0.4)
Always: More than once most nights	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Missing	90 (9.0)	15 (7.9)	105 (8.8)	n/a
Sleep quality overall				
Very good	155 (15.5)	21 (11.0)	176 (14.8)	64 (15.6)
Fairly good	477 (47.9)	86 (45.2)	563 (47.5)	213 (52.2)
Fairly bad	225 (22.6)	47 (24.7)	272 (22.9)	101 (24.7)
Very bad	50 (5.0)	18 (9.5)	68 (5.7)	30 (7.3)
Missing	88 (8.8)	18 (9.5)	106 (8.9)	n/a

Table 5.1. Continued.

	All pregnant female UKHLS participants in W1 and/or W4: **Sample 1 (n=995)**	All participants in the clinical GDM 'at risk/diagnosed' sample: **Sample 2 (n=190)**	All pregnant female UKHLS participants in W1 and/or W4 and all participants in the clinical GDM 'at risk/ diagnosed' sample: **Sample 1+2 (n=1,185)**	All participants in Sample 1 and 2 with complete data on sociodemographic, health, lifestyle and sleep variables: **Sample 3 (n=408)**
	n (%)	n (%)	n (%)	n (%)
Sleep duration				
<5hrs	45 (4.5)	10 (5.2)	55 (4.6)	27 (6.6)
≥5hrs to <6hrs	78 (7.8)	23 (12.1)	101 (8.5)	52 (12.7)
≥6hrs to <7hrs	203 (20.4)	38 (20.0)	241 (20.3)	90 (22.0)
≥7hrs to ≤9hrs	506 (50.8)	97 (51,0)	603 (50.8)	216 (52.9)
>9hrs	57 (5.7)	9 (4.7)	66 (5.5)	23 (5.6)
Missing	106 (10.6)	13 (6.8)	119 (10)	n/a
Cannot get to sleep within 30min				
Rarely/never: Not during past month	347 (34.8)	36 (18.9)	383 (32.3)	131 (32.1)
Infrequent: Less than once a week	159 (15.9)	67 (35.2)	226 (19.0)	96 (23.5)
Regular: Once or twice a week	152 (15.2)	49 (25.7)	201 (16.9)	80 (19.6)
Frequent: Three or more times a week	121 (12.1)	28 (14.7)	149 (12.5)	66 (16.1)
Always: More than once most nights	110 (11.0)	0 (0.0)	110 (9.2)	35 (8.5)
Missing	106 (10.6)	10 (5.2)	116 (9.7)	n/a
Wake up middle of the night/early morning				
Rarely/never: Not during past month	134 (13.4)	2 (1.0)	136 (11.4)	37 (9.0)
Infrequent: Less than once a week	104 (10.4)	73 (38.4)	177 (14.9)	86 (21.0)
Regular: Once or twice a week	167 (16.7)	82 (43.1)	249 (21.0)	103 (25.2)
Frequent: Three or more times a week	207 (20.8)	23 (12.1)	230 (19.4)	89 (21.8)
Always: More than once most nights	280 (28.1)	0 (0.0)	280 (23.6)	93 (22.7)
Missing	103 (10.3)	10 (5.3)	113 (9.5)	n/a

Table 5.1. Continued.

	All pregnant female UKHLS participants in W1 and/or W4: **Sample 1 (n=995)**	All participants in the clinical GDM 'at risk/diagnosed' sample: **Sample 2 (n=190)**	All pregnant female UKHLS participants in W1 and/or W4 and all participants in the clinical GDM 'at risk/ diagnosed' sample: **Sample 1+2 (n=1,185)**	All participants in Sample 1 and 2 with complete data on sociodemographic, health, lifestyle and sleep variables: **Sample 3 (n=408)**
	n (%)	n (%)	n (%)	n (%)
Trouble staying awake during the day				
Rarely/never: Not during past month	750 (75.3)	31 (16.3)	781 (65.9)	264 (64.7)
Infrequent: Less than once a week	83 (8.3)	93 (48.9)	176 (14.8)	92 (22.5)
Regular: Once or twice a week	53 (5.3)	48 (25.2)	101 (8.5)	40 (9.8)
Frequent: Three or more times a week	19 (1.9)	7 (3.6)	26 (2.1)	12 (2.9)
Always: More than once most nights	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Missing	90 (9.0)	11 (5.7)	101 (8.5)	n/a

5.7.3 Pre-existing sociodemographic, health and lifestyle characteristics as predictors of sleep in pregnancy

Analysis of the relationship between gestational age at interview/questionnaire completion and each of the seven sleep characteristics confirmed the very different patterns of sleep experienced by pregnant women during the course of pregnancy (see Table 5.2.1,5.2.2). When trimester two was used as referent (on the basis that the largest proportion of participants were interviewed during this trimester [n=266; 65.2%] and the literature suggesting that the second trimester has less unfavourable sleep than either the first or third trimesters; Hedman et al., 2002; Suzuki et al., 1994), the analyses indicated that participants interviewed during trimester one were less likely to report: frequent trouble sleeping due to coughing/snoring loudly; fairly/very bad sleep quality; or difficulty staying awake while driving/eating or socialising; and were more likely to report using sleep medication and trouble getting to sleep within 30 minutes. However, the relatively small sample of participants interviewed in the first trimester (n=43; 10.5%) meant that only the relationship with the last of these (i.e. sleep latency) achieved statistical significance (OR:2.07; 95%CI:1.04,4.09). In contrast, participants interviewed in trimester three more frequently reported trouble getting to sleep within 30 minutes (OR:1.82; 95%CI:1.13,2.94) but were less likely to report difficulty staying awake while driving/eating or socialising (OR:0.73; 95%CI:0.39,1.37). They were also *less* likely to report sleep medication use (OR:0.66; 95%CI: 0.07,6.05) and *more* likely to report: sleeping <7 or >9hrs (OR:1.88; 95%CI:1.18,3.01); frequent waking in the middle of the night/early morning (OR:1.83; 95%CI:1.06,3.16); and bad/very bad sleep quality (OR:1.85; 95%CI:1.14,2.98). Indeed, the multinomial analyses presented in Table 5.3, which further explore the relationship between sleep duration and sociodemographic , health and lifestyle factors, indicate that participants interviewed in trimester three had two to three times the odds of reporting sleep duration of less than 7hrs but lower odds of reporting sleep duration longer than 9hrs. While those interviewed in trimester one were also more likely to report sleep duration of <6hrs they were also *more* likely to report sleeping longer than 9hrs.

These variations in sleep characteristics at different stages of pregnancy are similar to

those described in previous analyses of the UKHLS data (Chapter 3, Chapter 4), and in previous studies of pregnant women elsewhere (e.g. Osaikhuwuomwan et al., 2014). They underscore the importance of adjusting for gestational age at interview/questionnaire completion as either a competing exposure (for variables that temporally precede pregnancy) or a potential confounder (for variables characterising health and/or lifestyle during pregnancy).

Multivariable analyses of the n=408 pregnant participants with complete data on all of the harmonised variables also suggest substantial variation in the association between sociodemographic, health and behavioural characteristics and each of the seven sleep characteristics (see Table 5.2.1,5.2.2). For example, both before and after adjustment for confounding, there was little evidence that ethnic minority participants (considered at higher risk of GDM), those with pre-existing physical health conditions or those exposed to smoking and/or alcohol had elevated odds of reporting less favourable sleep. Likewise, older participants (aged >30yrs), those who were multiparous and those who were unmarried/not cohabiting were only found to report differences in three of the seven sleep characteristics, with: lower odds of more frequent trouble sleeping due to coughing/snoring loudly (adjusted OR:0.59; 95%CI: 0.37,0.94), higher odds of reporting less than good quality sleep (adjusted OR:1.62; 95%CI:1.01,2.60) and lower odds of more frequent sleep medication use (adjusted OR:0.10; 95%CI:0.01,0.61) than younger, nulliparous participants and those who were married/cohabiting, respectively.

Indeed, only pre-existing psychological health conditions, previous GDM and GDM risk/diagnosis were found to be associated with more than two sleep characteristics; participants with pre-existing psychological health conditions being: three times more likely to report trouble sleeping as a result of coughing and/or snoring loudly (adjusted OR:3.04; 95%CI:1.37,6.74); two and a half times more likely to report less than good sleep quality (adjusted OR:2.65; 1.22,5.76); and three times more likely to report more frequent trouble staying awake while driving, eating or socialising (adjusted OR:3.14; 95%CI:1.35,7.26) than participants without pre-existing psychological conditions. Although the small number of participants reporting the use of sleep medication reduced the precision of the analyses thereon, participants with pre-existing

psychological health conditions had almost eight times the odds of reporting sleep medication use than those without such conditions (adjusted OR:7.52; 95%CI:0.92,61.0).

Table 5.2.1: Multivariable logistic regression analyses examining sociodemographic, health and lifestyle-related characteristics associated with the risk of less favourable responses to items on the first four of seven self-reported sleep characteristics amongst pregnant in UKHLS (n=282) and GDM 'at risk' (n=126), all of whom had complete data on all variables.

Sleep characteristic (referent)	Sleep duration (≥7hrs and ≤9hrs)		Cannot sleep within 30min (Rarely/never:Not during past month)		Wake in night/early morning (Infrequent: Less than once a week or Rarely/never: Not during past month)		Coughing or snore loudly (Rarely/never: Not during past month)	
Sociodemographic, health and lifestyle characteristic (referent)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)
Age group (≤30yrs)								
>30yrs	1.34 (0.90,1.98)	1.30 (0.87,1.94)	0.96 (0.65,1.42)	0.95 (0.64,1.42)	1.06 (0.69,1.62)	1.05 (0.68,1.61)	**0.60 (0.38,0.95)**	**0.59 (0.37,0.94)**
Ethnicity-based GDM risk (Low risk)								
High risk	1.51 (0.93,2.43)	1.52 (0.93,2.46)	1.04 (0.65,1.69)	1.07 (0.66,1.74)	0.82 (0.49,1.37)	0.83 (0.49,1.38)	1.11 (0.64,1.92)	1.13 (0.65,1.98)
Partnership status (Partner)								
No Partner	0.60 (0.31,1.06)	0.56 (0.31,1.01)	0.57 (0.31,1.03)	0.60 (0.32,1.11)	0.57 (0.29,1.13)	0.56 (0.28,1.13)	1.78 (0.84,3.78)	2.13 (0.98,4.63)
Parity (Nulliparous)								
Multiparous	**1.68 (1.12,2.52)**	1.53 (0.99,2.36)	1.06 (0.71,1.58)	1.01 (0.66,1.56)	1.21 (0.78,1.87)	1.23 (0.77,1.95)	0.89 (0.56,1.42)	1.05 (0.64,1.73)
Pre-existing physical health conditions (None)								
One or more	0.87 (0.50,1.51)	0.81 (0.45,1.45)	1.09 (0.63,1.90)	0.99 (0.56,1.77)	1.92 (0.98,3.75)	1.87 (0.94,3.74)	1.05 (0.55,1.98)	0.89 (0.45,1.76)
Pre-existing psychological health conditions (None)								
One or more	1.21 (0.59,2.47)	1.14 (0.53,2.47)	1.67 (0.79,3.55)	1.42 (0.64,3.14)	1.38 (0.60,3.15)	1.04 (0.43,2.49)	**2.59 (1.24,5.39)**	**3.04 (1.37,6.74)**
Previous GDM (No)								
Yes	0.96 (0.62,1.49)	1.18 (0.72,1.92)	**0.44 (0.28,0.69)**	**0.49 (0.30,0.80)**	**0.47 (0.30,0.75)**	**0.51 (0.31,0.85)**	**2.32 (1.43,3.77)**	**2.33 (1.35,4.02)**
Gestational age at sleep interview/questionnaire completion (Trimester 2)								
Trimester 1	1.15 (0.60,2.21)	n/a	**2.07 (1.04,4.09)**	n/a	1.02 (0.51,2.03)	n/a	0.69 (0.30,1.56)	n/a
Trimester 3	**1.88 (1.18,3.01)**	n/a	**1.82 (1.13,2.94)**	n/a	**1.83 (1.06,3.16)**	n/a	0.91 (0.53,1.57)	n/a
Smoking (primary or secondary; referent: No)								
Yes	1.05 (0.60,1.85)	0.96 (0.52,1.75)	1.08 (0.61,1.91)	0.93 (0.50,1.71)	0.98 (0.53,1.82)	0.86 (0.44,1.65)	1.20 (0.63,2.28)	1.22 (0.61,2.45)
Alcohol consumption (No)								
Yes	**0.60 (0.37,0.97)**	0.63 (0.38,1.05)	0.91 (0.57,1.46)	0.86 (0.52,1.42)	0.77 (0.47,1.26)	0.70 (0.41,1.19)	0.78 (0.44,1.37)	0.86 (0.47,1.58)
GDM risk/diagnosis (No risk)								
Risk but GDM-free	1.08 (0.68,1.73)	1.34 (0.81,2.20)	**0.56 (0.35,0.90)**	0.63 (0.39,1.04)	**0.55 (0.34,0.91)**	0.59 (0.35,1.16)	1.40 (0.80,2.43)	1.31 (0.73,2.37)
GDM diagnosed	1.31 (0.76,2.27)	1.40 (0.78,2.53)	**0.50 (0.28,0.87)**	**0.49 (0.27,0.89)**	0.57 (0.32,1.02)	**0.52 (0.28,0.96)**	**2.84 (1.57,5.12)**	**2.56 (1.36,4.81)**

Table 5.2.2: Multivariable logistic regression analyses examining sociodemographic, health and lifestyle-related characteristics associated with the risk of less favourable responses to items on the last three of seven self-reported sleep characteristics amongst pregnant female participants in UKHLS (n=282) and GDM 'at risk' sample (n=126), all of whom had complete data on all variables.

Sleep characteristic (referent)	Use of medicine to help sleep (Rarely/never: Not during past month)		Sleep quality overall (Fairly good or Very good)		Trouble staying awake in day (Rarely/never: Not during past month)	
Sociodemographic, health and lifestyle characteristic (referent)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)	Unadjusted OR (95%CI)	Adjusted[1] OR (95%CI)
Age group (≤30yrs)						
>30yrs	1.72 (0.31,9.50)	1.79 (0.32,9.94)	1.21 (0.80,1.85)	1.18 (0.77,1.81)	0.82 (0.49,1.37)	0.81 (0.48,1.35)
Ethnicity-based GDM risk (Low risk)						
High risk	0.73 (0.08,6.37)	0.71 (0.08,6.20)	1.07 (0.64,1.77)	1.07 (0.64,1.78)	1.28 (0.71,2.33)	1.29 (0.70,2.34)
Partnership status (Partner)						
No Partner	**0.15 (0.03,0.78)**	**0.10 (0.01,0.61)**	1.02 (0.56,1.87)	1.00 (0.53,1.88)	1.96 (0.81,4.78)	2.08 (0.84,5.16)
Parity (Nulliparous)						
Multiparous	1.24 (0.22,6.86)	1.09 (0.17,6.89)	**1.63 (1.05,2.54)**	**1.62 (1.01,2.60)**	0.63 (0.38,1.06)	0.64 (0.37,1.11)
Pre-existing physical health conditions (None)						
One or more	1.14 (0.13,9.92)	0.36 (0.02,4.94)	0.94 (0.52,1.70)	0.80 (0.42,1.51)	1.32 (0.67,2.59)	1.21 (0.59,2.50)
Pre-existing psychological health conditions (None)						
One or more	**5.98 (1.05,33.9)**	7.52 (0.92,61.0)	**2.43 (1.18,4.98)**	**2.65 (1.22, 5.76)**	**2.57 (1.18,5.58)**	**3.14 (1.35,7.26)**
Previous GDM (No)						
Yes	2.68 (0.53,13.5)	5.71 (0.74,43.6)	1.18 (0.74,1.87)	1.33 (0.81,2.17)	**2.21 (1.30,3.76)**	**1.82 (1.01,3.28)**
Gestational age at sleep interview/questionnaire completion (Trimester 2)						
Trimester 1	1.55 (0.17,14.2)	n/a	0.73 (0.34,1.55)	n/a	0.54 (0.20,1.44)	n/a
Trimester 3	0.66 (0.07,6.05)	n/a	**1.85 (1.14,2.98)**	n/a	0.73 (0.39,1.37)	n/a
Smoking (primary or secondary; referent: No)						
Yes	**6.58 (1.29,33.48)**	4.04 (0.67,24.2)	1.10 (0.60,1.99)	1.03 (0.54,1.96)	1.32 (0.66, 2.66)	1.54 (0.72,3.29)
Alcohol consumption (No)						
Yes	cnbc[2]	cnbc[2]	0.67 (0.40,1.13)	0.67 (0.38,1.16)	1.05 (0.57, 1.92)	1.12 (0.59,2.14)
GDM risk/diagnosis (No risk)						
Risk but GDM-free	2.42 (0.33,17.4)	5.25 (0.48,56.5)	0.98 (0.59,1.63)	1.15 (0.67,1.96)	1.72 (0.93,3.16)	1.57 (0.82,3.00)
GDM diagnosed	3.80 (0.52,27.5)	3.33 (0.31,34.9)	1.39 (0.78,2.45)	1.18 (0.64,2.17)	**2.71 (1.41,5.19)**	**2.15 (1.07,4.31)**

[1]**Age** and **Ethnicity-based GDM risk** were adjusted for one another, and for gestational age as a competing exposure; **Partnership status** was adjusted for ethnicity-based GDM risk and age, and for gestational age as a competing exposure; **Parity** was adjusted for partnership status, ethnicity-based GDM risk and age, and for gestational age as a competing exposure; **Pre-existing physical health conditions** was adjusted for parity, partnership status, ethnicity-based GDM risk and age, and for gestational age as a competing exposure; **Pre-existing psychological health conditions** was adjusted for parity, partnership status, ethnicity-based GDM risk and age, and for gestational age as a competing exposure; **Previous GDM** was adjusted for parity, partnership status, ethnicity-based GDM risk and age, and for gestational age as a competing exposure; **Gestational age** was not adjusted for any preceding covariates; **Smoking** was adjusted for gestational age, previous GDM, pre-existing psychological and physical health conditions, parity, partnership status, ethnicity-based GDM risk and age; **Alcohol consumption** was adjusted for gestational age, previous GDM, pre-existing psychological and physical health conditions, parity, partnership status, ethnicity-based GDM risk and age; and **GDM risk/diagnosis** was adjusted for gestational age, smoking, pre-existing psychological and physical health conditions, parity, partnership status, and age (i.e. not for previous GDM or ethnicity-based GDM risk).
[2]These effect sizes could not be calculated (cnbc) due to insufficient numbers of participants with the relevant characteristics.

Table 5.3: Multinomial logistic regression analyses examining sociodemographic, health and lifestyle-related characteristics associated with the risk of reporting less favourable sleep durations (<6hrs or >9hrs) amongst pregnant in UKHLS (n=282) and GDM 'at risk' sample (n=126), all of whom had complete data on all variables

Sleep duration(216) (referent)(n=408)	Extremely short (<5hrs) (≥7hrs and ≤9hrs) (n=27)		Very short (≥5hrs and <6hrs) (≥7hrs and ≤9hrs) (n=52)		Short (≥6hrs and <7hrs) (≥7hrs and ≤9hrs) (n=90)		Long (>9hrs) (≥7hrs and ≤9hrs) (n=23)	
Sociodemographic, health and lifestyle characteristic (referent)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)	Unadjusted RRR (95%CI)	Adjusted[1] RRR (95%CI)
Age group (≤30yrs)								
>30yrs	1.22 (0.54,2.74)	1.20 (0.53,2.71)	1.57 (0.84,2.91)	1.56 (0.83,2.91)	1.54 (0.93,2.54)	1.47 (0.88,2.45)	0.63 (0.26,1.51)	0.62 (0.25,1.51)
Ethnicity-based GDM risk (Low risk)								
High risk	1.29 (0.49,3.42)	1.33 (0.50,3.56)	1.08 (0.49,2.33)	1.08 (0.49,2.36)	1.74 (0.98,3.10)	1.72 (0.95,3.09)	1.98 (0.76,5.15)	2.06 (0.78,5.41)
Partnership status (Partner)								
No Partner	0.43 (0.16,1.19)	0.43 (0.15,1.25)	0.46 (0.21,1.02)	**0.41 (0.17,0.94)**	0.89 (0.41,1.91)	0.81 (0.36,1.79)	0.45 (0.15,1.32)	0.48 (0.16,1.49)
Parity (Nulliparous)								
Multiparous	**2.74 (1.06,7.07)**	2.62 (0.97,7.05)	1.76 (0.92,3.37)	1.56 (0.79,3.10)	**1.93 (1.13,3.28)**	**1.79 (1.02,3.13)**	0.60 (0.25,1.43)	0.55 (0.21,1.44)
Pre-existing physical health conditions (None)								
One or more	2.25 (0.91,5.56)	1.96 (0.72,5.31)	0.56 (0.21,1.53)	0.37 (0.12,1.13)	0.90 (0.45,1.80)	1.05 (0.51,2.19)	0.24 (0.03,1.86)	0.22 (0.02,1.75)
Pre-existing psychological health conditions (None)								
One or more	2.17 (0.66,7.05)	1.18 (0.30,4.60)	**2.61 (1.08, 6.31)**	**2.97 (1.11,7.92)**	0.43 (0.12,1.51)	0.41 (0.11,1.55)	0.56 (0.07,4.49)	0.77 (0.09,6.47)
Previous GDM (No)								
Yes	0.59 (0.21,1.63)	0.94 (0.30,2.91)	0.95 (0.48,1.89)	1.49 (0.69,3.22)	1.10 (0.57,1.73)	1.05 (0.57,1.93)	1.38 (0.55,3.43)	1.25 (0.44,3.54)
Gestational age at sleep interview/questionnaire completion (Trimester 2)								
Trimester 1	2.20 (0.65,7.41)	n/a	1.88 (0.76,4.64)	n/a	0.34 (0.10,1.20)	n/a	1.94 (0.65,5.77)	n/a
Trimester 3	**3.39 (1.39,8.25)**	n/a	**2.11 (1.04,4.28)**	n/a	**1.95 (1.11,3.41)**	n/a	0.21 (0.02,1.68)	n/a
Smoking (primary or secondary; referent: No)								
Yes	1.84 (0.68, 4.94)	1.49 (0.49,4.46)	1.17 (0.55,2.78)	0.87 (0.34,2.19)	0.71 (0.32,1.58)	0.73 (0.32,1.70)	1.35 (0.43,4.27)	1.20 (0.34,4.16)
Alcohol consumption (No)								
Yes	0.47 (0.15,1.42)	0.45 (0.14,1.48)	0.81 (0.40,1.66)	0.85 (0.39,1.82)	0.54 (0.28,1.02)	0.56 (0.28,1.10)	0.57 (0.18,1.75)	0.68 (0.20,2.27)
GDM risk/diagnosis (No risk)								
Risk but GDM-free	0.87 (0.32,2.35)	1.41 (0.49,4.08)	0.91 (0.42,1.95)	1.19 (0.53,2.69)	1.07 (0.59,1.94)	1.24 (0.66,2.34)	1.86 (0.74,4.69)	1.83 (0.68,4.90)
GDM diagnosed	1.00 (0.31,3.18)	1.11 (0.32,3.81)	1.56 (0.70,3.45)	1.57 (0.65,3.74)	1.41 (0.72,2.78)	1.53 (0.74,3.13)	0.70 (0.15,3.33)	0.90 (0.17,4.55)

[1]**Age** and **Ethnicity-based GDM risk** were adjusted for one another, and for gestational age as a competing exposure; **Partnership status** was adjusted for ethnicity-based GDM risk and age, and for gestational age as a competing exposure; **Parity** was adjusted for partnership status, ethnicity-based GDM risk and age, and for gestational age as a competing exposure; **Pre-existing physical health conditions** was adjusted for parity, partnership status, ethnicity-based GDM risk and age, and for gestational age as a competing exposure; **Pre-existing psychological health conditions** was adjusted for parity, partnership status, ethnicity-based GDM risk and age, and for gestational age as a competing exposure; **Previous GDM** was adjusted for parity, partnership status, ethnicity-based GDM risk and age, and for gestational age as a competing exposure; **Gestational age** was not adjusted for any preceding covariates; **Smoking** was adjusted for gestational age, previous GDM, pre-existing psychological and physical health conditions, parity, partnership status, ethnicity-based GDM risk and age; **Alcohol consumption** was adjusted for gestational age, previous GDM, pre-existing psychological and physical health conditions, parity, partnership status, ethnicity-based GDM risk and age; and **GDM risk/diagnosis** was adjusted for gestational age, smoking, pre-existing psychological and physical health conditions, parity, partnership status, and age (i.e. not for previous GDM or ethnicity-based GDM risk).

5.7.4 The relationship between GDM risk/diagnosis and sleep

Given that comparatively few of the sociodemographic, health and lifestyle characteristics displayed strong associations with (m)any of the self-reported sleep characteristics examined in the present Chapter, it is striking that both measures relevant to GDM (i.e. GDM in a previous pregnancy and risk/diagnosis of GDM in the current pregnancy) were both associated with five of the seven sleep characteristics examined. These relationships were similar in direction and strength for both of these GDM-related variables. Thus, participants with either of these GDM-related variables were less likely to report frequent trouble getting to sleep within 30 minutes and frequent waking in the middle of the night/early morning; and were more likely to report frequent trouble sleeping due to coughing/snoring loudly, frequent sleep medication use, and frequent difficulty staying awake while driving/eating or socialising (see Table 5.2.1,5.2.2). This may not be surprising since the assessment of GDM risk in the current pregnancy was based, in part, on GDM in a previous pregnancy, and the other risk factor for GDM in the current pregnancy (ethnic minority status) displayed no significant relationships with any of the seven sleep characteristics examined.

However, there was little indication that either of the more commonly used self-reported sleep characteristics examined as potential consequences or determinants of GDM in previous studies, namely, sleep duration and sleep quality (Chapter 2) were related to GDM in a previous pregnancy or risk/diagnosis of GDM in the current pregnancy (see Table 5.2.1,5.2.2), even after disaggregating self-reported sleep duration into shorter (<7hrs) and longer (>9hrs) than 7-9hrs (see Table 5.3). However, these analyses did suggest a tendency for participants diagnosed with GDM to be more likely to have shorter sleep, and less likely to have longer sleep, than GDM-free participants considered to be at low risk of GDM. On the other hand, participants with GDM in a previous pregnancy and those who were GDM-free but considered at high risk of GDM were both somewhat more likely to report sleeping >9hrs (see Table 5.3).

Indeed, there was some evidence of a 'dose-response' relationship between GDM risk,

GDM diagnosis and other self-reported sleep characteristics in the present Chapter. Those participants diagnosed with GDM had consistently lower odds of reporting less favourable sleep latency and nocturnal/early morning waking; and consistently higher odds of trouble sleeping due to coughing/snoring loudly, and difficulty staying awake while driving/eating or socialising (see Table 5.2.1,5.2.2). These trends lend support to the suggestion that at least one of the physiological changes that is likely to accompany all pregnancies (i.e. glucose intolerance which, at higher levels warrants formal diagnosis as GDM due to the elevated risks to the mother and her unborn child) causes less favourable sleep amongst pregnant women.

5.8 Discussion

5.8.1 Study limitations

At the same time, with a sample size of just n=408 the present study had limited statistical power to detect small differences in sleep associated with the sociociodemographic, health and lifestyle characteristics examined, not least for: less common sleep characteristics, such as the use of sleep medication (which had a prevalence of just n=6/408, 1.3%); rarer potential determinants, such as smoking or alcohol consumption (with prevalences of n=56/408, 13.7% and n=93/408 or 22.7%, respectively); and multivariable analyses involving adjustment for several potential confounders/ competing exposures. However, the final sample size of n=408 exceeds that required to detect, assuming an equal number (i.e. 50%) were exposed/unexposed, at 80% power a 14% difference in sleep characteristics prevalent in around 50% (i.e. 43% vs. 57%; equivalent to an Odds Ratio of 1.30) of each sample (Kane, 2016); and a 5% difference in sleep characteristics that was common in most participants (i.e. 99% vs. 94% equivalent to an Odds Ratio of 9.51) of each sample.(Kane, 2016). As such, the present study is unlikely to be substantively underpowered. However, the shortage of variables amenable to harmonisation between the UKHLS and GDM 'at risk' sample datasets, and the possibility that the different measurement techniques used by each influenced the comparability and/or precision of these, remains a concern. The first of these issues means that the multivariable analyses presented in Tables 5.2.1,5.2.2 and 5.3are likely to be under-adjusted, not least for the three other recognised risk factors for GDM (family history of diabetes; a macrosomic neonate in a

previous pregnancy; and elevated BMI) but also for important sociodemographic and lifestyle characteristics such as: education, social class, employment status, diet and activity. Thus, these analyses may have generated stronger associations between sleep and the remaining (measured/available) variables that *could* be harmonised, including risk/diagnosis of GDM.

The second of these issues is likely to have worsened the variance observed in associations between harmonised predictors and self-reported sleep characteristics. These characteristics had themselves been measured using a custom item set for pregnant women in the UKHLS sample and separate items within the PSQI for participants in the GDM 'at risk' sample, thereby reducing the precision of any relationships observed or introducing systematic biases associated with the lower prevalence of diagnosed GDM amongst pregnant women in the UKHLS than participants recruited for the GDM 'at risk' sample. There is little doubt that the sources from which UKHLS and GDM 'at risk' participants were drawn had quite different distributions of sociodemographic, health and lifestyle characteristics (see Table 5.1). However, to a large extent, these reflect the decision to combine data from the UKHLS (as a comparator group) and the GDM 'at risk' clinical sample (comprising participants recruited specifically on the basis of their elevated risk of GDM) in order to generate a sample containing approximately n=100 women clinically diagnosed with GDM. Given the estimated current prevalence of GDM amongst pregnant women, which ranges from around 10-40% depending upon the population and diagnostic criteria applied (Guariguata et al., 2014; Argawal and Punrose, 2002), future population- or clinic-based studies would need to recruit n=250-1000 pregnant women overall to generate a similar target of n=100 women with GDM.

5.8.2 Pre-existing sociodemographic, health and lifestyle characteristics as potential determinants of sleep in pregnancy

These limitations aside, the present study provides further evidence that at least some of the variation in the less favourable sleep characteristics reported by pregnant women is associated with, and potentially attributable to, sociodemographic, health and lifestyle characteristics that precede pregnancy. This applies even in a study population designed to include a large proportion at risk of extreme glucose intolerance

corresponding to an elevated risk of GDM and/or a clinical diagnosis of GDM.

These findings offer the possibility that much of the poorer sleep reported by pregnant women may be unrelated to pregnancy per se. Moreover, although many of the characteristics involved (such as age, marital/cohabitation status and parity) may not be readily amenable to modification, the effects of these and others, such as smoking and alcohol, may be susceptible to generalised improvements in knowledge and behaviours that are relevant to sleep with the aim of reducing any additional effect of multiple environmental factors on sleep – a suggestion mooted in the preceding Chapter (Chapter 4).

It is notable, however, that the two self-reported sleep characteristics most commonly examined by previous studies, duration and quality (see Chapter 2), were largely unrelated to the majority of sociodemographic, health and lifestyle characteristics examined in the present study (see Table 5.2.1,5.2.2 and 5.3). This is striking given the importance afforded these two sleep characteristics (in part, perhaps, as a result of their apparent ease of measurement) and the strong associations with sociodemographic, health and behavioural factors reported by some, though by no means all, previous studies of sleep in pregnancy (e.g. Signal et al., 2007; Zafarghandi et al., 2012; O'Keeffe and Onge, 2013). However, with the exception of gestational age at interview/questionnaire completion, the only two participant characteristics to exhibit a substantial relationship with sleep duration and quality were parity (multiparous participants reporting shorter sleep durations and worse sleep quality) and pre-existing psychological health conditions (which were associated with an increased odds of reporting less than good sleep quality). These findings suggest that women retain primary responsibility for children even when pregnant with a subsequent child (Lee et al., 2000) and that this impacts on the amount and quality of sleep multiparous women receive. Likewise, the established role that sleep plays in psychological well-being, and vice versa (Kaneita et al., 2007) is likely to explain the impact of pre-existing psychological health conditions on reported sleep quality evident here, not least because pregnancy can be a time when hormonal changes and anxiety surrounding pregnancy, delivery and postnatal responsibilities serve to undermine psychological wellbeing and sleep (Hall et al ., 2009; see also Chapter 6 in this thesis).

Nonetheless, parity and psychological health aside, the present study indicates that researchers may need to broaden the range of sleep characteristics they study (i.e. beyond duration and quality) when exploring patterns, causes and consequences of variation in sleep amongst pregnant women.

5.8.3 GDM risk/diagnosis and pregnancy-specific predictors of sleep

In the absence of interventions that successfully address those pre-existing sociodemographic, health and lifestyle characteristics that reduce the possiblities of attaining good sleep, it remains unclear whether the generally poorer sleep experienced by pregnant women simply reflects the *additional* (i.e. additive/cumulative) or *facilitatory* (i.e. exacerbating) impact on these pre-existing characteristics of the many unavoidable changes (hormonal, physiological and anatomical) that accompany pregnancy, or whether any of these changes influence sleep *irrespective* (i.e. independently) of such pre-existing characteristics.

5.9 Key findings

Indeed, because the present Chapter found tangible evidence of a dose-response relationship between GDM risk/diagnosis and at least four of the seven sleep characteristics examined *after* adjusting for a wide range of preceding sociodemographic, health and lifestyle factors (operating as potential confounders) and gestational age at interview/questionnaire completion (operating as a competing exposure), these findings suggest that at least some aspects of the changes in sleep that occur during pregnancy reflect, or are the result of, the physiological changes that routinely accompany pregnancy (of which glucose intolerance/GDM risk/diagnosis is but one example; Qiu et al., 2010). It therefore remains to be seen which of the other changes in sleep that occur during pregnancy reflect, or are determined by, other hormonal, physiological and anatomical changes that normally accompany pregnancy. While some of the changes that accompany pregnancy (particularly the anatomical changes occuring as the foetus develops) seem likely to pose particular challenges to sleep – not least because of their impact on bladder and lung capacity, and the effect thereof on the frequency of nocturnal micturition and breathlessness – others appear to have some benefits, such as the impact of increasing levels of progesterone on obstructive sleep apnoea amongst pregnant women, even though the frequency and

severity of snoring is thought likely to increase during pregnancy (Maasilta et al., 2001; Dzaja et al., 2005).

Indeed, perhaps the most unexpected finding from the present study was that GDM risk/diagnosis (as a marker for increasing levels of pregnancy-related hyperglycaemia) was associated with both an *increased* frequency of reporting trouble sleeping due to coughing/snoring loudly and staying awake while eating, driving and/or socialising, and a *decreased* frequency of reporting trouble getting to sleep within 30 minutes and waking in the middle of the night/early morning. If other physiological, hormonal and anatomical changes that occur during pregnancy have similarly mixed relationships with different sleep characteristics, it may be that poor sleep may not be an unavoidable consequence or characteristic of pregnancy in otherwise healthy women with sociodemographic, health and lifestyle characteristics that are conducive to good sleep. Even then, less (or indeed, more) favourable sleep characteristics may nonetheless offer a sensitive marker for pregnancy-related problems that are otherwise hidden. This possibility deserves further investigation.

Chapter 6

How do expectant mothers make sense of the changes in sleep they experience during pregnancy?

6.1 Summary

Using in-depth qualitative analysis of web-based forum posts from pregnant women (and women with past experience of pregnancy) the present Chapter offers detailed insights into the *experience* and *understanding* of sleep during pregnancy – experiences that are felt to be specific to pregnancy, and information that is 'exceptional' to pregnant women (and poorly understood even by those health care professionals who specialise in their care). Alongside evidence of the ways in which such 'virtual communities' facilitate and produce shared understanding of such phenomena (and the constraints imposed on the forms such 'sharing' takes within the context of moderated web-based forums); the Chapter also describes the breadth of sleep and sleep-related characteristics which are felt to be affected by pregnancy. These characteristics cover all but one (snoring/coughing) of the characteristics covered by popular, generic sleep instruments, and are generally understood to be affected by hormonal, physiological and/or anatomical changes that are inherent to (and widely considered inevitable within) pregnancy. In contrast, there is little evidence that pregnant women recognise the potential role that pre-pregnant, pre-existing differences in sociodemographic circumstances *or* changes in behaviour, lifestyle or health *during* pregnancy play in exacerbating (or mitigating) the effects of pregnancy on sleep – even though such circumstances and behavioural factors feature prominently in the advice offered by forum users to those experiencing sleep problems. These findings suggest that sleep in pregnancy tends to be problematized (i.e. considered/identified as a 'problem') by pregnant women, in line with the approach adopted by much of the research and medical discourse on this topic. It remains to be seen whether this 'problematisation' compromises the objectivity of self-reported sleep characteristics provided by pregnant women.

6.2 Introduction

Despite substantial research on the sleep of pregnant women, using both objective (polysomnography and actigraphy; Tsai et al., 2016; Herring et al., 2013) and subjective (self- completed sleep instruments and custom sleep item sets; Facco et al.,2010; Ko et al., 2012) techniques, comparatively few studies have explored the experiences of pregnant women themselves. The benefits of such studies are that they offer greater understanding of the perceived impact of pregnancy on sleep, as well as insights into the factors that are considered responsible, as these are experienced and understood by pregnant women themselves.

To-date the only comprehensive qualitative investigation into the sleep of pregnant women that could be found in the literature was the study by Kennedy et al., (2007) which conducted in-depth semi-structured interviews with first-time mothers (n=20) shortly after delivery, in which they reflected upon the changes in sleep that had occurred over the course of their pregnancy, and how they had understood and responded to these. Kennedy et al. (2007) concluded that sleep becomes a "negotiated behaviour" amongst pregnant women as they prepare for, and come to terms with, the more frequently disturbed sleep and unexpected levels of exhaustion they experience. While their study reflected, and largely confirmed, the less favourable sleep found amongst quantitative studies of pregnant women (see Chapters 3, 4 and 5 of this thesis), it also offered a revealing insight into the psychological, attitudinal and behavioural responses of these women, who were often able to accommodate and adapt to the changes in sleep they experienced. These responses also reflected a greater degree of agency amongst women who are commonly considered to be purely passive recipients of pregnancy-related effects (Dzaja et al., 2005).

Unfortunately, Kennedy et al.'s (2007) remains the only in-depth study of pregnant women's experiences of sleep, includes dreaming changed which described as vivid, weird dream of the infant or disturbing scenarios in which they were in danger such as car accident. Several women acted upon their disturbing dreams by being more cautious. e.g. (driving slowly) which reflects a preparation and attachment of their infants. Much of the remaining literature in this area has focussed on dream- related phenomena (e.g. Larra-Carasco et al., 2013; 2014; Margherita et al., 2015; Oriol et al.,

2016). These studies highlight the increased frequency of nightmares and vivid dreams recalled by pregnant women, many of which focus on adverse pregnancy outcomes and related anxieties, other on crimes involving (for example) the abduction of their child. Similarly vivid dreams were evident amongst some of the posts in the material examined for this Chapter.

The aim of the present study, therefore, was to explore pregnant women's experiences of sleep, by examining the content of material posted to web-based discussion forums. These forums offer a rich resource of contemporary experiences, views and beliefs, much of it offered spontaneously by users operating within virtual communities to share their experiences with others. As such they provide opportunities for identifying those aspects of sleep that are particularly important to pregnant women, and for assessing the extent to which these might be associated with: circumstances and behaviours that precede pregnancy; changes in lifestyle, behaviour and mood during pregnancy; and the hormonal, physiological and anatomical changes that accompany pregnancy.

6.3 Methods

6.3.1 Identification and thematic coding of material from web-based forums

To help refine the present study's aims and methods, dedicated searches of three bibliographical databases (Ovid-SP,Embase and Google Scholar) were undertaken to assess whether any previous studies had identified web-based forums focussing on the experiences of pregnant women; or had examined these (or similar forums) as sources of qualitative data on sleep and sleep-related experiences. These searches did not produce any results, although several studies had used similar forums for recruiting participants (e.g. Tikotzky and Sadeh, 2009) and more specifically for qualitative research (e.g. Hsiung, 2000), including those focussing on forums developed for/used by pregnant women (e.g. Fredricksen et al., 2008; Arden et al., 2014; Betts et al., 2014). These articles offered advice and insights into the potential challenges, limitations, benefits, ethical considerations and analytical constraints involved there with (Im and Chee, 2001; 2006; Kelly and McKenzie, 2002; Madge and O'Connor, 2002; Bradley and Carter, 2012). Of particular relevance to the present study were the articles by

Arden et al. (2014), Betts et al. (2014) and Fredricksen et al. (2008) because these offered insights into the likely availability of web-based forums containing posts from pregnant women, and included: n=21 UK-based "parenting forums"; "multiple discussion forums"; and www.barnimagen.com (a forum containing posts in Norwegian), respectively. As such they also confirmed that these sorts of forums could be readily accessed using the Google search engine.

However, in the absence of a definitive list of websites focussing on issues relevant to pregnant women (and, specifically, those hosting web-based forums on which users can post queries, responses and comments), the present study undertook a systematic search of the internet, using www.google.com to generate such a list. Subsequent screening of the websites identified by this search was conducted by two researchers (the candidate and the lead suprevisor) to exclude those which contained no posts relevant to sleep, and to extract sleep-related posts. These posts were then subjected to repeated, independent close-reading (Tesch, 1990) by both of these researchers (and a third researcher with specialist expertise in anthropological qualitative research [Professor Thea de Wet, University of Johannesburg] to identify and define (both conceptually and functionally) discrete themes contained therein.

There are two key stages in identifying and coding themes (Braun and Clarke, 2006): the first involving the identification of emergent themes relevant to phenomena, processes and characteristics thereof, and evident in the language used by actors/participants involved in the production of the qualitative data examined; and the second involving the classification of themes within overarching 'types' from which it is then possible to identify the distribution of, and relationships between, such themes in order to generate 'grounded theories' (i.e. understanding and explanation derived from and situated within, the qualitative material examined):

1- Familiarisation with the data, involving: in this instance, repeated 'close-reading' of all sleep-related posts within the forums examined; comparing material presented within and between posts; examining the development of material posted by individual contributors (both individually, and collectively when posts occur in sequences reflecting discussion, debate and the sharing of views and

experiences); and 'active reading' to identify patterns, intentions and meanings explicitly and implicitly contained therein, including those relevant to potential 'higher order' themes (i.e. those identified at Step 2, below);

2- Generating initial codes, involving: classifications generated 'upwards' (i.e. based on the minutiae of detail evident within the qualitative material) and 'downwards' (i.e. based on common attributes of emergent themes and merging of these into composite thematic codes, reflecting shared characteristics amongst the data therein.

As such, this stage of analysis includes close-reading and careful examination of the structure, format, procedures and user practices was undertaken to generate a comprehensive understanding of how each website facilitated, managed and constrained the contributions provided by users, as permitted and/or constrained by the rules and restrictions imposed by the design and moderation/administration. This approach was intended to describe both the context and the content of web-based user forums selected for inclusion in the present study, and thereby better understand what any posts might represent– whether as representations of user experiences, or as expressions of fact, views, beliefs – a context-sensitive approach considered necessary given the absence of any obligation on the part of users to post such material, and the potential social and psychological factors likely to act as rewards for doing so. This provided a firm basis for developing a formal thematic classification that applied during the initial coding of the raw data.

3- Searching for themes, involving: a further round of close-reading and detailed examination of the qualitative material to allocate the initial (and composite) 'thematic codes' (identified at Step 2, above) to all relevant material; grouping the initial and composite thematic codes into potential overarching themes; and, finally, comparing material allocated to these codes to check for consistency, complementarity and continuity – a process in which further codes can also

emerge (and initial and composite codes may be replaced, refined, merged or disaggregated to better reflect the qualitative material on which these are based). In the process, some initial codes develop to form overarching themes, while others form sub-themes; and there may also be other thematic codes identified that do not integrate well with any of the others, and can nonetheless remain as 'others.'

4- Reviewing themes, involving: in this instance, the three researchers reviewing and refining the themes and thematic codes developed by others; reviewing specifically at the level of 'coded data extracts' (qualitative material extracted as exemplary of the thematic code[s] applied) to assess their face validity and to test the plausibility of these groupings of material and their relevance to the underlying phenomena and processes (including those pertinent to the topic matter [in this instance, sleep in pregnancy] and to the forms in which the qualitative material was generated [in this instance, publicly shared views, experiences, knowledge and belief from pregnant women engaging in online web-based discussion forums]). This involves close-reading of all collated extracts for each thematic code, and considering whether each appear to form a consistent/coherent pattern, or whether some of the data extracts within it might (better) fit elsewhere (if at all). It is a process that permits additional material, and specific phrases within existing thematic extracts, to be (re)coded and thereby address the likelihood that some such themes might be missed or mis-coded during earlier coding stages.

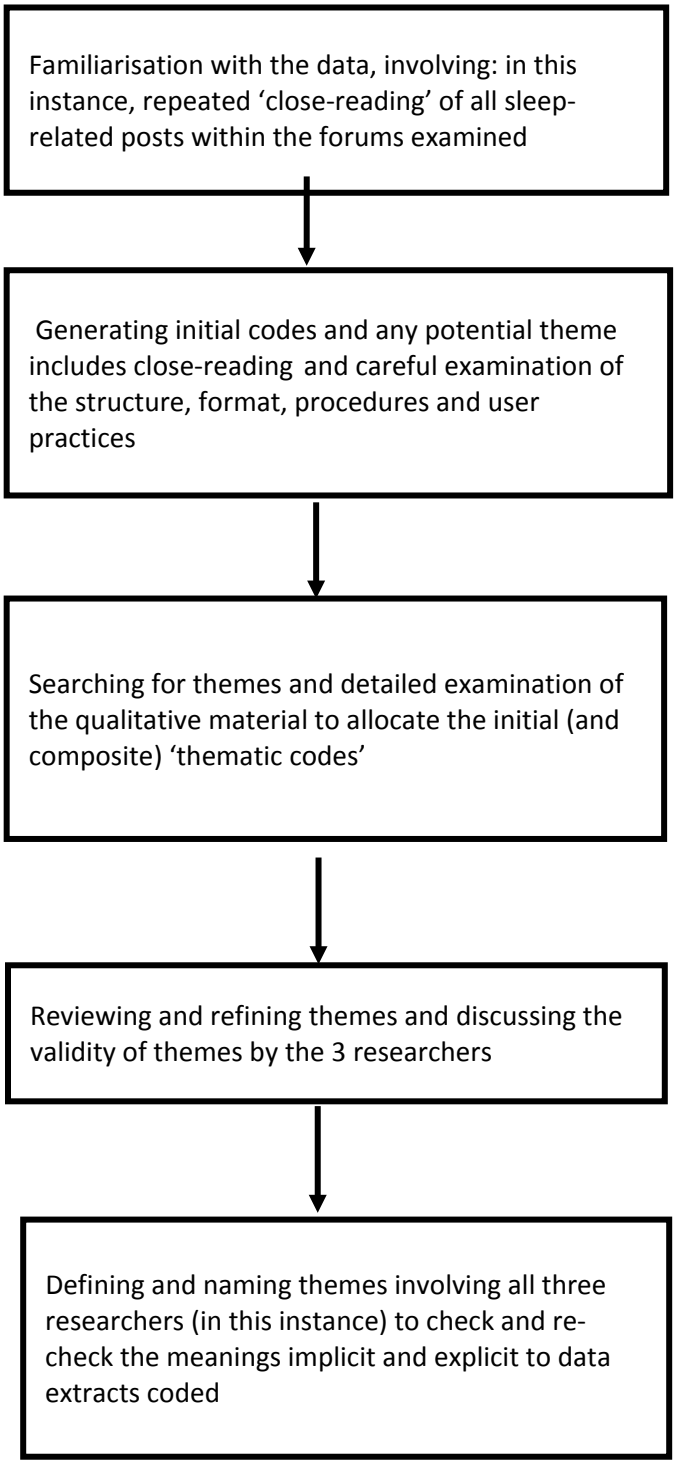
Subsequent discussion amongst the three researchers was used to assess the face validity of themes and to achieve consensus on any disagreements regarding their conceptual and functional meanings considering theoretical and analytic approach.

5- Defining and naming themes, involving: finally, a further round of defining and refining thematic codes occurs when these are formally defined and labelled – again, an iterative process involving all three researchers (in this instance) to check and re-check the meanings implicit and explicit to data extracts coded as exemplars of the themes identified. The development of clear definitions and

names for each coded theme helps not only to reduce and standardise the number of codes recognised (by merging those that are cognitively, semantically or functionally similar), but also to create an epistemological map of the inter-relationships between coded themes based both on their occurrence (and reliance on co-location) together, but also on the meanings that emerge from 'focussing out' from initial codes to composite codes, to overarching themes, and those evident amongst certain types of posts and web forums and those evident in others.

The Methodological approach adopted when identifying and thematically coding material from web-based forums containing user posts relevant to sleep in pregnancy (adapted from Kim and Kuljis, 2010), has been summarized in Figure 6.1 (below).

Figure 6.1: Identification and thematic coding of material from web-based forums containing user posts relevant to sleep in pregnancy.



6.3.2 Theoretical framing

Careful consideration was given to the theoretical framing of the circumstances and sociocultural processes likely to lie behind users' active involvement/participation in sharing experiences, needs and opinions in public; in order to avoid the potential for biases (as the analyses and interpretations based on these data were likely to be integral to the production of such material). In this regard, the present study sought to recognise the potential role of these structurally, socially, culturally and psychologically determined biases in the 'who', 'when' and 'why' of users' pro-active engagement with web-based forums, whether by initiating threads (by posting material) or engaging with others. These biases are likely to influence whose voices are evident and are therefore 'heard' in such forums, not simply because posting material relies on access to the internet (together with the time and technical expertise to do so), but also because the act of posting itself reflects a willingness to share experiences and views in public. Within this theoretical framing of the web-based forums used as sources of data in the present study, there was therefore substantial scepticism applied to both the external and internal validity of the material these forums provide.

6.3.3 Thematic content analysis

Given the nature of the material produced by web-based discussion forums – which were thought likely to take the form of brief pieces of text with limited information on the person generating these, their background or circumstances – the present study sought an approach to qualitative analysis capable of identifying a coherent hierarchical taxonomy of themes (Hsieh and Shannon, 2005), evident in both their conceptual and functional relationships, from what was likely to be limited amounts of text-based material. This approach involved four distinct phases: question specification; selection of data sources; data preparation; and data abstraction. Subsequent analysis of conceptual and functional relationships between emergent themes generated additional themes, exploring broader patterns relating not only to the topic in question, but also to the context within which the information emerged (Kim and Kuljis, 2010). Analysis of these qualitative data offers insights into the experiences, knowledge, views and beliefs of web-forum users and what might constitute 'accepted practice' amongst those posting material.

6.4 Ethical considerations

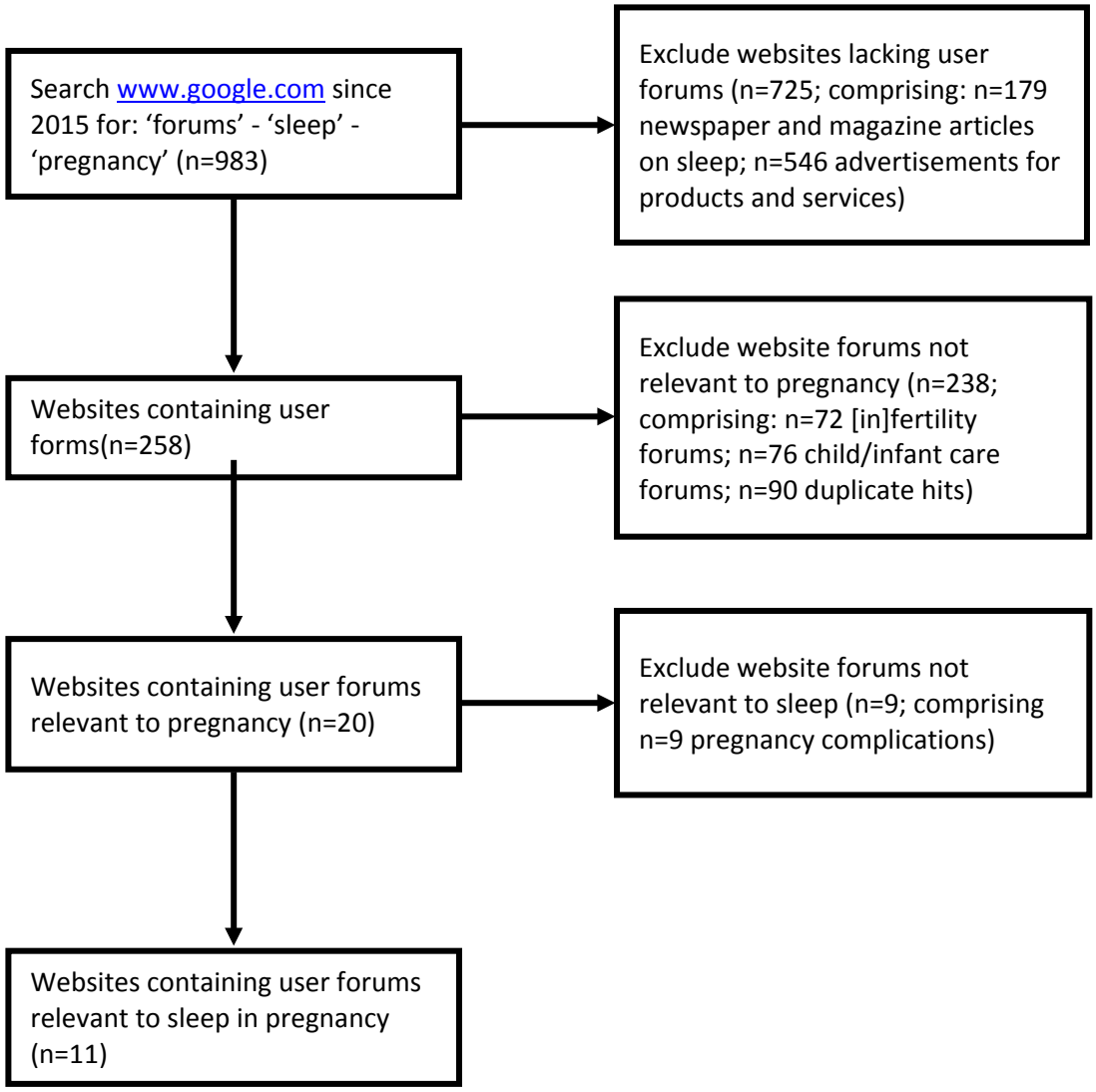
While material posted online offers a convenient source of readily available data that might not appear to require formal ethical approval, their ethical use still requires careful consideration (Kelly and McKenzie, 2002; Bradley and Carter, 2012) – not least to in order to respect the sources of these data and the 'implied consent' of those sharing information, ostensibly for their own benefit and for the benefit of others, rather than with the explicit understanding that this information might then contribute to research. For these reasons, ethical guidance was sought from the Chair of Leeds School of Medicine Research Ethics Committee who confirmed that data available within the public domain would not require formal ethical approval (see Appendix 6.1). In addition, the present study examined the Terms and Conditions/Terms of Use of each of the web forums identified as potential sources of information and, where required, contacted the relevant administrators to outline the aims of the study and the measures adopted to collect, analyse and report material posted on their user forums for possible inclusion in the analyses that follow. This involved an undertaking not to make direct contact with forum users or to post material in order to obtain responses from users and, at the same time, taking care to attribute material posted by users in such a way as to respect any measures they had taken to protect their identity, such as the use of pseudonyms as usernames.

6.5 Results

6.5.1 Web-based forums addressing sleep in pregnancy

The systematic search of the internet, using www.google.com, identified a total of n=983 'candidate' websites ostensibly relevant to the interests and concerns of pregnant women. Of these, most (n=725/983; 76.5%) provided only limited opportunities for user engagement (such as administrator contact details, and/or a feedback/query submission forms). Of the remainder, all provided forums on which readers/users were able to participate by posting queries, responses or comments; though of these only n=20/258 (7.8%) were relevant to pregnancy; and only n=11/258 (4.3%) were found to contain at least one thread or post relevant to sleep and/or fatigue (see Figure 6.2).

Figure 6.2 Internet search strategy for web-based forums containing user posts relevant to sleep in pregnancy.



The format and structure of these n=11 web forums has been summarised in Table 6.1 , the majority of which (n=8/11; 72.7%) had aims indicating they had been specifically developed for, and marketed to, parents, mothers and/or pregnant women (i.e. ED, PF, MN, MFM, NM, HGS, BC and WTE; see Table 6.1 for abbreviations); the remainder (n=3/11; 27.3%) being websites that had been developed for users to post material on religious (CA), neighbourhood (EDF) or general medical (MDJ) issues. Nonetheless, all of these forums required participants to register prior to posting material, a process that generally involved confirming they had read and accepted the web forum's 'Terms and Conditions' (T&C) or 'Terms of Use' (ToU), and activating a validation code sent to their email address.

Both the T&C/ToU, and additional, related user information provided by some, though not all, forums, indicated that administrators reserved the right to moderate, withhold or remove material that breached these conditions; and that users found to be in breach thereof could be blocked from posting material. However, it was generally unclear to what extent moderation of posts occurred and whether this took place prior to posts appearing online; in real time (i.e. as material was submitted); or *post hoc* (i.e. after material had been posted). Given that none of the web forums required participants to pay a membership or subscription fee at registration (except for those offering additional benefits to 'premium' contributors/supporters; or those posting commercial material/advertisements), it seems likely that the resources available for moderation were limited to income from product advertising or donations, meaning relatively few staff were available to moderate posts, enquiries or complaints. Nonetheless, it is important to acknowledge that at least some of the material submitted by participants to these web forums may have been withheld or withdrawn, because this would mean that the posts available for analysis in the present study may not have reflected the full range or amount of material submitted.

While registration usually required users to provide some fairly detailed personal information (generally their email address together with their name, date of birth, location, expected date of delivery, and stage of pregnancy), apart from the use of validation emails/activation codes, none of the sites sought to verify the personal information provided, and instead accepted that users were who they claimed to be,

and that the data they provided was true. Most websites also permitted (or required) participants to choose a pseudonym as a username to identify the material they posted, and to hide the identity of those posting material, thereby offering a degree of protection, privacy and security. Some appeared to use: combinations of first and surnames with/without dates or unique ID numbers (e.g. 'Ellyn E' and 'Beth B(86)' [NM]); or combinations of these and pseudonyms (e.g. 'mariemunday83', 'laura150610', 'TrishC' and 'littlestlou' [ED]). A few included location and/or pregnancy-relevant information (such as gestational age/due date and parity; ostensibly generated from the personal details requested at registration) alongside the names/ pseudonyms of users posting material. Others classified users according to the date of registration and/or frequency of posting (using such terms as 'Hi, I'm new' vs. 'New Member' [NM]; or 'Rookie', 'Savvy', Enthusiast', 'Addict' or 'Retired PF'er' [PF]).

Due to the inability to verify identities, it is impossible to be certain whether any of the personal data provided by users at registration (and repeated underneath user names attached to posts) was accurate. In addition, it is possible that some users might have had multiple accounts with different usernames. Indeed, because the T&C/ToU for a number of the web-based forums specifically forbade individuals from having multiple accounts, this suggests that this practice exists, and that this might have occurred within the data examined for the present study. Nonetheless, at the very least, the use of usernames provided a mechanism for identifying the user account from which each post was uploaded, thereby facilitating the linking of posts from these accounts over time and across subtopics (since most of the sites recorded and displayed the date and time at which each post was uploaded). This information might offer useful insights into both the temporal trends for posting behaviours, and the times of day at which posts on particular issues were uploaded. However, the location of the forums in different time zones makes interpreting the electronic time 'stamps' of each post necessarily tentative, since these might reflect the local time that the user uploaded the post, or when the web forum host received this. See Table 6.1

Table 6.1. A summary of the web-based discussion forums (n=1) providing sources of data posted by pregnant women regarding sleep in pregnancy.

Web forum, aims and/or disclaimer	Location	Provider	Terms and conditions/of use	User registration
Emma's Diary: Pregnancy and Baby Chat Forum [ED] (http://www.emmasdiary.co.uk/forums) Aim: "The Site provides users with access to a variety of information and on-line resources, including on-line forums, through its network of properties" Disclaimer: "The information on the website is for general information and it is not intended as, nor should it be considered as a substitute for seeing your own GP, midwife or healthcare professional. You are advised to seek professional medical advice if you have any concerns or suspect you have a medical problem"	UK	"provided by Emma's Diary®, a division of LCMB [Lifecycle Marketing Mother and Baby]… a limited company registered in England and Wales" LCMB was incorporated in the UK in 2010	Terms and conditions: Explicit Moderation: Administrator reviews all posts before submission and has the right to remove any material posted/uploaded if it does not comply with the website's terms and conditions.	Registration requires: user's date of birth, postcode and email address Registration confirmed by: validation/activation email Post character/word limit: None explicit Post identification: Date and time stamp; membership date; user name; number of posts by user
East Dulwich Forum [EDF] (http://www.eastdulwichforum.co.uk/forum) Aim: "This forum is intended to be for use by people who live in, drive through, have an interest in or just want more information about London's East Dulwich." Disclaimer: "Everyone who uses this forum is free to post their thoughts, requests, recommendations, rants, wants, needs, desires, questions and more on here without unnecessary obstruction therefore we, the people who set up this forum, are not responsible for other people's writings."	UK	"East Dulwich Forum Team" The first post under the thread labelled "About this forum" was dated July 2006	Terms and conditions: Explicit Moderation: Users are liable for the consequences of posting inaccurate or illegal material. The management reserves the right to refuse/suspend membership.	Registration requires: user's email address Registration confirmed by: validation/activation email Post character/word limit: None explicit Post identification: Date and time stamp; date of membership; username; number of posts by user

Table 6.1. Continued.

Web forum, aims and/or disclaimer	Location	Provider	Terms and conditions/of use	User registration
Pregnancy Forum [PF] (http://www.pregnancyforum.co.uk) Disclaimer: "By accessing or using the Web Site, you acknowledge that you have read, understand, and agree to be bound by these terms and conditions […] Warning: This is a public forum. Your posts can be read by anyone with an internet connection."	UK	"managed under licence by Webby Media LTD" Webby Media was incorporated in the UK in 2009 (and dissolved in 2012)	Terms and conditions: Explicit Moderation: Users are liable for the consequences of posting inaccurate or illegal material. The management reserves the right to refuse/suspend membership.	Registration requires: user's date of birth, location and email address Registration confirmed by: validation/activation email Post character/word limit: None explicit Post identification: Date and time stamp; date of membership; username; number of posts by user
Mumsnet [MN] (http://www.mumsnet.com/Talk/pregnancy) Aim: "Make parents' lives easier by pooling knowledge, advice and support. We try, as far as possible to let the conversation flow and not to over-moderate. Mumsnet is a site for grown-ups."	UK	"Mumsnet is a business funded mainly by advertising and we try to be a profitable one but our overarching aim is not the pursuit of profits. We are independently owned and we endeavour to conduct business in an ethical manner." Mumsnet was incorporated in the UK in 2000	Terms and conditions: Explicit Moderation: Users are liable for the consequences of posting inaccurate or illegal material. The management reserves the right to refuse/suspend membership.	Registration requires: user's email address Registration confirmed by: validation/activation email Post character/word limit: None explicit Post identification: Date and time stamp
Made for Mums [MFM] (http://www.madeformums.com/forum/) Aim: "MadeForMums is run by a small group of (mostly mum) journalists, who want to create a top-notch online home for mums, mums-to-be and anyone who is trying to start a family – as well as dads (look past our name!)" Disclaimer: "We accept no liability in respect of any user	UK	"owned and published by Immediate Media Company Ltd" Immediate Media Company was incorporated in the UK in 2011	Terms and conditions: Explicit Moderation: Users are liable for the consequences of posting inaccurate or illegal material. The administrators reserve the right to remove material that does not comply with the forum's Terms and Conditions.	Registration requires: user's email address Registration confirmed by: validation/activation email Post character/word limit: None explicit Post identification: Date and time stamp; username; number of post views

Table 6.1. Continued.

Web forum, aims and/or disclaimer	Location	Provider	Terms and conditions/of use	User registration
Net Mums [NM] (http://www.netmums.com/coffeehouse/) Aims: "Help families have fun with and enjoy their children; Bring people together to make our local communities more lively and friendly; Make it unnecessary for any mum to feel lonely or isolated; Make sure every parent has access to all of the local support and advice available - from other mums and from professionals; Give mums a voice, locally and nationally, on issues of importance to them" Disclaimer: "[…] the support and information in the forum and site does not constitute any form of advice, recommendation or arrangement by Netmums and is not intended to be relied upon by users in making (or refraining from making) any specific decisions or to be a substitute for obtaining professional advice. You should consult a doctor, health or appropriate professional if you require specific advice."	UK	Netmums Plc Netmums was incorporated in 2002	Terms and conditions: Explicit Moderation: Users are liable for the consequences of posting inaccurate or illegal material. The management reserves the right to withdraw membership from anyone not committed to the Terms and Conditions.	Registration requires: user's email address Registration confirmed by: validation/activation email Post character/word limit: None explicit Post identification: Date and time stamp; number of post views
Huggies [HGS] (http://www.huggies.com.au) Aim: "[…] the leading baby and parenting site in Australia and New Zealand […] the Huggies Forum is a facility available to Huggies Baby Club members to express their own thoughts and opinions." Disclaimer: "All thoughts and opinions expressed on the forum are the thoughts and opinions of the participants and not ours"	Australia	"…operated by Kimberly-Clark Australia Pty Limited" Kimberly-Clark Australia was registered in 2000	Terms and conditions: Explicit Moderation: Users are liable for the consequences of posting inaccurate or illegal material. Moderators and the Customer Advisory Service address unacceptable behaviour by other members (including the removal of material and restricting access to the site to anyone not complying with Terms and Conditions).	Registration requires: user's email address Registration confirmed by: validation/activation email Post character/word limit: None explicit Post identification: Date stamp; username; number of posts by user.

Table 6.1. Continued.

Web forum, aims and/or disclaimer	Location	Provider	Terms and conditions/of use	User registration
Baby Center [BC] (http://www.babycenter.com/400_pregnancy-sleep-help_970336_375.bc Aim: "BabyCenter provides parents with trusted information, advice from peers, and support that's Remarkably Right® at every stage of their child's development." Disclaimer: "Any opinions, advice, statements or other information expressed or made available by Users or third parties, including but not limited to bloggers, are those of the respective User or other third party and not of BabyCenter. BabyCenter does not endorse and is not responsible for the accuracy or reliability of any opinion, advice or statement made on the Web Site."	USA	"A member of the Johnson & Johnson family of companies." Baby Center was founded in 1997 and acquired by Johnson & Johnson in 2001	Terms and conditions: Explicit Moderation: Users are liable for the consequences of posting inaccurate or illegal material. The administrators prevent any disruption or posting of inappropriate content.	Registration requires: user's pregnancy history; and email address Registration confirmed by: validation/activation email Post character/word limit: None explicit Post identification: Date stamp; number of posts by user
What to Expect [WTE] (http://www.whattoexpect.com/) Aim: "Filled with the latest in pregnancy and parenting information and news – presented with What to Expects trademark warmth, humor, and empathy — the site is also home to a close-knit community of more than 13 million moms worldwide." Disclaimer: "The material on this website is provided for educational purposes only and is not to be used for medical advise, diagnosis or treatment, or in a place of therapy or medical care. User of this site is subject to our terms of use and privacy policy."	USA	Everyday Health, Inc. Everyday Health, Inc first filed with the USSEC in 2006	Terms and conditions: Explicit Moderation: Users are liable for the consequences of posting inaccurate or illegal material. Any posts or posting behaviour that breaches Terms and Conditions can lead to expulsion from and refused access to forums in the future.	Registration requires: user's date of birth; pregnancy history; and email address Registration confirmed by: validation/activation email Post character/word limit: None explicit Post identification: Date stamp; number of posts by user

Table 6.1. Continued.

Web forum, aims and/or disclaimer	Location	Provider	Terms and conditions/of use	User registration
Catholic Answers [CA] (http://forums.catholic.com/) Aim: "Registered members are able to: submit questions about the faith to experts from Catholic Answers; participate in all forum discussions; communicate privately with Catholics from around the world; plus join a prayer group, read with the Book Club, and much more."	USA	Catholic Answers Inc Catholic Answers Inc was first granted charitable status by the USIRS in 1982	Terms and conditions: Explicit Moderation: Users are liable for the consequences of posting inaccurate or illegal material. Accounts will be cancelled if they contain any offensive elements.	Registration requires: user's date of birth and email address Registration confirmed by: validation/activation email Post character/word limit: None explicit Post identification: Date and time stamp; number of posts by user
MDJunction [MDJ] (http://www.mdjunction.com/) Aim: "MDJunction is a meeting place for people who deal with health challenges, a comfort zone to help and get help by people who are in your spot." Disclaimer: "The information provided in MDJunction is not a replacement for medical diagnosis, treatment, or professional medical advice."	USA	"MDJunction is funded by private people, committed to doing good. In addition we receive payments for advertisements on site and affiliation fees." No records relevant to 'MDJunction' or 'People Helping People' were listed on USIRS or USSEC Website copyright notice	Terms and conditions: Explicit Moderation: Users are liable for the consequences of posting inaccurate or illegal material. The moderators address bad language or illegal statements.	Registration requires: user's email address Registration confirmed by: validation/activation email Post character/word limit: None explicit Post identification: Date stamp; number of posts by user

In spite of the potential limitations of the text-based material provided by web-forums, one key benefit of using these as sources of qualitative data was the volume of posts available. This is evident in the number of threads and posts identified as relevant to sleep and/or fatigue; n=49 and n=1,358, respectively; see Table 6.2). Somewhat unsurprisingly, most of these threads (n=46/49; 93.9%) were found within the n=8 web-based forums developed specifically for parents/mothers/pregnancy, while only one such thread was found on each of the more generic forums (CA, EDF and MDJ). This may reflect the perceived 'exceptionalism' of pregnancy-related experiences and concerns amongst forum users, suggesting it is viewed as privileged knowledge only available/relevant to, and understood by, women who were/had been pregnant, and was not more widely acknowledged and understood. Certainly, the view that pregnancy was a unique physical, psychological and emotional experience that the 'uninitiated' would be unable to fully understand, is evident from a number of the thread titles summarised in Table 6.2 (particularly threads 40, 41 and 48). This is also apparent in the analyses that follow, from posts within many more of the threads. At the same time, the fact that only one generic medical forum (MDJ) was amongst the web-based forums found to contain user posts relevant to sleep and sleep-related issues in pregnancy might indicate that this 'exceptionalism' extended to a preference for 'sharing' with other mothers/pregnant women rather than with those with experience of similar issues from a more medicalised perspective. This is evident in one of the posts included in the analyses that follow, which described user experiences as "more believable" than the content of health service websites [1st post in NM thread 45].

Amongst the n=8 parent/mother/pregnancy-specific forums there was substantial variation in the prevalence of threads relevant to sleep and sleep-related issues in pregnancy. Around half of the forums contained just n=1-4 such threads (MFM n=1; HGS n=1; MN n=2; WTE n=4; BC n=7; ED n=15). There was also no evidence that those forums that had been established for more than 10 years (BC 1997 n=7; MN 2000 n=2; HGS 2000 n=1; NM 2002 n=4) contained any more threads on sleep and sleep-related issues than those established more recently (WTE 2006 n=4; PF 2009 n=8; ED 2010 n=15; MFM 2011 n=1). As such, the distribution of sleep and sleep-related threads

amongst these web-based forums may simply reflect their relative success amongst online networking sites. See Table 6.2.

Table 6.2: Summary of the threads and thread-specific posts found to include references to sleep and sleep-related issues amongst the n=12 web-based forums examined in the present study.

Thread code and title	Number of posts	Web forum source
1. "Why oh why cant i sleep!!!! Sleep tips please!!"	5	PF
2. "I can't stop sleeping!"	11	PF
3. "Pregnancy? Sleep? Help!"	12	BC
4. "Tips on Changing Pregnancy Sleep Cycles"	11	CA
5. "Ahhhh! Can't sleep won't sleep"	20	PF
6. "How do you sleep?"	22	PF
7. "Early morning wake-ups"	5	PF
8. "I can't sleep !!!"	13	PF
9. "I just can't lay on my left side"	19	WTE
10. "Toilet trips at nightime"	12	PF
11. "Partner won't stop snoring."	10	WTE
12. "NO SLEEP & still pregnant"	12	WTE
13. "Snoring Husband = No Sleep for Pregnant Wife"	8	NM
14. "38+6 weeks pregnant and exhausted!"	2	ED
15. "Insomnia – anyone else get it in early pregnancy?"	22	MN
16. "vivid nightmares!"	7	ED
17. "Tell us about your weird dreams during pregnancy!"	11	MFM
18. "Im having nightmares during my pregnancy about deaths, what does that mean?"	240	BC
19. "Trouble Sleeping"	7	HGS
20. "Night shifts – am I crazy?!?"	27	NM
21. "I'm pregnant, in my third trimester, and feel exhausted at work. What should I do?"	214	BC
22. "Sleep bras"	2	ED
23. "Maternity pillows?"	14	ED
24. "Sleeping tablets: really need help/ advice"	16	MN
25. "Is anyone going through Night Terrors? Any suggestions to make this easier for both of us?"	76	BC
26. "pregnant and cant sleep due to twitchy legs/arms"	17	EDF
27. "Sleep medication question"	16	WTE
28. "Does pregnancy mess up your sleep cycle?"	10	MDJ
29. "Feel short of breath all the time!"	11	NM
30. "Any advice please" [blood/brown stained discharge]	4	ED
31. "Pain in pregnancy"	1	ED
32. "SOMEONE PLEASE HELP" [tingling hands and feet]	2	ED
33. "Big bump at 9 weeks?"	2	ED
34. "Headache in pregnancy"	11	ED
35. "Heartburn – 38 weeks"	19	NM
36. "Morning sickness ERM NO!! 24 hour sickness :("	21	NM
37. "Suffer from itching and rashes during pregnancy"	25	BC
38. "Is lower back pain okay in early pregnancy???"	31	NM
39. "I'm SO hungry!"	10	NM
40. "How is your partner dealing with you being pregnant"	15	PF
41. "Anyone else's husband not get how hard this is?"	23	BC
42. "Pregnant after miscarriage"	55	NM
43. "Fitness"	1	ED
44. "morning sickness worries"	5	ED
45. "What did you experience days before labour started?"	237	NM
46. "Taking Cyclizine during pregnancy"	2	ED
47. "One thing you missed during pregnancy?"	19	ED
48. "Husband is distant during pregnancy"	17	BC
49. "Previous Pregnancy Complications – I'm so worried!"	6	ED

6.5.2 Thematic analysis of thread structure

Repeated close-reading of the n=1,358 posts contained within the n=49 threads identified as relevant to sleep and sleep-related issues in pregnancy, indicated that these threads were initiated by a post focusing on sleep (see Table 6.2 threads 1-28) or emerged as a secondary consideration (be it a contributory factor to any experiences or advice) within threads initiated for, and focussing on, other somewhat unrelated issues (see threads 29-49 in Table 6.2). Regardless of the topic initiating the thread, posts took one of three principal forms:

The first was common to all thread-initiating posts, although it was occasionally contained in subsequent posts as the threads spread, and took the form of 'requests' for advice or reassurance, often expressed in desperate terms; for example:

> "***Why oh why cant i sleep!!!! Sleep tips please!!*** *– Exhausted byt my body just wont give in! Im getting 4 and a bit hours a night. Before getting preggers I was a good 8-9 hrs a night kind of girl but during tri 1 n now tri 3 it just isn't happening between spd n reflux i dnt know what to do!!!"* [precious_cargo; 22nd December 2014, 04h59; 1st post in PF thread 1]
>
> *"**SOMEONE PLEASE HELP -** 37 weeks pregnant and I'm suffering with tingling sensations in my hands and feet which are really disturbing me from getting any sleep* […]*"* [closkii4eva; 7th December 2015, 12h31; 1st post in ED thread 32]
>
> ***"Tips on Changing Pregnancy Sleep Cycles –*** *… every night I wake up around 3-4am and stay wide awake until 8-9am* […] *in the evening from 4pm-9pm I will be just wiped out. I can barely walk around! But once the clock strikes 10, I am wide awake until midnight. Nothing I do changes this* […] *Please note that this is not to ask for medical advice. I am looking for non-medical suggestions to improve sleeping or falling asleep, or just comraderie*[5] *understanding about pregnancy symptoms!"* [hasikelee; 11th May 2008, 19h26; 1st post in CA thread 4]

[5]Excerpts from posts have been reproduced exactly as they appeared, including typographical or grammatical errors.

The second contain 'responses' and are subsequent to the thread-initiating post. They offer shared experiences (empathy and/or sympathy), information and/or advice; for example:

> **"I'm pregnant, in my third trimester, and I feel exhausted at work. What should I do?** – *I know EXACTLY how you feel. I now have a 9 week old, but my 8th month of pregnancy was so exhausting!* […] *When the time came for me to legally be able to go out on maternity leave (4wks before due date) I jumped at it and left. It was great to relax and prepare for my labor that went amazing and flawless! so take advantage of the time you have […]" [BabyCenter member; 19th August 2007, no time stamp; 4th post in BC thread 21]*
>
> *"Heartburn – 38 weeks – I had AWFUL heartburn/reflux when I was expecting my dd, I used to vomit stomach acid in the middle of the night (blergh). The only things I found to help were not sleeping flat on my back (just support yourself with a few pillows), limiting intake of acidic drinks […]" [Amy S(675); 9th September 2009, 10h11; 10th post in NM thread 35]*

The third form consists of 'situational updates'. These are somewhat similar to a social media 'status' post or an 'announcement' of an event or an activity which, in the context of the posts examined for the present study, were rarely evident in any but the longer threads (for example, see Table 6.2, threads 18, 21 and 45). They tended to emerge mid-thread, sometimes with minimal relevance to the thread's initial query or containing a different 'follow-up' query; for example:

> **"Im having nightmares during my pregnancy about deaths, what does that mean? –** *im 14 weeks and i be having nightmares of miscarriage and crazy stuff.. i still have them sometimes. it scares me and my doctor like she don't want to give me another ultrasound as yet to assure me my baby is ok. this is my first pregnancyand it was hard for me to get prego for a while* […] *But i want to see my baby all the time, only because these dreams creep me out."* [nefertitiarthur; 12th March 2011, no time stamp; 10th post thread in BC thread

18]

"Toilet trips at nightime – […] *a bit of a pointless post .. just want to moan [Emoticon][6]"*[tweetyfoo; 28th August 2012, 23h27; 1st post in PF thread 10]

"Pregnant after miscarriage – *Hi ladies, I never wrote on any of these forums, but I decided to do so now… Sorry for tmi, but i feel I should just let it all off my chest, thank you for reading. Xx"* [Alice F(82); 6th May 2016, 16h04; 53rd post in NM thread 45]

"Pregnant after miscarriage – *I have just found out that I'm pregnant which is great. But I had a miscarriage in April and I'm really worried that it will happen again. I'm checking my underwear every 30 minutes waiting for the blood. I don't want to feel like this anymore and wondering if anyone else has been through this x"* [michelle s(268); 19th August 2016, 20h08; 55th post in NM thread 45]

On three occasions (see Table 6.2, threads 17, 45 and 47), threads examined were found to have been initiated by web forum administrators or users acting as administrators, rather than spontaneously by forum users themselves. These 'admin posts' operated more like 'prompts' than 'requests', although they were often worded as questions. Although these were uncommon, just 6.1% (n=3/49) of the threads identified, they did provide evidence of participation by administrators/moderators within the three forums concerned (MFM, NM and ED) and generated subsequent posts from users that tended to take the form of 'situational updates' rather than 'responses' *per se*; for example:

"Tell us about your weird dreams during pregnancy! *– Hi everyone, We've been noticing of you our Birth Clubs* [sub-forums; …] *are chatting about having very strange, vivid and intense dreams during pregnancy. And it's certainly something we remember, too. So we'd love it, please, if you'd come and share with us the details of your weirder pregnancy dreams.* […]" [DanielleMFM – MFM Administrator; 1st March 2016, 13h01; 1st post in MFM thread 17]; *"Haha– these are brilliant! Please keep them coming!"* [HelenMFM – MFM Administrator; 7th March 2016, 12h21; 5th post in MFM

[6] [Emoticon] indicates the presence of a symbol representing a smile or frown. These were available for use in some of the forums examined to convey the user's feelings or intended tone.

thread 17]; and *"I had a dream about something bad happening to my eldest too it was horrible :(and then last night I was dreaming about what food I want to eat lol and dreamt about losing the baby :("* [Sj83 – MFM Member; 20th March 2016, 15h21; 9th post in MFM thread 17]

What did you experience days before labour started? *– This thread is mainly to save women like me constantly Googling "signs of labour" lol. It's better i think to read experiences first hand than from the nhs website etc, i find they are more believable. So what we're your bodily experiences days before you went into labour?"* [Hayley T (182); 14th October 2014, 22h39; 1st post in NM thread 45]; and *"Lots of weeing, I had to give myself a cut off time for having a drink, I may as well have lived in the bathroom! Not being able to sleep, being hungry at 4am, Braxton hicks for about a week and a show."* [Sarah lee W; 29th October 2014, 13h12; post 62 in NM thread 45]

"One thing you missed during pregnancy? *– Come on ladies lets confess the one thing that you most missed during pregnancy. Mine was not being able to lick the cake mixture bowl out because of raw eggs!! I've made up for it now though lol!"* [cyounger90; 20th August 2013, 16h08; 1st post in ED thread 47]; and *"Sleep! I miss sleeping the whole night through. I wake up itching, for the loo or changing position* […]*"* [k_e; 22nd August 2013, 19h46; 12th post in ED thread 47]

Other evidence of participation from administrators of forum content was also found in a fourth forum (BC) and consisted of what appeared to be edited collections of 'tips' from user posts, including one entitled:

"What I wish I'd known about staying comfortable in the third trimester" [Unauthored; no date and time stamp; BC]

This was included n=16 posts (see Table 6.2) before these were opened up to 'discussion', including two relevant to sleep:

"I sleep with small travel pillows instead of those big bulky pregnancy pillows. They give you that little boost where you need it, and you can roll over

easily without messing up the bedclothes and waking your spouse." [4th excerpt]

"If you can't get comfortable in bed, try a different spot. The couch or recliner may be your ticket to a good night's sleep." [16th excerpt]

6.5.3 Thematic analysis of user posting practices, behaviours and motivation

The three forms taken by posts within the threads examined in the present study appear to reflect (and offer) various types of benefits to forum users. With the exception of n=2 threads which contained only one post (see Table 6.2, thread 31 on pain and thread 43 on keeping fit), all of the users initiating these threads received: reassurance (that their experiences were not unique and/or unusual); advice (on what had worked for other users facing similar issues); or knowledge (from others users who felt competent to diagnose or prescribe). At the same time, the act of 'sharing', and the perceived honesty that posting online permitted, generated solidarity that was reflected in subsequent 'thank you' posts from those initiating threads, for example:

"[…] *You make me feel I am not alone!!* […]*"* [Kri5ty; 27th May 2011, 09h24; MN thread 24]

" [..,] *it feels good to also talk honestly with someone that is going through what I did*
[…]*"* [Lorna A(68); 4th December 2012, 02h20; NM thread 42]

"cheers ladies, I know I'm not alone. Finally got back to bed at 07:30 […]*"* [Daggers; 28th August 2006, 11h20; PF thread 5]

"Im so pleased to read that im not the only one!! Thought id gone mad! [...]*"* [becca.1; 24th January 2016, 08h40; ED thread 16]

Disputes and disagreements amongst users were far less common but when these did occur it was clear that some contributions were far from supportive or thoughtful; for example:

"YOU are a disgrace. I'm sure you've been told where to put your comment, but I can't help but be enraged enough to answer you […] *I pray that the single men in my life never end up with someone like you. And I hope that all young*

women have enough courage and strength to do things for themselves- unlike you […]*"* [BabyCenter member; 18th May 2012, no time stamp; BC thread 21]

This shows that the benefits of posting material on web-based forums can be accompanied by the risk of disagreement and conflict, although such instances were rare amongst the posts on sleep and sleep-related issues examined in the present study. As such, this may indicate the extent to which forum moderators were responsible for blocking posts considered aggressive or inappropriate.

6.5.4 Thematic analysis of sleep and sleep-related issues

While it is clear from Table 6.2 that sleep and sleep-related issues (particularly those experienced as causing sleep-related concerns) emerged as thread-initiating problems for many of those containing posts relevant to sleep, it is also evident that sleep was relevant to threads initiated on a wide range of other topics – from physical symptoms (such as pain, discomfort, heartburn and morning sickness) to social concerns (including those relating to the behaviour of partners/husbands) and anxieties about the future (particularly those relating to pregnancy loss and preparation for labour). As such, much of the sleep-related focus of the forum posts examined in the present study was framed by a tendency to problematize fatigue and poor sleep as characteristic of pregnancy. Thus, in a telling post from one of the many users contributing to one of the longer threads (see Table 6.2, thread 42) they began to describe a previous miscarriage in the following terms:

"It started on Monday night when I came home from work, i so far had a pretty normal pregnancy a lot of tiredness and morning sickness […]*"* [Caroline H(898); 3rd December 2012, 00h35; NM thread 42]

Elsewhere, numerous posts reflected the experiences of women for whom the severity of sleep problems far exceeded what they had experienced in previous pregnancies; for example:

"I'm demented [Emoticon]. I'm now averaging between 8 and 10 toilet visits during the night now, it takes ages to get back to sleep so I feel like I'm just drifting off and I'm wide awake again for the loo. I don't have the strongest bladder (runs in the family), pre pregnancy I'd always be up t least once or

twice in the night anyway … but I can't help but feel this is excessive! […]*"* [tweetyfoo; 28th August 2012, 23h27; 1st post in PF thread 10]

"I wake up every night between 1-3am and can't sleep until the sun comes up, then only get 1 hour max. This is getting ridiculous […]*"* [Saschele; May 2013, 05h13; 1st post in WTE thread 12]

"[…] *I am sorry you are suffering so much but it is reassuring to know others are in the same boat. Most of the* [pregnancy] *books refer to insomnia but not severe insomnia as we know it.* […]*"* [newbishad; 18th January 2008, 12h02; post 6 in MN thread 15]

"[…] *I'm reaching breaking point. I can't go on like this with only getting a few hours sleep each night. It has a massive knock-on effect for every aspect of my life. I just can't cope with it.* […]*"* [MorrisZapp; 22nd March 2010, 15h35; 1st post in MN thread 24]

Such comments represented the sleep that users experience during pregnancy as inherently problematic, and covered the eight principal sleep characteristics commonly addressed by items contained in the most popular self-administered sleep instruments, such as the Pittsburgh Sleep Quality Index (Buysse et al. 1989) or the Basic Nordic Sleep Questionnaire (Partinen and Gislason 1995); as well as the characteristics required to classify 'insomnia' and 'sleepiness', as defined by the American Academy of Sleep Medicine in their *Revised International Classification of Sleep Disorders* (AASM, 2001). A summary of these seven characteristics, accompanied by exemplary/defining posts, has been provided in Table 6.3, which covers: sleep duration; sleep latency (i.e. difficulty falling asleep); sleep disturbance/awakening (late at night/early in the morning); use of sleep medication (including prescribed and non-prescribed medicines and natural remedies); sleep inertia (i.e. feeling refreshed/alert upon waking); overall sleep quality; and daytime sleepiness (i.e. difficulty staying awake at work/home).

The only commonly recognised sleep characteristic that was hardly mentioned in any of the web-based forum posts examined in the present study was 'coughing/snoring'. Indeed, the only references to snoring while pregnant emerged from threads dealing

with the impact of, or on, partners'/husbands' snoring, which suggests that experiences of coughing/snoring largely depend upon the accounts of bed partners:

> *"now my other half is moaning cause I snore!!!* [Emoticon]" and *"*[…] *i haven't always snored but it has going 1o times worse since being preg!* […]*"* [hev&madi; 29th April 2006, 12h09; 13th and 17th posts in PF thread 5]
>
> *"Oh I understand, is it possible that your husband has sleep apnoea? I feel for you because both me and my fella both snore* [.] *now while pregnant I haven't snored but my fella has snored a million times worse* […]*"* [Leoni K(4); 24th January 2013, 18h10; 2nd post of NM thread 13]

Nonetheless, an entire thread dealt with the breathlessness experienced by pregnant women and the associated anxiety this could cause, particularly later in pregnancy when the growth of the baby influences the space available for lung expansion. This suggests that breathing- related issues (other than coughing and snoring) remain important in the sleep experienced by pregnant women:

> *"*[…] *I'm currently 29 weeks and have been feeling breathless and short of breath for the past few weeks, but the past 2-3 days has been particularly worse! I just feel like I'm not taking in enough oxygen, I can't sit up straight because of it, I have to be reclined back on the sofa and it's also really affecting my sleep.* […] *I'm not in pain or anythin it's just very uncomfortable feeling like you can't breathe properly. It's really getting me down…… TIA"* [Natalie O(165); 27th August 2016, 17h28; 1st post of NM thread 29]

Whilst there were numerous posts dealing with interactions between different sleep characteristics (particularly the role of extended sleep latency and/or more frequent sleep disturbance/awakening on sleep duration, sleep inertia and daytime sleepiness), forum posts mainly focused on the impact of pregnancy-related changes as determinants of extended latency, more frequently disturbed sleep and daytime sleepiness. There is a long list of such determinants (see threads summarised in Tables 6.2 and 6.3) and these were often presented with reference to the trimester of pregnancy in which they had occurred. In terms of sleep latency, such 'perceived determinants' included: itchiness; restless limbs; breathing difficulties; sore breasts;

abstention from sleep medication; and worries about pregnancy (both previous and current), delivery, responsibilities postpartum and social circumstances (including relationships with partners/husbands, other household members, and physical household features that militate against favourable sleep). Determinants relevant to disturbances also included: itchiness; restless limbs; breathing difficulties; and worries; as well as vivid dreams and nightmares; heartburn and nausea; pain and discomfort; nocturia; and the behaviour of, and noise from, bed partners, children and household pets.

Table 6.3: A summary of the seven sleep characteristics considered important to pregnancy, identified within posts to web-based forums. Excerpts from exemplary posts are provided alongside each of the characteristics identified

Sleep characteristic	Excerpts from exemplary forum posts	Post/thread reference
Sleep duration:	*"[…] I managed 6 hours last night with a pee brake between. […]"*	[5th post in PF thread 1]
	"[…] I can't remember the last time I slept through the night! […]"	[12th post in PF thread 6]
	"[…] I'm averaging about 4 hours per night. 10:30-12:30 and 3-5. […]"	[4th post in WTE thread 12]
	"[…] Im 14 weeks and have been getting an average of 3 hours sleep for the past month. […]"	[9th post in MN thread 15]
	"[…] Basically for 4 days I get a total of 9 hours sleep and that is not good sleep at all! […]"	[8th post in BC thread 21]
Sleep latency:	*"Does anybody else find themselves waking up early […] and then not being able to get back to sleep? […]"*	[1st post in PF thread 7]
	"I can't get to sleep in the first place!!"	[11th post in PF thread 8]
	"[…] 3.30am-ish and I've not been to sleep. […]"	[4th post in PF thread 10]
Sleep disturbance/awakening:	*"[…] I switch back and forth from right to left every 1-2 hours […] I find no position is comfortable anymore :("*	[18th post in WTE thread 9]
	"[…] I posted last week about my record of 13 [toilet] *trips in one night!!! […]"*	[9th post in PF thread 10]
	"[…] I woke up to the sound of myself sobbing because of these dreams, and was unable to get back to sleep […]"	[2nd post in BC thread 18]
Sleep medication:	*"[…] I hate to take them* [antihistamine and paracetamol] *everynight […]"*	[2nd post in BC thread 3]
	"[…] I've been told by GP that I really shouldn't be taking my sleeping tablets in pregnancy […]"	[1st post in MN thread 24]
	"[…] if I […] pop a pill, I'd feel so worried and guilty about it that it would probably keep me bloody awake! […]"	[4th post in MN thread 24]
	"[…] was told to get some magnesium phosphate. […] totally safe to take as homeopathic […]"	[17th post in EDF thread 26]
	"[…] I used to take melatonin a lot before pregnancy so I was disappointed when I was told not to use it now."	[15th post in WTE thread 27]
	"[…] I don't think I'll risk it [paracetamol] *ive done enough risky stuff so far to last my whole prenanacy"*	[7th post in MDJ thread 28]
Sleep inertia:	*"[…,] bright as a button in the morning was up at the crack of dawn […]"*	[8th post in PF thread 2]
	"[…] up every morn at 5:45 I feel like a zombie […]"	[11th post in PF thread 10]
	"I have been getting very bad nightmares to the point I get a panic attack when I wake. […]"	[5th post on ED thread 16]
	"[…] wake up at least twice a night- and I mean wide awake ready to start the day kind of wake up […]"	[7th post on BC thread 3]
Overall sleep quality:	*"[…] I probably get 405 hrs of sleep but it doesn't feel really restful. […]"*	[7th post in WTE thread 12]
	"[…] I'm not sleeping well at all, […]"	[1st post in ED thread 14]
	"[…] sleeping on my side but it feels uncomfy so I've not been sleeping too well lately. […]"	[1st post in ED thread 23]
Daytime sleepiness:	*"[…] My worst time is about 3pm in the afternoon, just can't keep my eyes open!!"*	[4th post in PF thread 1]
	"[…] It's affecting my work because I'm half dead all day too. […]"	[1st post in NM thread 13]
	"[…,] I am finding it especially hard to concentrate at work, […]"	[1st post in HGS thread 19]

For the most part, the vast majority of these perceived determinants were understood to be a *direct* result of pregnancy itself. There was little acknowledgement that pre-pregnant sleeping practices might influence the extent to which users are vulnerable to the potential impact of pregnancy-related changes on their sleep or the extent to which pre-pregnant sleeping practices might have enabled them to cope with any impact of pregnancy on sleep. Instead, posts referred to pre-pregnant sleep primarily as a reference or baseline against which their experiences in pregnancy were judged. This included the post cited earlier, in which PF user 'tweetyfoo' compared their experience of nocturia before and during pregnancy, as well as a number of other examples; including:

> *"I'm not a 'tired' type of person, I usually have loads of energy. BUT since I have found out I carrying a little sesame seed, and a little before, I can't stop sleeping!* […] *I am getting up very early (for me) at about 8 every morning. DH can't understand why I am not having a lie in! I am like a button in the mornings and then exhausted in the afternoons – I can literally feel my eyes closing!* […]*"* [Julia; 1st August 2005, 18h30; 1st post in PF thread 2]
>
> *"I'm normally a very sound back sleeper, but I started on my left side around 10 weeks just to get use to it. Even though my left hip joint gets sore I try to stay on my left.* […]*"* [mybabyJagger; 26th April 2015, 07h31;12th post of WTE thread 9]
>
> *"*[…] *I used to be a heavy sleeper, but not since becoming preggo."* [Crunchmama4life; 29th March 2010, 07h41; 7th post in WTE thread 11]
>
> *"*[…] *Haven't slept thru the night since 1st trimester* […] *Prepregnancy, I needed an average of 9-10 hrs to function normally. Been feeling quite zombie like now!"* [rachrad04; May 2013, 08h38; 7th post of WTE thread 12]
>
> *"I've always had trouble staying asleep. Before I was pregnant I used Healtheries sleeping pills, which were brilliant. However, they're not recommended for women who are pregnant or breast feeding. I am now 32 weeks and I'm finding the lack of sleep unbearable* […]*"* [Groovy; no date and

time stamp; 1st post in HGS thread 19]

"I have ME, and have had insomnia for years, i obviously stopped taking my tablets when i found out i was pregnant […] *went back to my docs who said there was nothing the could do… surely that's more dangerous to the baby?* […]*"* [Kri5ty; 27th May 2011, 09h25; 14th post in MN thread 24]

Elsewhere, the potential contribution that lifestyle, behaviour and household contexts might make to sleep during pregnancy, and how changing these might help address specific or general sleep problems, was principally evident from 'response' posts and the advice these contained. This often presented as long lists of tips and suggestions, referenced as being effective for the user posting the 'response' or based on traditional practices and remedies,with fewer based on advice from health care professionals. This seems to suggest that forum users resorted to behavioural and contextual interventions to address the sleep-related problems that emerge during pregnancy. These included dietary changes, the use of natural remedies, changes in activity/exercise and modifications to their sleeping arrangements. An example of such a list includes one post providing ten 'suggestions' in a 'response' post offered in the ***"I can't sleep !!!"*** thread (PF thread 8):

"[…] 1. Switch tv off an hr before Bed and read, go to sleep when you can't read any more

2. Hot milky drink an hour before bed

3. No naps during the day

4. Eat something before going to bed as your metabolism doesn't switch off when your sleeping

5. A walk in the afternoon evening

6. Classical music played at a low volume

7. Lavender spray on pillow – (I asked my dr if lavender is ok in pregnancy and she said yes)

8. Warm bubble bath

9. Dairy to write down all days stresses/ worries/ anxiety

10. If you spend 20 minutes trying to sleep but can't get up and do something else then try again in half an hr or so" [Furbaby; 26th January 2012, 16h37; 13th post in PF thread 8]

6.6 Discussion

6.6.1 Potential limitations

There are several potential limitations with the sources of data examined in the present study which need to be considered before drawing interpretations and conclusions from the analyses undertaken for this Chapter. Principally these relate to this study's reliance on web- based forums that do not necessarily comprise a comprehensive list of the websites where users can share their experiences of sleep in pregnancy; and the limited information concerning the management and administration of those forums that may have impacted on the material available for analysis.

Systematic searches of the internet pose a challenge due to the impact of the commercial services provided by many search engines, which give preference to 'premium' websites in search results. It is highly unlikely then that the present study identified every web-based forum on which pregnant women have posted material relevant to their experiences of sleep. Indeed, the inclusion of web forums as diverse as CA and EDF indicate that such material posts may occur in somewhat unexpected places. However, since the present study has generated a comprehensive sample of relevant material from a range of English-medium websites hosted in Europe, North America and Australasia, the material used is likely to offer substantial insights into the sleep-related experiences considered important to women during pregnancy.

Although the present study acknowledged the potential advantages and disadvantages of using web-based forums as sources of qualitative data during its design phase (see Methods section), analysis of these data reveals that the benefits of using these forums, as sources of empathy, reassurance and advice. In particular, the topics raised are primarily those experienced as problematic by forum users; and possible solutions are offered in the responses of other forum users. Web-based forums offer few explanations based on pre- pregnant sleep patterns and lifestyle changes following pregnancy, and instead emphasise pregnancy-related (hormonal, physiological and anatomical) changes as potential determinants of sleep. This means that the absence of other potential (pre-pregnant, lifestyle and behavioural) determinants of sleep in pregnancy may not accurately reflect either the lower prevalence of these amongst forum users, or their apparent lack of understanding of

the potential role these might play. However, it does seem likely to reflect the dominant role that pregnancy-related changes are felt to play in the changes in sleep occurring during pregnancy.

Finally, it remains unclear whether the material available on each of the web-based user forums accurately reflects the diversity of experience, advice and reassurance in the material posted to these forums, since all of the web forums examined in the present study reserved the right to monitor or block material that its administrators/moderators judged had breached their forum's T&Cs/ToU (see Table 6.1). Moreover, it was unclear if any of the web forums actually moderated material submitted by users in advance of posting this on the forum website (see Table 6.2) and how the potential delay entailed by moderation might affect user satisfaction.

Many of the requests for help posted by forum users were stamped in the middle of the night/early morning, suggesting it is unlikely that many web forums moderated material consistently before it was posted – even though one, Emma's Diary, claimed to do so (see Table 6.1). It therefore remains possible that web forum administrators removed certain sleep-related topics, deeming these inappropriate for inclusion on these web forums; however, the presence of posts involving topics related to sexual behaviour or disagreements between users suggests that the material examined in the present study would not have been substantively affected.

6.6.2 Web-based discussion forums as sources of empathy, reassurance and advice for expectant mothers experiencing sleep problems

These limitations aside, it is clear that web-based forums offer a valuable resource for enhancing our understanding of sleep in pregnancy and perhaps a whole host of similarly 'hidden' experiences considered unique to specific populations. In part, this is due to the sense of closeness and anonymity offered by web-based networking which enables forum users to seek out those with similar experiences and encourages them to 'share' without any apparent fear of disclosure. These benefits of web-based communication have been described for numerous other 'virtual communities', including those unable or unwilling to disclose their experiences in person or in public (Bjelke et al., 2016; Elo and Kyngäs, 2008). The present study demonstrates the benefits of sharing others' experiences, particularly when these are felt to be

'exceptional' and poorly understood by others (including, in this instance, those healthcare professionals who specialise in their care).

The benefits of participation in web-based forums were also evident from the posts examined and their content. Although there was some evidence of the 'status' reports common amongst mainstream social networking sites, such as Facebook®, particularly in those posts classified as 'situational updates' in the present study, most posts took the form of 'requests' for reassurance, information or advice and 'responses' containing these. Regardless of the issues discussed, and even when little concrete advice was given, the intimacy evident in many 'responses' and in the subsequent 'thank you' posts from users who had initiated threads indicates that the 'responses' they received were often sufficient to offer reassurance that the issues they had raised were not unfamiliar and that they were 'not alone.'

6.6.3 Lessons learned from pregnant women shared their sleep experiences in web- based forums

The thread-initiating posts examined in the present study dealt specifically with: inadequate sleep duration; extended sleep latency; frequently disturbed sleep and frequent awakenings; both excessive *and* inadequate sleep inertia; poor sleep quality; and difficulty staying awake during the daytime. Added to these was a high level of uncertainty and anxiety regarding the use of sleep medication and lay/traditional remedies during pregnancy, particularly amongst those who had relied on these to help them sleep prior to conception. However, very few posts addressed concerns with coughing/snoring during pregnancy. This is surprising given the evidence offered by a growing number of studies that snoring may worsen during pregnancy (Franklin et al., 2000; Loube et al., 1996; Guilleminault et al., 2000). The limited number of posts on this topic may cast some doubt on previous estimates of snoring prevalence amongst pregnant women. Perhaps, more importantly, what these posts suggest is that snoring may only be detected (and therefore become an issue) when this affects the sleep of bed-sharing partners/husbands. Given the impact of bed partners' snoring on the sleep experienced by pregnant women (see Table 6.1 threads 11 and 13 consisting of n=18 posts), it appears that the prevalence of snoring may be under-acknowledged and under- reported by pregnant women themselves, particularly those

who do not bed-share, or whose bed-partners do not complain. Since the frequency of self-reported snoring remains a key component of current efforts to screen for potential sleep apnoea (Facco et al., 2012), the present study highlights the necessity of gaining information from bed-partners to accurately assess whether snoring occurs. In addition, the presence of a dedicated thread on perceived breathing difficulties during pregnancy, including posts describing their impact on sleep (see Table 6.2, thread 29) suggests that these difficulties may cause an increased risk of sleep apnoea during pregnancy (irrespective of snoring), and also warrant further attention.

A number of potential determinants thought most likely to be responsible for changes in some characteristics experienced as poorer quality, less restful sleep are described in these posts. Extended sleep latency and more frequent sleep disturbance were attributed to pregnancy- specific changes of a hormonal, physiological and anatomical nature. In particular, heartburn and nausea, associated with 'morning sickness', together with pain and discomfort, restless limbs and itching were all described as extending sleep latency in posts by web forum users. These issues also played a role in the frequency of awakenings experienced during pregnancy, which were repeatedly attributed to an increased frequency of nocturia. This was particularly the case during the final stages of pregnancy when the size of the baby is likely to have limited the space available for urine storage by the bladder.

6.7 Key findings

It is nonetheless striking how little attention forum users paid to their experiences of sleep prior to pregnancy, or to lifestyle, behavioural and contextual changes that were commonly considered to worsen sleep. It therefore remains unclear whether the severe impact of pregnancy on sleep described by many of the web-based forum users in the present study accurately reflects the unavoidable consequences of pregnancy *per se* on sleep. Instead it may simply reflect received wisdom from professionals and/or other women who have experienced pregnancy. It may also represent the lack of attention paid to the possible role that sleeping practices prior to conception, and to social and behaviour changes occurring during pregnancy, might play in the quality of sleep achieved whilst pregnant.

Studies of 'positive deviants' i.e. healthy pregnant women with pre-conception sleep

patterns objectively assessed as healthy (Frauscher et al., 2014) may help to prevent the potential over-reporting and misattribution of less favourable sleep during pregnancy. Such research might offer greater clarity on the utility and prevalence of *Pregnancy Associated Sleep Disorder* (as proposed by the AASM, 2001); and on population-based interventions and associated lifestyle advice that might help improve and protect the sleep of women, both before and during pregnancy.

Chapter 7

A review of the self-administered instruments and custom sleep item sets used to examine sleep in pregnancy

7.1 Summary

The final analytical Chapter in this thesis drew on the systematic review (of previous studies exploring the sleep of pregnant women described in Chapter 2) to assemble a comprehensive list of all self-administered instruments and custom sleep item sets used by these studies. Examining the content of these (a total of n=30 instruments and item sets in all) revealed the breadth of sleep characteristics covered, yet only a small number of instruments/item sets covering most of the characteristics experienced as salient by pregnant women. As such, this review identified a key flaw in past studies of sleep in pregnancy: the lack of appropriate instruments/custom sleep item sets for use in pregnancy. This flaw means that many previous studies of sleep in pregnancy (including those using the more comprehensive sleep instruments/custom item sets) will not have been able to fully assess the range of sleep characteristics affected by pregnancy. It also means that few (if any) of these studies will have been able to fully represent the range of experiences described by pregnant women or to distinguish between pre-existing sleep 'problems' and those occurring as a result of pregnancy-specific (i.e. hormonal, physiological and anatomical) and pregnancy-related (i.e. behavioural, circumstantial and health-related) changes occurring *during* pregnancy. Although more of the sleep instruments and custom sleep item sets examined in this review would have been capable of assessing the 'mild insomnia' or 'mild sleepiness' considered necessary to diagnose PASD (Pregnancy Associated Sleep Disorder), as defined by the American Academy of Sleep Medicine in its initial and revised International Classification of Sleep Disorders, none would have been able to establish that these occurred in the absence of other sleep disorders, or other sleep-affecting somatic or psychological disorders (as the ICSD requires). This might explain the paucity of previous studies examining PASD, and may also explain the lack of consensus evident

in prior studies of sleep in pregnancy. The Chapter concludes with a number of recommendations designed to address these shortcomings.

7.2 Introduction

Pregnancy-related changes in sleep prompted the American Academy of Sleep Medicine (AASM), to include pregnancy associated sleep disorder (PASD) as a 'proposed disorder' in its *International Classification of Sleep Disorders: Diagnostic and Coding Manual* [ICSD] – "a primary diagnostic, epidemiological and coding resource for clinicians and researchers in the field of sleep and sleep medicine". (AASM, 2001: 18)The AASM is the professional body that sets standards and guidelines in sleep medicine health care and research.See (Appndix 7.1).

Several studies concerning sleep during pregnancy have addressed PASD including those on insomnia, RLS, snoring and sleep-disordered breathing, excessive sleepiness, and specific awakenings (Pien and Schwab, 2004; Lopes et al., 2004; Krishnan and Collop, 2006). In addition, there is a growing evidence that poor sleep in pregnancy may contribute to the development of physical and psychological difficulties (including chronic diseases that may affect foetal outcomes, and pre/postnatal depression; Chang et al., 2010).

To-date, previous studies have essentially established two key ways to assess sleep in pregnancy:

- Objective Measures: using technical measures/technology to identify individual sleep stages and/or detect related movement/activity during sleep (such as actigraphy or polysomnography); and
- Subjective Measures: using questionnaires (both validated 'instruments' and 'custom sleep item sets', or structured interviews) to measure sleep among patients or participants. There are a large number of sleep questionnaires that have been developed for use in sleep research, and some studies of sleep in pregnancy have used their own 'custom sleep item sets' specific to their particular interests and foci.

A systematic review of previous studies exploring sleep in pregnancy (Chapter 2) revealed little evidence of that dedicated sleep instruments had been specifically

developed for use in pregnancy. This highlighted the importance of assessing the utility of existing sleep instruments (and of the items they contained) for use in studies of sleep in pregnancy; and of identifying what might be the most sensitive instrument(s) currently available for capturing variation in sleep following (and during) pregnancy.

The aims of this chapter were therefore to: establish the extent to which sleep instruments (and custom sleep item sets) that have been used with pregnant women comprehensively capture all of the relevant sleep related issues described by pregnant woman themselves and/or those necessarily for the diagnosis of the PASD; and identify which of these existing instruments/custom item sets might offer the best assessment of sleep in pregnancy.

7.3 Methods

7.3.1 Identifying instruments and items used to assess self-reported sleep in pregnancy

To generate a comprehensive list of the validated instruments and custom item sets used by previous studies exploring the sleep of pregnant women, the present study undertook a systematic search of the literature by combining the search terms used for 'pregnancy' and for 'sleep' in previous systematic reviews (n=622) related to each of these terms (see also the approach adopted for the systematic review described in Chapter 2 of this thesis). These search terms (summarised in Tables 7.1.1-7.1.2) were applied to both OvidSP-Medline and Embase (on 30 November 2012; updated on 30 November 2015; and again on 30 October 2016), without filters or limits, using the Boolean operator 'OR' for search terms within 'pregnancy' and within 'sleep'; and the Boolean operator 'AND' for combining those terms relevant to 'pregnancy' with those relevant to 'sleep'.

The search terms for pregnancy and for sleep were derived from previous systematic reviews of each topic. Results are displayed in Tables 7.1.1 and 7.1.2 below:

Table 7.1.1 Search terms identified for “sleep”

NO.	Search Terms	Frequency
1.	Central sleep apnoea treatment	2
2.	Central sleep apnoea	2
3.	Sleep apnoea	5
4.	Apnoea	2
5.	Obstructive sleep apnoea	3
6.	Sleep-related breathing disorders	2
7.	Insomnia	5
8.	Sleep	14
9.	Sleep time	2
10.	Sleep duration	2
11.	Sleep hours	1
12.	Time in bed	1
13.	Sleep quantity	1
14.	Sleep quality	1
15.	Sleep disorder	4
16.	Sleep disorders	4
17.	Sleep disordered	1
18.	Time spent asleep	1
19.	Time spent sleeping	1
20.	Time sleeping	1
21.	Time asleep	1
22.	Sleep length	1
23.	Hypopnea syndrome	1
24.	Dyssomnia	1
25.	Parasomnia	2
26.	Hypersomnia	1
27.	Sleep disturbance	1
28.	Sleeplessness	1
29.	Sleepiness	1
30.	Sleep efficiency	1
31.	Sleep latency	1
32.	Sleep problem	2
33.	Sleep disturbance	1
34.	Sleep difficulties	1
35.	Nightmare	1
36.	Sleep terror	1
37.	Sleep deprivation	1

Table 7.1.2 Search terms identified for “pregnancy”

NO.	Search Terms	Frequency
1.	Pregnancy	46
2.	Pregnant	2
3.	Pregnan*	5
4.	Pregnant women	4
5.	Pregnancy complication	17
6.	Pregnancy Trimester	2
7.	Obstetric	8
8.	Obstetric complication	2
9.	Obstetrical	3
10.	Obstetrical complications	1
11.	Maternal	8
12.	Maternal age	2
13.	Maternal complications	1
14.	Pregnancy Outcome	16
15.	Pregnancy in Adolescence	1
16.	Pregnancy Rate	3
17.	Maternity care	1
18.	Prenatal	6
19.	Prenatal care	3
20.	Perinatal	2
21.	Prenatal Diagnosis	6
22.	Antenatal	5
23.	Gestational outcome	1
24.	Gestation	3
25.	Gravid	1

Duplicate articles occurring in the results of both searches were identified and removed, and the resulting list of articles was then carefully examined to identify any that described empirical studies using self-administered instruments or custom item sets to assess the sleep of pregnant female participants. The key inclusion criteria were that the studies had involved: the collection of primary data; the use of one or more self-administered instruments or custom item sets relevant to the assessment of sleep; and the completion of these instruments/item sets by female participants with reference to/during pregnancy.

This 'screening' of search results involved examining the title and abstract of each article, and then classifying these as 'definitely relevant' (i.e. met all inclusion criteria); 'definitely not relevant' (i.e. failed one or more of the inclusion criteria); or 'relevance unclear' (i.e. where the abstract was not available for review or where this did not contain sufficient information to assess relevance). Articles classified as 'definitely not relevant' were excluded at this stage, while the full-length versions of all the remaining articles (i.e. both 'definitely relevant' and 'relevance unclear') were obtained from the University of Leeds Library, through inter-library loan, or directly from the authors themselves.

A second round of 'screening' was then undertaken, involving the careful examination of each article, paying particular attention to the Methods and Results sections, to establish which of these articles might be classified as 'definitely relevant', and to identify any self-administered instruments and any custom sleep item sets used by the authors thereof to assess the self-reported sleep of pregnant participants.

To ensure the consistent application of the inclusion criteria used for each round of screening, these were undertaken independently by two researchers (the candidate and a colleague, Amal Alghamdi) and any disagreements in initial screening classifications were then resolved by discussion and consensus. Following both rounds of screening, the extraction and identification of self-administered sleep instruments and custom sleep item sets within each of the articles classified as 'definitely relevant' was undertaken only by one of these researchers (the candidate). However, a 10% sub-sample of articles was reviewed by a third researcher (the lead supervisor) to confirm

that all relevant instruments and item sets had been correctly identified and extracted.

7.3.2 Evaluating the sleep characteristics addressed by self-administered questionnaires and custom items

To ensure that the present review accurately identified all of the sleep characteristics addressed by instruments and custom item sets included in each of the articles examined, the original versions of these instruments and item sets were obtained from the articles in which these were first described and introduced. Copies of each instrument and each item set were then subjected to repeated close-reading to establish an appropriate coding framework for the content analyses of the sleep and sleep-related characteristics that they were capable of assessing. This involved extracting and tabulating the original wording of any items (and any related answer categories/options) corresponding to emerging thematic codes, and using a comparison between these to reach consensus on the codes and the application of these to items. Once complete, this process helped: to establish the frequency with which items relevant to different sleep and sleep-related characteristics appeared in the instruments and custom item sets reviewed; to identify which of these instruments/item sets covered the largest number (i.e. the most comprehensive range) of sleep and sleep-related characteristics; and to identify which of these characteristics were most, and least, likely to have been included amongst the instruments and item sets reviewed.

Two further analytical steps were then taken. The first was to identify the sleep and sleep-related characteristics considered to be particularly important to pregnant women from web forum posts analysed previously (see the qualitative analyses summarised in Chapter 6) – characteristics that included: the timing of sleep and naps; sleep duration; sleep latency; use of prescription and non-prescription medication, and non-medical remedies for sleep; frequent awakening caused by heartburn, nausea, aches and pains, restless legs, discomfort and/or nocturia; snoring or apnoea; bed-sharing with a partner; overall sleep quality; sleep inertia; and daytime sleepiness.

The second analytical step was undertaken with reference to the criteria necessary for the diagnosis of PASD as recommended by the American Academy of Sleep Medicine in

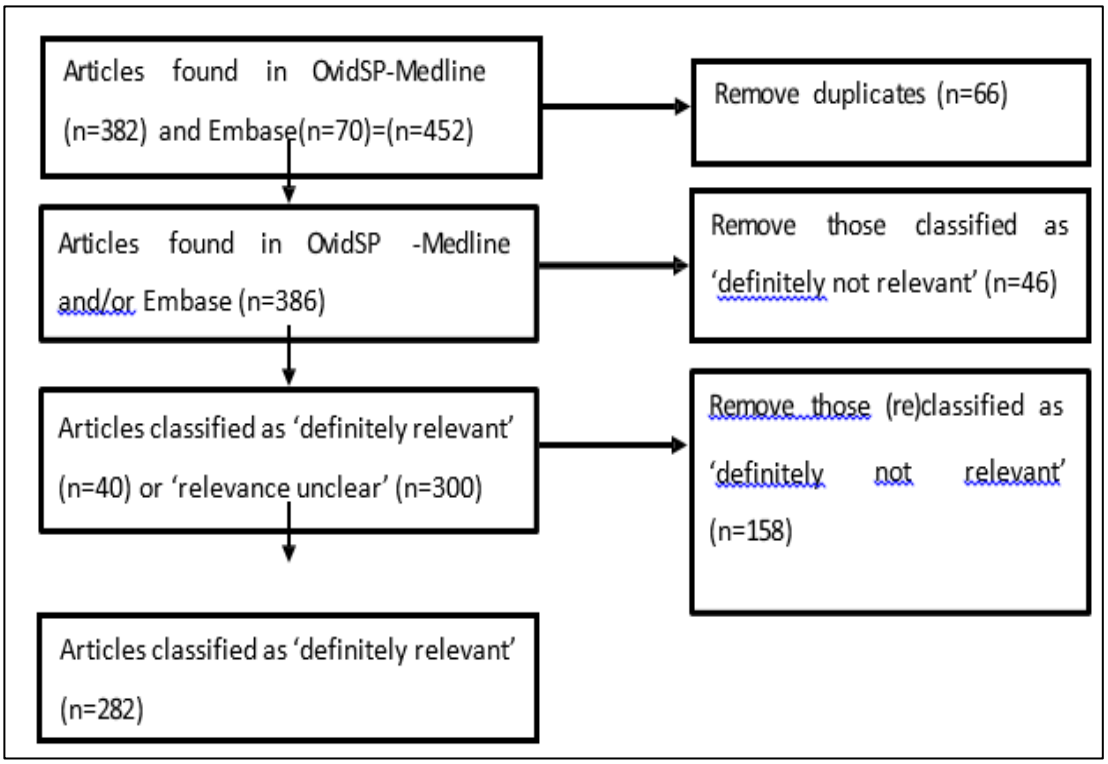
their 2001 Revision of the ICSD. setting aside the recommendation that this include objective polysomnographic assessment, PASD minimally requires the presence of 'mild insomnia' or 'mild sleepiness', for each of which information is required on: sleep duration; sleep inertia; sleep quality; and daytime sleepiness. The diagnosis of PASD also requires confirmation that the onset of insomnia and/or sleepiness did not precede pregnancy, as well as evidence that "other sleep disorders" and "other medical or mental disorders" likely to be responsible for the insomnia/sleepiness observed are also absent. While assessing items capable of assessing pre-conception sleep and sleep-related characteristics falls well within the present review, the identification of suitable items capable of accurately assessing "other medical or mental disorders", both before and during pregnancy do not. This will therefore require further work on instruments and items developed specifically for this purpose. Similarly, since the diagnosis of PASD also requires the absence of "other sleep disorders", it may be that additional work will be required to identify instruments or items capable of confirming the absence of the large number of other sleep disorders included thus far in the ICSD, although the approach adopted by Frauscher et al. (2014) in their recent study of "healthy sleepers" may prove effective in the interim. Alternatively, such information might simply be obtained by using items requesting prior experiences and or prior diagnoses of (other) sleep disorders.

7.4 Results and Discussion

The updated searches conducted on 30 October 2016 returned a total of n=382 articles from OvidSP-Medline, and n=70 from Embase, of which n=66 (14.6%) articles were returned as duplicates in both searches. Merging the results of both searches and removing duplicate articles left a total of n=386. The titles and, where available, abstracts of these articles (n=386) were then subjected to screening against the review's two inclusion criteria (as described earlier). This initial round of screening identified n=46 (11.9%) articles as 'definitely not relevant' and n=40 (10.4%) as 'definitely relevant'; the vast majority of articles (n=300; 77.7%) being classified as 'relevance unclear'. Subsequent review of full-text copies of the latter eliminated half (n=158; 52.7%) as 'definitely not relevant' and the remaining n=142 (47.3%) were added

to the articles (n=40) identified as 'definitely relevant' following the first round of screening. This brought the total number of articles meeting the review's inclusion criteria to n=282 or 73.1% of the n=386 articles screened. These steps are summarised in Figure 7.1.

Figure 7.1 Summary of the steps involved in the systematic search for, and subsequent screening of, articles fulfilling the review's three inclusion criteria.



Close-reading of these n=282 articles identified n=22 self-administered sleep instruments and n=8 custom sleep item sets that had been used in studies assessing the sleep of pregnant women (see Table 7.2). The most commonly used existing sleep instruments were the PSQI (n=70; 24.9%) and the ESS n=60 (21.2%); though fewer than a quarter of the articles/studies reviewed used either of these. Subsequent thematic content analysis of these n=22 instruments and n=8 custom item sets revealed that they covered n=13 discrete sleep and sleep-related characteristics, including: the period over which sleep was recalled; the timing of any periods of sleep, and any naps taken, during the day and night; the duration of sleep; sleep latency/time taken to fall asleep; the use of sleep medication/remedies; frequent awakening/disturbance; snoring and

coughing while asleep; breathing difficulties and symptoms of sleep apnoea; the presence/absence of a bed partner (which is considered particularly important for the assessment of snoring and/or sleep apnoea); sleep inertia/tiredness upon awakening; daytime sleepiness (particularly associated with both work and/or social activities); and comparative recollections or assessments of sleep prior to conception.[7] While a range of additional sleep and sleep-related characteristics were addressed by some of the instruments/item sets reviewed (including: aches and pains; limb movements; and dreaming, amongst others), these related more to the perceived causes of sleep latency, frequent awakening and sleep quality, than to the prevalence of the n=13 sleep and sleep-related characteristics *per se* (see Table 7.2)

[7]Every item identified as relevant/corresponding to each these n=13 sleep and sleep-related categories has been extracted from the instruments and/or custom item sets in which they were identified, and the original wording of these items (and any corresponding answer categories/options) have been collated in Appendix 7.2, arranged in n=13 sections (one for each of the sleep or sleep-related characteristics)

Table 7.2 Self-administered sleep instruments and custom item sets used by the articles =282) included in the review.

	Instrument/custom item set (abbreviation	Source reference	Frequency of use
1	American Society of Anesthesiologists Checklist (ASAC)	Gross et al. (2006) *Anesthesiology* **104:** 1081.	26
2	Athens Insomnia Scale (AIS)	Soldatos et al. (2000) *Journal of Psychosomatic Research* **48:** 555-60.	1
3	Bergen Insomnia Scale (BIS)	Care and Cellter (2008) *Perceptual and Motor Skills* **107:** 691-706.	1
4	Basic Nordic Sleep Questionnaire (BNSQ)	Partinen and Gislason (1995) *Journal of Sleep Research* **4:** 150-5.	6
5	Berlin Sleep Questionnaire (BSQ)	Netzer et al. (1999) *Annals of Internal Medicine* **131:** 485-91.	30
6	Epworth Sleepiness Scale (ESS)	Johns (1991) *Sleep* **14:** 540-5.	60
7	General Sleep Disturbance Scale (GSDS)	Lee (1992) *Sleep* **15:** 493-8.	30
8	Insomnia Severity Index (ISI)	Morin (1993) *Insomnia: Psychological assessment and management.* New York: Guilford Press.	12 (4.2)
9	Insomnia Symptom Questionnaire (ISQ)	Okun et al. (2009) *Journal of Clinical Sleep Medicine* **5:** 41-51.	6
10	International Restless Leg Syndrome Study Group Rating Scale	International Restless Legs Syndrome Study Group (2003) *Sleep Medicine* **4:** 121-32.	50
11	Izci et al. Custom Sleep Item Set (Izci-CSIS)	Izci et al. (2005) *Sleep Medicine* **6:** 163-9.	2
12	Johns Hopkins Telephone Diagnostic Interview Form for Restless Leg Syndrome (JHTDIF-RLS)	Hening et al. (2003) *Sleep Medicine* **4:** 137-41.	40 (14.2)
13	Kaneita et al. Custom Sleep Item Set (Kaneita-CSIS)	Kaneita et al. (2005) *Preventive Medicine* **41:** 877-82.	1
14	Leeds Sleep Evaluation Questionnaire (LSEQ)	Hindmarch (1975) *Arzneimittel Forschung* **25:** 1836-9.	1
15	Marques et al. Custom Sleep Item Set (Marques-CSIS)	Marques et al. (2011) *Psychiatry Research* **186:** 272-80.	1
16	Micheli et al. Custom Sleep Item Set (Micheli-CSIS)	Micheli et al. (2011) *Epidemiology* **22:** 738-44.	6
17	Mindell and Jacobsen Custom Sleep Item Set (Mindell-CSIS)	Mindell and Jacobson (2000) *Journal of Obstetric, Gynecologic and Neonatal Nursing* **29:** 590- 7.	6 (2.1)
18	Morningness-Eveningness Questionnaire (MEQ)	Horne and Ostberg (1975) *International Journal of Chronobiology* **4:** 97-110.	1
19	Neau et al. Custom Sleep Item Set (Neau-CSIS)	Neau et al. (2009) *European Neurology* **62:** 23-9.	1
20	Nielsen and Paquette Custom Sleep Item Set (Nielsen-CSIS)	Nielsen and Paquette (2007) *Sleep* **30:** 1162-9.	1
21	Pittsburgh Sleep Dairy (PSD)	Monk et al. (1994 *Journal of Sleep Research* **3:** 111-20.	2
22	Pittsburgh Sleep Quality Index (PSQI)	Buysse et al. (1989) *Psychiatry Research* **28:** 193-213.	70
23	Sleep and Health Questionnaire (SHQ)	Kump et al. (1994) *American Journal of Respiratory and Critical Care Medicine* **150:** 735-41.	4 (1.4)
24	Sleep Disorders Questionnaire (SDQ)	Douglass et al. (1994) *Sleep* **17:** 160.	1
25	Sleep Quality Scale (SQS)	De Diana (1976) *Sleep Research* **5:** 101.	6
26	STOP-BANG Sleep Apnea Questionnaire (SBSAQ)	Chung (2008) *Journal of the American Society of Anesthesiologists* **108:** 812-21.	1
27	Structured Interview Guide for the Hamilton Depression Rating	Williams (1988) *Archives of General Psychiatry* **45:** 742-7.	12
28	Ursavas et al. Custom Sleep Item Set (Ursavas-CSIS)	Ursavas et al. (2007) *Respiration* **76:** 33-9.	1
29	Verran and Snyder-Halpern Sleep Scale (VSHSS)	Snyder-Halpern and Verran (1987) *Research in Nursing and Health* **10:** 155-63.	4
30	Women's Health Initiative Insomnia Rating Scale (WHIIRS)	Levine et al. (2003) *Psychological Assessment* **15:** 123.	16

The distribution of these n=13 characteristics across the n=30 sleep instruments and custom item sets reveals that none generated data on all of these. Unsurprisingly, those instruments and custom item sets intended to focus only on specific sleep and sleep- related characteristics (such as sleepiness, restless legs syndrome or sleep apnoea) were least likely to have items capable of generating data on many of the other characteristics. Likewise, the more generic sleep instruments, designed to provide a broad assessment of sleep across a range of sleep and sleep-related characteristics,

were more likely to include items covering a broader range of characteristics relevant to pregnancy. Indeed, the five instruments/custom item sets capable of capturing nine or more of the characteristics most important to pregnant women themselves included two of the most popular 'generic' sleep instruments in current use (the Pittsburgh Sleep Quality Index [PSQI] Buysse et al., 1989; and the Basic Nordic Sleep Questionnaire [BNSQ] Partinen and Gislasen, 1995). This might go some way towards explaining why these two instruments (particularly the PSQI) had been used by so many of the primary studies of sleep in pregnancy examined for this review (see Table 7.3).

Table 7.3 Thematic content analysis of items contained in the instruments (n=22) and custom item sets (n=8) used by studies (n=282) exploring sleep in pregnancy.

No	Instrument or custom item	Retrospective recall period	Timing of sleep/naps	Sleep duration	Sleep latency	Sleep medication	Frequent awakenings	Snoring	Apnoea	Presence of bed-	Sleep quality	Sleep inertia	Daytime sleepiness	Pre-conception
1	ASAC	X	X	X	X	X	X	✓	✓	X	X	✓	✓	X
2	AIS	1 month	X	✓	✓	X	✓	X	X	X	✓	X	✓	X
3	BIS	1 month	X	X	✓	X	✓	X	X	X	✓	✓	✓	X
4	BNSQ	3 months	✓	✓	✓	✓	✓	✓	✓	X	✓	✓	✓	X
5	BSQ	1 month	X	X	X	X	X	✓		X	X	✓	✓	X
6	ESS	X	X	X	X	X	X	X	X	X	X	✓	✓	X
7	GSDS	1 week	✓	X	X	✓	✓	X	X	X	✓	✓	✓	X
8	ISI	2 weeks	X	X	X	X	✓	X	X	X	✓	✓	✓	X
9	ISQ	1 month	X	X	✓	✓	✓	X	X	X	✓	✓	✓	X
10	IRLSSGRS	X	X	X	X	X	✓	X	X	X	X	X	X	X
11	Izci-CSIS	1 month	X	X	X	X	X	✓	✓	X	X	X	X	X
12	JHTDIF-RLS	X	X	X	X	X	X	X	X	X	X	X	X	X
13	Kaneita-CSIS	1 month	X	✓	✓	X	✓	X	X	X	✓	✓	X	X
14	LSEQ	X	X	X	✓	X	X	X	X	X	✓	✓	✓	X
15	Marques-CSIS	≥1 month	X	X	✓	✓	✓	X	X	X	X	X	X	X
16	Micheli-CSIS	X	X	✓	X	X	X	✓	✓	X	X	X	X	X
17	Mindell-CSIS	2 weeks	✓	✓	✓	X	✓	✓	✓	✓	✓	✓	✓	✓
18	MEQ	1 week	✓	✓	X	X	X	X	X	X	X	✓	✓	X
19	Neau-CSIS	X	X	✓	✓	X	✓	X	X	X	X	X	X	✓
20	Nielsen-CSIS	9 months	X	X	X	X	✓	X	X	✓	X	X	X	✓
21	PSD	Last night	✓	✓	✓	X	✓	X	X	✓	✓	X	X	X
22	PSQI	1 month	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	X
23	SHQ	X	✓	✓	✓	✓	✓	✓	✓	X	✓	✓	✓	✓
24	SDQ	6 months	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
25	SQS	1 month	X	✓	✓	X	✓	X	X	X	X	X	✓	X
26	SBSAQ	X	X	X	X	X	X	✓	✓	X	X	✓	X	X
27	SIGHDRS	1 week	✓	✓	✓	X	✓	X	X	X	X	X	X	X
28	Ursavas-CSIS	X	X	X	✓	X	✓	✓	✓	✓	X	X	X	✓
29	VSHSS	1 night	X	✓	✓	X	✓	X	X	X	✓	✓	✓	X
30	WHIIRS	1 month	X	X	✓	X	✓	X	X	X	✓	X	X	X

However, neither of these more generic questionnaires contained items on self-reported sleep prior to conception. This is a key consideration for distinguishing between changes in sleep and sleep-related characteristics resulting from: the hormonal, physiological and anatomical changes that accompany pregnancy; the changes in mood and/or behaviour that may have been caused by these changes; and those changes originating in contexts, lifestyles or behaviours occurring prior to pregnancy. Given that this information is crucial for assessing both the independent and overall impact of pregnancy on sleep, it is somewhat surprising that so few of the primary studies examined for this review used sleep instruments or custom sleep item sets that were capable of generating such data. In fact, only n=6/30 (20%) of the instruments/item sets examined contained items capable of collecting this information. Moreover, all but two of these (the little-used Sleep and Health Questionnaire [SHQ] and Sleep Disorders Questionnaire [SDQ]) comprised custom sleep item sets (Mindell-CSIS; and Neau-CSIS; Nielsen-CSIS; and Ursavas-CSIS) that had been generated specifically to match the study's focus on pregnancy. Unfortunately, Nielsen and Paquette's (2007) study focused specifically on dreams and dream-related characteristics during pregnancy and the postpartum period, meaning that their custom sleep item set contained few items capable of assessing other, more generic, sleep and sleep-related characteristics. As a result, the present review identified just two existing sleep instruments (SHQ and SDQ) and three custom item sets (Mindell-CSIS; Neau-CSIS; Ursavas-CSIS) as being suitable for generating reasonably comprehensive assessments of sleep in pregnancy. However, none of these contained items capable of assessing all of the sleep and sleep-related characteristics considered particularly important to pregnant women.

Nonetheless, fewer sleep and sleep-related characteristics are necessary to assess the presence of PASD. Only sleep duration; sleep inertia; sleep quality; and daytime sleepiness are necessary to identify 'mild insomnia' or 'mild sleepiness', although additional items are required to confirm their onset did not precede pregnancy. The present review found that all but one (Ursavas-CSIS) of the five sleep instruments and custom sleep item sets containing items addressing pre-conception/pregnancy sleep appeared capable of assessing the presence of PASD. Nonetheless, it is worth repeating

that the ICSD (AASM, 2001) recommends that the diagnosis of PASD warrants polysomnographic assessment *and* confirmation that no "other sleep disorders" are present (and may, therefore, be potentially responsible for the insomnia or sleepiness observed). As such, any assessment of PASD using the four instruments/custom item sets identified as suitable for this use (i.e. SHQ, SDQ, Mindell-CSIS and Neau-CSIS) will necessarily remain tentative in the absence of polysomnographic assessment, and without items capable of excluding the presence of any "other sleep disorders."

7.5 Conclusion and Recommendations

The present review found that previous studies examining the sleep of pregnant women have used a wide range of established sleep questionnaires as well as a range of study-specific custom sleep item sets. While this may reflect, and be responsible for, the lack of consensus amongst the researchers involved, and the contradictory findings reported (Systematic Review Chapter 2), it also means that it is not yet possible to subject the results of these studies to formal meta-analyses. At the same time, detailed examination of the items contained within these instruments and custom item sets revealed that few contain the breadth of items required to generate comprehensive assessments of the sleep and sleep-related characteristics experienced as important by pregnant women. Although this may be less of a limitation to those studies focussing on very specific aspects of sleep (such as dreams, or obstructive sleep apnoea), it is likely to have led many other studies to ignore both unfavourable *and* favourable changes in sleep that accompany pregnancy, simply because the instruments/custom item set used failed to generate data on these.

Indeed, there is evidence that some researchers are aware of the limitations of using existing sleep instruments to study the sleep of pregnant women, because a good number of the studies reviewed here used more than one instrument with/without additional custom sleep items to ensure their studies were able to examine a more comprehensive range of sleep and sleep-related characteristics. Nonetheless, perhaps the most important omission from the instruments and custom item sets examined in this review were items assessing sleep and sleep-related characteristics *prior* to conception/pregnancy (which were missing from 80% of these instruments and custom

item sets). Since this information is crucial for identifying changes in sleep that are related to pregnancy (or pre-existing characteristics that are exacerbated following conception), only those studies that included one or more of the instruments/item sets containing such items would have been able to identify the independent contribution pregnancy might make to self-reported sleep.

Since only n=14/282 (5%) studies included in this review used instruments/item sets containing such items, this is likely to have led to substantial bias in the assessment of pregnancy's importance to sleep in the remaining n=268 studies. This potential bias warrants urgent attention in any future studies of sleep in pregnancy, and any future meta-analyses of these studies' findings. In particular, future research into the changes in sleep that accompany pregnancy should consider developing a standardised instrument (similar to that developed specifically for obstructive sleep apnoea (OSA) in pregnancy; Facco et al., 2012) that is capable of addressing all of the limitations identified in those instruments and item sets examined in this review; not least to facilitate future meta-analyses of findings generated in different contexts and with different populations of pregnant women.

Finally, since items assessing sleep and sleep-related characteristics prior to conception/pregnancy are also required to support a diagnosis of PASD – which , as defined in the revised version of the ICSD (AASM, 2001), should only be diagnosed where the onset of the disorder occurs following conception – the instruments and item sets used by most of the studies included in this review will not have been able to offer any tentative assessment of the prevalence of this disorder. This may partly explain why so few studies appear to have been conducted on PASD, as evident in the absence of any empirical primary studies focussing on human participants returned by searches on this term in OvidSP-Medline or Embase. However, this may also reflect the tentative nature of the disorder (as one of n=11 'proposed' sleep disorders listed in both the original 1990 ICSD and its 2001 Revision (AASM, 2001) since it, and n=4/11 'proposed' disorders are no longer included in the most recent ICSD (the third Revision, AASM, 2014).

Chapter 8

Discussion

8.1 Summary of findings

At the outset of this thesis, which set as its overarching aim an improved understanding of sleep in pregnancy, six key questions (KQs) were posed:

KQ1: What might be learnt from previously published studies about the sleep of pregnant women; and the methodological challenges that such studies present? (including the potential for publication bias)?

KQ2: Are differences in self-reported sleep between pregnant and non-pregnant women associated with *pre-existing* differences in sociodemographic and health characteristics?

KQ3(i): What contributions might variation in exercise, diet and other lifestyle behaviours *during* pregnancy make to variation in sleep *amongst* pregnant women?

KQ3(ii): To what extent might the relationship between lifestyle and sleep *during* pregnancy be influenced by the hormonal, physiological and anatomical changes that occur at *different stages* of pregnancy?

KQ4: Might variation in any of the hormonal, physiological and/or anatomical changes that accompany pregnancy be associated with variation in self-reported sleep amongst pregnant women?

KQ5: How might the lived experiences of sleep amongst pregnant women reflect, and further illustrate, what is known from quantitative analyses of variation in self-reported sleep characteristics during pregnancy?

KQ6: Do any of the self-administered sleep instruments that have been used to examine self-reported sleep in pregnancy provide a comprehensive assessment of sleep in pregnancy and/or a basis upon which clinical assessments of *Pregnancy Associated Sleep Disorder* (PASD) might be made?

Each of these six KQs have been addressed in successive chapters of this thesis, using a range of different methods as follows: KQ1 - a systematic review of published primary quantitative observational studies; KQ2, KQ3(i), KQ3(ii) and KQ4 - three multivariable quantitative analyses of cross-sectional observational datasets; KQ5 - qualitative thematic content analyses of web forum posts by pregnant women; and KQ6 - a critical review of self-administered sleep instruments used by studies identified in the systematic review undertaken to address KQ1. This mixed-methods approach sought to triangulate between different ways of 'knowing', in a 'pluralistic' sense (Krieger and Davey Smith, 2016), the likely causal processes that determine the nature and extent of any changes in sleep that occur during pregnancy.

Together these six chapters of this thesis offer a comprehensive insight into the current state of knowledge about a widely reported, but nonetheless incompletely understood, phenomenon: the substantial (and often unfavourable) changes to women's sleep that are thought to accompany pregnancy. To a large extent, the systematic review undertaken at the beginning of this thesis reflects this view, offering substantive evidence across a wide range of contexts and different countries that various aspects of sleep change following conception, and continue to change (often for the worse) as pregnancy progresses.

However, most of these studies are based on cross-sectional analyses with modest numbers of participants, and often rely upon participants recruited from clinical contexts (such as antenatal care). Therefore, prone to: type 1 and type 2 errors, that is, false associations occurring by chance, and true associations that lack precision, respectively. They also have limited generalizability to non-clinical populations. While relatively few of these studies used so-called 'objective' measures of sleep (such as actigraphy and/or polysomnography), this may represent less of a concern when attempting to understand the impact of pregnancy on sleep (particularly as experienced by, and meaningful to, pregnant women themselves) as extensive variation in the more 'subjective' instruments used to collect self-reported data on sleep. The many different 'scores' that such instruments produce makes it difficult to interpret and compare data.

In addition, although some of the studies included in the systematic review aimed to adjust for potential confounders when comparing the sleep of pregnant and non-pregnant women, or the sleep of pregnant women at different stages of pregnancy, most of these used multivariable statistical models. Consequently, they were either under-adjusted, meaning that they had not been adjusted for measureable potential confounders) or had been inappropriately adjusted because adjustments had been made for variables acting as mediators on the causal path between pregnancy/stage of pregnancy and sleep. For these reasons, despite the substantial number of published studies that have examined sleep in pregnancy, the impact of pregnancy on sleep still remains unclear;as does the relative importance of: factors preceding pregnancy; sleep-relevant lifestyles, contexts and behaviours that are subject to change following conception; and the hormonal, physiological and/or anatomical changes that occur as a result of pregnancy.

Furthermore, the use of a diverse range of study designs, sampling frameworks and measurement techniques means it is not yet even possible to conduct meaningful meta-analyses of the sleep characteristics most commonly examined by these studies, such as sleep duration. This constitutes a substantive, weakness of the systematic review in this thesis, not least because meta-analyses often provide robust evidence of publication bias. In this instance, this might reflect a preference for publishing those studies that demonstrated an association between pregnancy and less favourable sleep as opposed to those that found no such associations.

To address many of these methodological and analytical concerns, subsequent chapters in this thesis drew on data from a large scale population survey, the UK Household Longitudinal Study (UKHLS) which collected data on pregnancy status and seven sleep characteristics together with a wide range of pre-existing sociodemographic and health characteristics. It also gathered contemporaneous measures of exercise, diet and related behavioural factors relevant to pre- and post-conception variation in sleep.

Analyses of data from the UKHLS established that the less favourable sleep reported by pregnant as compared to non-pregnant women was not just the result of pre-existing differences in sociodemographic or health characteristics. Nor was this solely due to

systematic differences in fertility or the frequency of sleep medication use between these two groups. However, only five of the seven sleep characteristics displayed substantial differences between pregnant and non-pregnant women following adjustment for confounding, and there were no clear differences between these two groups in coughing/snoring. This was the opposite to findings reported by several previous studies of these characteristics in pregnancy (Facco et al., 2010; Loube et al., 1996;Guilleminault et al., 2000).

The subsequent chapter(Chapter 4) generated similar findings, even in the much smaller sub-samples of UKHLS participants necessary for analyses requiring complete data on exercise, diet and related behaviours together with complete data on body mass index and participants' gestational age at interview/questionnaire completion. Subsequent analyses of these smaller sub-samples of UKHLS participants also generated clear evidence that contemporaneous reports of lifestyles and behaviours considered 'less healthy' were associated with an elevated risk of unfavourable sleep amongst pregnant women.

While some of these risks were attenuated following adjustment for potential confounders such as sociodemographic and health factors established prior to pregnancy, others remained strong. Nevertheless, this chapter also confirmed the changing pattern of sleep during pregnancy observed in the chapter 3, namely, that women interviewed during Trimester three and, to some extent, Trimester one reported less favourable sleep than those interviewed in Trimester two. Indeed, after adjustment for gestational age at interview/questionnaire completion, only two of the dietary behaviours considered 'less healthy' remained important risks for self-reported sleep, and in both instances these were associated with a *lower* risk of less favourable sleep following adjustment for gestational age.

This was interpreted as evidence that, following adjustment for trimester-determined variation in lifestyle and behaviour, women with ostensibly 'healthier' dietary behaviours exhibited an elevated risk of less favourable sleep because their 'healthier' behaviours reflected attempts to address pregnancy-related complications, such as

gestational diabetes mellitus (GDM). Data on this were unavailable for inclusion in these analyses) associated with residual variation in *less* favourable sleep.

To further assess the direct impact on sleep of GDM, one of the key hormonal, physiological and/or anatomical changes that accompany pregnancy, the three quantitative chapters(3,4,5) concluded with analyses drawing on a combined dataset comprising pregnant UKHLS participants and a clinical sample of women considered 'at risk' of GDM. This sample was generated by recruiting women undergoing screening for GDM at the Leeds Teaching Hospitals NHS Foundation Trust. Using a harmonised subset of pre-existing sociodemographic and health variables, and comparable measures of sleep, behaviour and glucose intolerance collected/reported during pregnancy, these analyses found that GDM risk/diagnosis was associated with less favourable sleep even after adjustment for potential confounders (and gestational age at interview/examination as a competing exposure).

These analyses also found clear evidence of a 'graded' relationship between GDM risk/diagnosis and sleep, such that participants diagnosed with GDM had a higher risk of less favourable sleep than those considered 'at risk' (but lacking a formal diagnosis of GDM). Moreover, both of these groups had a higher risk of less favourable sleep than those not considered 'at risk' of GDM. Together with the attenuation of risk following adjustment for gestational age at interview/questionnaire completion (identified in chapter 3,4), these analyses provide substantive evidence that at least one of the many physiological changes that accompany pregnancy (glucose intolerance) exhibits an association with less favourable sleep in a manner that appears to reflect a 'dose response' relationship. This means that it is likely to affect all pregnant women according to the extent of glucose intolerance they exhibit.

Whilst these chapters build upon, and in many respects strengthen, the evidence provided by previous quantitative observational studies of sleep in pregnancy (particularly with regard to more appropriate adjustment for confounding), they also rely upon self-administered instruments developed for general use in the wider population, covering male and female; pregnant and non-pregnant). As such they do not necessarily offer insights into the sleep-related experiences of pregnant women

that are either comprehensive or holistic, and may lack detail on factors that are particularly relevant to these women.

For this reason, and in the interests of the benefits that can be obtained from mixed-methods triangulation within a pluralistic approach to causal inference (Krieger and Davey Smith, 2016), it was appropriate for the Results Chapter of this thesis to examine in some detail the sleep-related concerns and experiences of pregnant women themselves, using data generated through their use of web-based forums. Although this source of data might lack the focus, scope and consistency achieved by researcher-facilitated interviews or focus groups using prepared topic guides, the more spontaneous production of web forum material from interactions amongst pregnancy forum users might arguably offer a less constrained source of data on pregnant women's lived experiences of sleep. Moreover, this source is free from any interviewer bias.

Analysis of these data suggests that for pregnant women, sleep becomes a significant concern when it is disrupted by the hormonal, physiological and anatomical changes that accompany pregnancy. Worries about their baby's health, the delivery and motherhood also feature strongly. These concerns relate to: excessive sleepiness (particularly during the first trimester); the impact of gastric reflux, restless legs, and the breathlessness, back ache and discomfort that can accompany the growth of the baby; and the frequency of nocturnal and early morning awakenings (often associated with nocturia), with associated difficulty getting back to sleep (i.e. sleep inertia and extended sleep latency). Some web forum posts mention the role of pre- existing/pre-pregnancy factors, or of contemporaneous lifestyle and behaviours (i.e. those occurring during pregnancy), in the sleep experienced during pregnancy. Where these were cited, this was only included within responses to posts and sometimes drew on generic sleep hygiene advice. Occasionally, these 'advisers' drew on experiences they themselves had found beneficial prior to pregnancy. In the main, then, the sleep concerns of pregnant women went some way beyond the variation in self-reported sleep characteristics (i.e. sleep duration, latency, disturbance, coughing/snoring,

medication use, quality and daytime sleepiness) assessed by previous primary quantitative studies (including those reported in this thesis).

However, these concerns were nonetheless understood by pregnant women as mainly being caused by ostensibly unavoidable hormonal, physiological and anatomical changes occurring during pregnancy. Indeed, there was little evidence that preceding/pre-existing sociodemographic and health factors, or poor pre-existing/contemporaneous sleep practices were widely recognised as relevant in the web forum posts of pregnant women. There was also little evidence that pregnant women considered the possibility that these factors might increase the impact of hormonal, physiological and anatomical changes on sleep during pregnancy.

This suggests that these factors are: either uncommon amongst women of childbearing age; or not recognised as important considerations that might increase the subsequent risk of less favourable sleep during pregnancy. Given the high prevalence of less favourable self-reported sleep characteristics amongst the *non*-pregnant UKHLS participants examined in the first of the quantitative Results Chapters (chapter 3) in this thesis, it is possible that neither pregnant nor non-pregnant women recognise the contribution that sociodemographic, health and lifestyle factors make to sleep. It also seems likely that both groups consider the high prevalence of less favourable sleep experienced by non-pregnant women to be commonplace and in that sense 'normal'.

Finally, in order to offer some recommendations for future research in this area, the final Results Chapter in this thesis undertook a critical review of all self-administered sleep instruments that had been used in any of the primary observational quantitative studies examining sleep in pregnancy identified in the earlier systematic review. This review had three aims, the first being to identify the range of sleep-related characteristics that were addressed by items in each of these instruments. Second, it aimed to determine which, if any, of these instruments offered a comprehensive assessment of sleep characteristics in pregnancy, including those identified as particularly important by pregnant women themselves in the qualitative analysis of web forum posts offered in (Chapter 6). Finally, it aimed to identify the extent to which any of the instruments might be capable of offering an assessment of PASD (as defined in

the latest update to the American Academy of Sleep Medicine's *International Classification of Sleep Disorders: Diagnostic and Coding Manual* [ICSD], 2001).

The review indicated that these instruments generally fell into two groups. The first offered a more generic assessment of sleep across a wide (but nonetheless limited) range of sleep characteristics, many of which were included in the majority of these instruments. The second group focused specifically on particular sleep characteristics, such as restless legs syndrome or obstructive sleep apnoea, and contained few items relating to more generic sleep characteristics. None of the instruments offered a comprehensive/holistic assessment of sleep characteristics that included all of the sleep-related concerns considered important by pregnant women; and none were capable of providing the information required to diagnose PASD (setting aside ICSD's recommendation that this include objective polysomnographic assessment).

Thus, this review indicated that future studies of sleep in pregnancy (and particularly those that aim to assess the prevalence, aetiology and/or prognosis of PASD) should combine items drawn from validated instruments with bespoke items developed to provide data on all of the sleep characteristics and related sociodemographic, health and behavioural factors required. Where necessary, items should be drawn from more than one validated instrument. Studies of this type might help to generate the empirical evidence required to reach consensus on the development of a dedicated sleep instrument designed specifically for use in pregnancy; and on the inclusion therein of items assessing sleep *prior* to pregnancy.

8.2 Original contribution to knowledge

Drawing together the results of all six Results Chapters(2-7), it is clear that this thesis has made a substantial original contribution to our understanding and knowledge of sleep in pregnancy. These chapters identify, and go some way towards addressing, many of the weaknesses in previous observational quantitative studies of sleep in pregnancy. However, the limited of longitudinal studies of sleep conducted before and throughout pregnancy together with the absence of a comprehensive self-administered sleep instrument capable of assessing the full range of sleep characteristics relevant to

pregnancy and/or the assessment of PASD highlight the need for future research in these areas.

The three chapters(3,4,5) containing observational quantitative analyses of datasets made full use of recent advances in theories of causal inference to assess three areas: first, what role pre-existing sociodemographic and health factors might play in the sleep achieved by pregnant women; second, the influence of lifestyle and behavioural factors *during* pregnancy, and third, the impact of hormonal, physiological and anatomical changes occurring during the course of pregnancy. These analyses provided robust evidence that many of these factors are capable of acting as independent determinants of sleep in pregnancy, although the sample sizes on which these analyses were based did not permit any assessment of possible multiplicative interactions between different factors that might increase their impact on sleep.

These analyses were strengthened by the use of causal path diagrams, in the form of directed acyclic graphs. These use theoretical understanding of the temporal relationships between each of the variables available for analysis to strengthen the identification of appropriate adjustment sets for the multivariable statistical models these analyses involved. However, the evidence of directionality provided by this approach is not as strong as that provided by well-powered longitudinal analyses; nor is the evidence of causality as definitive as that provided by controlled trials of interventions addressing potential determinants of sleep at different stages of pregnancy, i.e. pre-conception and in each successive trimester.

Despite the limited number of relevant trials identified during the course of research for this thesis providing longitudinal data, it is still clear that the hormonal, physiological and anatomical changes occurring during the course of pregnancy are not the only factors responsible for the less favourable sleep reported by pregnant women. It is also clear that pregnancy-related changes of a hormonal, physiological and anatomical nature remain the focus of most published empirical studies of sleep in pregnancy; of most pregnant women's experiences and understandings of their sleep concerns; and of the AASM's classification of *PASD*.

While less favourable sleep seems likely to remain a significant concern for pregnant women, the extent of sleep-related problems and their potential value as markers of hidden health problems, or as determinants of risk for mother and child, is unlikely to be realised where pre-existing sociodemographic and household circumstances, together with contemporary lifestyles and behavioural practices conspire to undermine the sleep of men and women (both pregnant and non-pregnant) in high-income urbanised contexts such as the UK.

Such circumstances and practices are likely to potentiate the impact that the hormonal, physiological and anatomical changes occurring during pregnancy have on sleep in at least one of three ways. First, they establish physical and social contexts in which less favourable sleep is more common, irrespective of the physiological, psychological and behavioural wellbeing of individuals. Second, they can create a threshold of less favourable (or incipiently less favourable) sleep that has limited capacity to absorb or accommodate the impact of pregnancy-related hormonal, physiological and anatomical changes on sleep. Third, they serve to increase the sensitivity of individuals' sleep to these pregnancy-related changes, and thereby increase or exacerbating or accentuating their impact on sleep in a multiplicative fashion.

Unfortunately, limited evidence on each of these possible mechanisms is available from previous analyses of sleep in pregnancy, including those included in this thesis. However, it is instructive that just three of the studies identified during the course of research for this thesis attempted to intervene to improve sleep during pregnancy; the rest sought to address physical and social contexts and/or related lifestyle and behavioural practices of pregnant women that were likely to have posed substantial risks of less favourable sleep *prior* to, and regardless of, pregnancy:

- The first of these studies focused on women diagnosed with insomnia during the third trimester of pregnancy in Zanjan, Iran (Malekzadegan et al., 2010). It involved a four week programme of relaxation training, comprising two dedicated training sessions; materials summarising the relaxation technique taught; a log for participants to record relaxation practice at home; and a tape- recorded version of the relaxation technique). The women (n=47) receiving the relaxation intervention were

reported to have displayed a significant reduction in the intensity of insomnia compared to those randomized to standard antenatal care as controls (n=48), (Malekzadegan et al., 2010).

- The second study focused on women at 26-32 weeks gestation during routine antenatal care in Meshgin Shahr, Iran (Hassan-pour et al., 2014). It reported statistically significant improvements in total Pittsburgh Sleep Quality Index [PSQI] (Buysse et al., 1989) scores amongst the pregnant women (n=70) randomised to receive "sleep health training", comprising lectures on sleep hygiene, preparation for sleep and a CD of "calming music", compared to those of pregnant women (n=75) randomised to standard antenatal care alone (as controls).

- Although the third study (Kempler et al., 2012) has yet to report its findings, according to the protocol published in 2012 its intention was to randomise n=214 nulliparous pregnant women during the third trimester of pregnancy in Sydney, Australia, in two groups. One received two 90 minute 'psychoeducational sessions' (consisting of lectures aimed at improving participants' knowledge and understanding of maternal and infant sleep) *together with* the provision of booklets on "babies' sleep, managing sleep long term and relaxation strategies". The other (as controls) received just the booklets alone. Unfortunately, this study was not designed to assess the shorter-term effect of the 'psychoeducational' intervention on participants' sleep during the remaining weeks of pregnancy, and did not plan to collect outcome data on sleep until after delivery. However, the authors have confirmed significantly better PSQI and Insomnia Severity Index (Bastien et al., 2000) scores at 4 months postpartum amongst women randomised to the intervention, although not at 6 weeks or 10 months postpartum (Bartlett and Kempler, personal communication; 25th October 2016).

These studies offer tantalising evidence of the potential impact that interventions addressing sleep-related problems and concerns might make on the self-reported sleep

otherwise healthy pregnant women – interventions that appear to target the knowledge, understanding and anxieties of participants rather than any underlying hormonal, physiological or anatomical causes of less favourable sleep. As such, they indicate that the impact of pregnancy-related (hormonal, physiological and anatomical) changes on sleep appear potentiated by the widely held belief (amongst clinicians, researchers and pregnant women themselves) that pregnancy causes less favourable sleep in pregnancy – a belief that may undermine pregnant women's willingness or ability to attenuate any such effects and minimise the impact of these on the sleep they actually experience.

This does not rule out the possibility that some aspects of less favourable sleep that are associated with pregnancy might not act as markers for otherwise hidden risks to the mother and her baby; or that less favourable sleep presents cannot affect the wellbeing of the mother and her unborn child (particularly when sleep is, or is experienced as, *extremely* unfavourable). But these experimental studies do indicate that the utility of less favourable sleep as a marker for otherwise hidden risks *and* the potential impact of less favourable sleep on maternal and child wellbeing may *both* benefit from effective interventions that reduce the experience, and enhance the management of, the changes in sleep that commonly accompany pregnancy. This is because such interventions would reduce or eliminate that component of less favourable sleep that is unrelated to any underlying risks and that creates or accentuates the risk of harm to the mother and her baby.

8.3 Limitations

The specific limitations of each of the analyses conducted in the preceding Results Chapters of this thesis have already been highlighted in the relevant Discussion sections. However, it is important to assess in more detail here four key design-related and conceptual constraints that apply to the thesis as a whole.

These limitations relate to four key design-related and conceptual constraints: first, the reliance of the thesis on existing analyses, datasets and instruments; second, the sampling frames used by/for each of the sources of data (and the impact of these on the sample sizes available for analysis, and on the external validity/wider applicability

of the thesis' findings); third, the focus on self-reported and subjective/experiential assessments of sleep; and fourth, an apparent preoccupation with less favourable (as opposed to more favourable) sleep characteristics and with the classification of Sleep Associated Sleep Disorder (which might reflect unconscious/inherent bias in favour of the view that pregnancy is accompanied by less favourable sleep).

The decision to make extensive use of existing studies, datasets and instruments was informed both by pragmatic constraints (related to the limited time available to generate sufficient data de novo given the fixed-term nature of all doctoral studies and related financial support), and by a desire to learn from and build upon pre-existing work in this field rather than attempting to 'reinvent the wheel'. Indeed, the focus of the thesis developed out of an existing survey of sleep amongst women at risk of gestational diabetes (GDM) and those diagnosed with GDM that had been developed by one of the four supervisors (Dr Eleanor Scott) and had already received ethical approval and commenced data collection at the time the candidate started their studies at the University of Leeds. This clinic-based survey (which ultimately contributed data only to the last of the three observational quantitative Chapters in this thesis (chapter5) was originally designed as a comparison of self-reported sleep characteristics in pregnant women classified as either 'at risk' of or 'diagnosed with' GDM whilst receiving routine and specialist antenatal care at Leeds Teaching Hospitals NHS Foundation Trust. But these data, together with information contained in antenatal and perinatal medical records, were also offered for secondary analysis and inclusion in this thesis. Although this provided a ready source of valuable data for use by the candidate, it also meant that the challenges facing the collection of (complete) data from study participants – particularly the effort required to extract reliable (and complete) data on sociodemographic, behavioural, health and healthcare variables from medical records – became apparent to the candidate at an early stage in their doctoral studies. This led the candidate and their supervisors to conclude that there would be insufficient time available to collect enough data from enough pregnant women to support the analyses required to address the original aims of the thesis. This, in turn, lead to a search for alternative, additional sources of data to augment the limited scope and statistical power of the data available from further prospective surveys of pregnant women and

their clinical records. There is little doubt that this decision strengthened the scope of the analyses that were then undertaken for inclusion in this thesis, and that these benefitted from a better understanding of the challenges previous studies had faced, and of the limitations (and flaws) of these studies and of datasets available for secondary analysis (including data collected by the UK Household Longitudinal Study; upon which the bulk of the quantitative analyses included in this thesis were based). The early identification of these limitations and flaws ensured that the observational quantitative analyses undertaken for this thesis were often able to address, avoid or circumvent these. Nonetheless, an unavoidable consequence of relying on existing studies, datasets and instruments is that conclusions of this thesis remain tentative rather than definitive; and offer firmer recommendations for future aetiological, diagnostic and prognostic research than for targeted interventions on the determinants of sleep in pregnancy it was able to establish.

The extensive use of existing studies, datasets and instruments also has an impact on the analytical power and external validity of the analyses presented in this thesis. For example, the vast majority of previous studies conducted on healthy pregnant women and on those diagnosed with GDM (the two groups of studies included in the systematic review conducted during the course of this thesis), were conducted in North America, Western Europe and Scandinavia – all of which are high-income, industrialised and predominantly urbanised contexts which are far from ideal when seeking to assess the influence of pregnancy on sleep independent of pre-existing environmental and social influences thereon (influences that seem more prevalent in densely inhabited urban conurbations, with lifestyles enhanced by comparatively cheap and dependable supplies of electricity and modern technology). Likewise, the population-based data on sleep drew on items included in a large, contemporary survey of households within the UK that may have little relevance to contexts elsewhere, particularly those with very different climatic conditions, population densities, levels of urbanisation and the associated impacts of modern lifestyles on sleep (Buck and McFall, 2011). Finally, although the thesis sought to identify sleep-related concerns relevant to the diagnosis of *Pregnancy Associated Sleep Disorder* (AASM, 2001; in order to explore the possibility of interventions to address these) and those relevant to the views and experiences of

women themselves (using existing sources of data offered spontaneously through publicly accessible web forums), the limited collection of prospective data during the course of the thesis meant that much of the analysis is framed by the scope of existing classifications of sleep 'disorders' and existing self-administered sleep instruments. These tend to focus on a small number of generic sleep characteristics (such as the seven characteristics covered by items in the UKHLS sleep module) or very specific sleep characteristics (with limited relevance to the sleep experienced by pregnant women). Whilst the potential for confirmation bias inherent in the former (i.e. the possibility that, by approaching sleep in pregnancy from a problematic perspective, the data were chosen to confirm this perspective) will be discussed shortly; the thesis sought to address the limitations of existing self-administered sleep instruments through a critical review of all such instruments found to have been successfully used by previous studies of sleep in pregnancy. This review (summarised in Chapter 7) identified and documented the limited utility of these instruments for the assessment of sleep in pregnancy. To address this limited utility, the review then offered tangible suggestions for improvements in instrument design (see also: *Conclusions and recommendations for future research*, below).

These justifications aside, it is nonetheless fair to view this thesis as offering less of a definitive assessment of sleep in pregnancy and more of a firmer understanding of:

What is known – that pregnancy *is* indeed associated with less favourable sleep, but that much of this may be the result of pre-existing differences in the sociodemographic and health characteristics of pregnant and non-pregnant women, and of contextual and behavioural determinants of sleep operating independently of (and perhaps in a permissive, cumulative or interactive fashion with) the hormonal, physiological and anatomical changes occurring during pregnancy;

What remains unclear – the relative contribution of these 'pregnancy-independent', 'pregnancy-sensitive' and 'pregnancy-specific' determinants of sleep, and which of these might warrant (and be amenable to) intervention, and when; and

What future studies – might be required, to (better) address these unknowns. In no small part, the absence of definitive evidence regarding the range, impact and relative

importance of potential determinants of (less favourable) sleep in pregnancy is due to the reliance of this thesis on existing datasets (particularly on previous studies using comparable designs, and on more pregnant UKHLS participants and more of these with complete data on sleep and other relevant variables).

These sources of data, though substantial and reasonably detailed, still lacked sufficient (complete) and precise information on sufficient numbers of previous studies or sufficient numbers of pregnant women to ensure they were capable of appropriately powered meta-analyses or multivariable statistical analyses, respectively. Whilst it is true that limited sample sizes are common amongst many primary and secondary observational analyses in epidemiology, these mean that the analyses presented in this thesis are speculative (rather than definitive), and have not been able to extend our understanding beyond the challenges such samples pose (and how these challenges might be addressed by future, particularly prospective longitudinal and experimental, studies). Of substantial concern here is that it was not possible to undertake the meta-analyses required to detect the likelihood of publication bias affecting past studies examining sleep in pregnancy (particularly studies that sought, found, and reported, associations between pregnancy and sleep that appear to confirm the widely held view that pregnancy poses an unavoidable, and potentially substantive and clinically important, risk of less favourable sleep).

The need for analytical scale and statistical power has led many observational studies in epidemiology (and elsewhere in the clinical and social sciences) to rely upon self-reported measures of variables that might be assessed with greater precision (and greater internal validity) using objective techniques, were the time and resources available. For some such studies, the decision to use self-reported measures reflects a trade-off between the greater statistical precision afforded by larger sample sizes (which help to reduce the confidence intervals of estimated effect sizes), and the lower precision of measurement. However, in the case of sleep this thesis has argued that self-reported measures are likely to offer less abstract and more meaningful insights into the sleep perceived/experienced by study participants; and that these might be very different to those offered by so-called 'gold standard' measures of sleep such as

polysomnography (and proxies thereof generated through actigraphy). Nonetheless, from a clinical perspective, self-reported sleep characteristics may lack the precision required to diagnose sleep 'disorders' in individual patients (not least those presenting with negative affect or mood disorders which are themselves symptoms and causes of unfavourable sleep (Ross et al., 2005). Indeed, the American Academy of Sleep Medicine's classification of *Pregnancy Associated Sleep Disorder* suggests that formal diagnosis requires polysomnographic assessment. Yet, despite the intention of this thesis to examine the meaningfulness of such a broad-based 'disorder' (one likely to include large numbers of women with otherwise completely 'normal' pregnancies), and to explore a range of potential determinants of sleep in pregnancy (including those directly attributable to pregnancy and those that are not), its focus on self-reported sleep characteristics seems entirely defensible given the relevance of these to the women concerned. This decision is also defensible given the important role that such self-reported experiences play in the sleep-related concerns expressed by pregnant women – concerns likely to be responsible for encouraging them to seek professional (and lay) advice, assessment and care. Indeed if, as some authors have suggested (Lee and Gay, 2004), sleep in pregnancy might offer a clinically useful marker for otherwise hidden risks for the wellbeing of mothers and their babies, *or* poses substantial risks to the psychological and physical wellbeing of both mother and child, then the self-reported sleep characteristics are likely to offer a more comprehensive and feasible measure of these than 'objective' (i.e. polysomnographic or actigraphic) assessments alone. Given the prevalence of less favourable sleep displayed by pregnant (*and* non-pregnant) women in data from the UKHLS (which aims to provide a representative sample of household and their inhabitants across the UK), screening for unfavourable sleep characteristics may be warranted for a substantial proportion of women both antenatally and prior to conception. This is something that would prove impracticable were this to require comprehensive polysomnographic (or even actigraphic) assessment. For these reasons, the focus brought to bear on the *self-reported* sleep characteristics of pregnant (and non-pregnant) women by this thesis seems not only pragmatic and sensitive, but also entirely sensible, not least at this stage of our aetiological understanding.

Finally then, it is necessary to consider the concern that this thesis approached the topic of sleep in pregnancy preoccupied with the AASM's classification of *Sleep Associated Sleep Disorder*, and a belief that pregnancy is usually associated with less favourable sleep. Such an approach would be at risk of 'confirmatory bias' were the analyses to focus upon pregnant women experiencing sleep *problems* rather than on those sleeping *well*. Such bias constitutes a substantial (though rarely acknowledged) challenge for much biomedical research, the aim of which is often to identify causes of *ill*-health and healthcare interventions capable of addressing these. Yet, from the very outset, the research undertaken for this thesis sought to adopt a sceptical and open-minded approach, not least since the ICSD's classification of *Pregnancy Associated Sleep Disorder* – a little-studied condition (despite its inclusion in the very first ICSD in 1990), that appears sufficiently broad to be applicable to a substantial proportion of pregnant women (including those without any substantive health concerns and those that go on to experience good pregnancy outcomes). This approach led the thesis to a critical review of previous studies that sought (found and reported) evidence of relationships between pregnancy and less favourable – a review that found numerous flaws in study design and analysis, yet too few comparable studies using similar designs to permit meta-analysis (and thereby an assessment of possible publication bias). Likewise, although the analyses undertaken for this thesis were constrained by the availability of sleep data generated using self-administered – instruments that have a tendency to problematize sleep by focussing, as they do, on sleep characteristics that relate to: "*trouble* falling to sleep within 30 minutes"; and "*difficulty* staying awake while eating, driving and/or socialising" – the analysis of data generated by such items permitted the identification not only of 'problematic' relationships (such as those between contemporaneous measures of health and most of the self-reported sleep characteristics examined), but also of 'absent' and (ostensibly) 'beneficial' relationships between sleep and pregnancy, sleep and pregnancy-related behaviours, and sleep and (at least one of the) pregnancy-specific physiological phenomena (glucose intolerance) thought to be exhibited by all pregnant women (albeit to differing degrees). Examples of these include: the absence of an elevated risk of frequent "*trouble* sleeping… [due to] coughing or snoring loudly" amongst pregnant women; and the far lower odds of

frequently using “medicine… to help you sleep” amongst pregnant UKHLS participants than those who were not pregnant at interview/questionnaire completion. As such, the thesis sought to avoid any tendency towards ‘confirmation bias’ by adopting an inductive and exploratory approach to its analyses rather than a deductive evaluation of the prevailing thesis that pregnancy *causes* less favourable sleep. This approach also led the thesis to carefully examine the potential role that sociodemographic and pre-existing health conditions might play in the self-reported sleep of pregnant and non-pregnant women, as well as the potential impact of variation in behavioural and lifestyle factors *during* pregnancy on the self-reported sleep of pregnant women. These are the first such analyses to consider the independent role such factors might play in the self-reported sleep of pregnant women. And although the results of these analyses remain tentative, they indicate that pregnancy *per se* may not be the only (or even the most important) determinant of the less favourable sleep commonly reported by pregnant women. Likewise, although the focus of much of the sleep-related experiences shared by pregnant women on the web forums examined by this thesis suggest that pregnancy is felt to be the responsible for the sleep concerns they describe, few of the women situated these concerns within the context of sleep problems or behaviours experienced prior to pregnancy (even though a good many of the issues they describe, particularly those involving the physical and social contexts where they lived, indicate an awareness that these accentuate the impact of pregnancy on sleep). For these reasons the thesis is likely to have succeeded in providing, at the very least, an ‘agnostic’ assessment of the possible role that pregnancy-related hormonal, physiological and anatomical changes play in the less favourable sleep reported by pregnant women; and made a credible attempt to identify the role that other factors (unrelated to pregnancy) – such as those associated with habits, circumstances and behaviours that precede/are well-established prior to conception, and those that are susceptible to change during pregnancy – that might potentiate or exacerbate the impact of pregnancy-specific changes on sleep.

8.4 Conclusion and Recommendations for future research

In conclusion, this thesis has provided a coherent synthesis of previous studies exploring the sleep of pregnant women and, through robustly designed secondary (and primary) analyses of existing (and novel) datasets, has established that factors operating beyond, and independently of, pregnancy also play an important part in the less favourable sleep reported by pregnant women. While clinical and academic interest in the sleep of pregnant women retains a focus on the aetiology and diagnostic/prognostic utility of less favourable sleep, and while this remains the pre-eminent understanding of sleep concerns amongst pregnant women themselves, this thesis suggests that this focus risks discounting the role of sleep-determining factors that are *not* specific to pregnancy. This is important given these factors may offer avenues for intervention that avoid the medicalization of (yet another) characteristic of pregnancy – a characteristic that (though commonly experienced, unpleasant and occasionally debilitating) perhaps carries little risk to the wellbeing of mother or baby. Sleep in pregnancy is also a characteristic that might be amenable to accommodation and adaptation through better understanding of the unavoidable consequences of the (hormonal, physiological and anatomical) changes that accompany pregnancy, and the role that lifestyle, behaviour and context can play in attenuating their impact on sleep. Yet this aspiration, and the synthesis of past and novel analyses on which it is based, remains tentative given the conceptual, analytical and data-related limitations of the material available for analysis in this thesis. As such this thesis concludes by recommending that future studies of sleep in pregnancy:

R1. Draw upon the beliefs, insights and experiences of stakeholders with specialist expertise in this area (including: nulliparous and multiparous pregnant women living in a diverse range of physical and sociocultural contexts; and both formal and informal healthcare providers who advise and support women in pregnancy), to better understand the 'lived experience' of sleep, sleep problems and sleep-related concerns during pregnancy;

R2. Develop consensus on the items required in self-administered instruments to capture sufficient data on the contextual, behavioural and experiential variables

necessary to support comprehensive assessments of sleep in pregnancy that more holistically reflect the experiences and needs of pregnant women;

R3. Establish the validity of such instruments across a diverse range of pregnant populations living in different physical and sociocultural contexts and displaying different sleep-relevant behavioural practices; and ensure that these instruments are capable of capturing the diversity of sleep characteristics relevant to such contexts and behaviours, as well as the prevalence of *Pregnancy Associated Sleep Disorder*;

R4. Assess the clinical utility of these self-administered sleep instruments (and of *Pregnancy Associated Sleep Disorder* diagnosed thereby) as diagnostic and prognostic tests of health risks to mother and child that are amenable to therapeutic (preventative, curative or palliative) intervention;

R5. Apply these instruments to well-powered longitudinal samples of women prior to conception and throughout pregnancy to establish the relative importance of pre-existing circumstances, behavioural changes and pregnancy-related hormonal, physiological and anatomical changes as determinants of sleep in pregnancy, and possible interactions between these; and

R6. Further explore the effectiveness of knowledge- and skill-based educational interventions that might help pregnant women attenuate, compensate for and/or cope with the impact of pregnancy-related hormonal, physiological and anatomical changes on their sleep.

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Appendices

Appendix 2.1 List of abbreviations used in the reviewed studies Tables(2.5-2.10).

♀	Woman/women, female/females
<	Less than
>	Greater than
AHI	Apnea Hyponea Index
BDI-SF	Beck Depression Inventory – Short Form
CI	Confidence interval
DBP	Diastolic blood pressure
DIS	Difficulty in initiating sleep
EDS	Excessive daytime sleepiness
EMA	Early-morning awakening
EPDS	Edinburgh Postnatal Depression Scale
ESS	Epworth Sleepiness Scale
ETS	Environmental tobacco smoke
GDM	Gestational diabetes mellitus
HIV	human immunodeficiency virus
MANCOVA	multivariate analysis of covariance
NGT	Normal glucose tolerance
NP	Non-pregnant
OGT	Oral glucose tolerance
OGTT	Oral glucose tolerance test.
OR	Odds ratio
OSA	Obstructive sleep apnoea
P	Pregnant
Pearson's	product moment correlation coefficients
RLS	Restless legs syndrome
RR	Relative risk
SBP	Systolic blood pressure
SD	Standard deviation
SDQ	Sleep Disorders Questionnaire
SE	Sleep efficiency

sFAB	Subjective frequency of awakening during night sleep
SIS	Subjective insufficient sleep
sNAP	Subjective morning nap time
SO	Sleep onset
SOL	Sleep onset latency
SSD	Short sleep duration
STAI	State and trait -anxiety inventory
sTWB	Subjective time of wakefulness in bed
TST	Total nocturnal sleep time
WASO	Wake up after sleep onset
WHIIRS	Women's Health Initiative Insomnia Rating Scale
x2 t-test	Two-sample t-test

Appendix 2.2 Critical appraisal checklist

Questions	Answers
What is the study design? (Appraisal assessment: given the observational nature of the data available, a cohort/longitudinal study design would provide evidence of directionality, whilst case-control and cross-sectional studies only offer evidence of association)	
What is the final sample size of participants included in the analyses? (Appraisal assessment: studies with larger sample sizes are more likely to have generated estimates of association in which there can be greater confidence)	
Did this study include pregnant and non-pregnant/pre-pregnant participants? (Appraisal assessment: studies with non-pregnant 'referent' participants are able to generate evidence of the possible impact of pregnancy on sleep; those using pre-pregnant sleep measurements in women measured also during pregnancy, are able to generate evidence in which each participant acts as their own control)	
Did this study examine pregnant participants in more than one of the three trimesters of pregnancy? (Appraisal assessment: measurements of sleep from more than one trimester will enable studies to assess potential changes in sleep during the course of pregnancy)	
Did this study use a validated self-reported sleep instrument/measurement? (Appraisal assessment: studies collecting self-reported sleep characteristics are likely to generate more accurate and comparable data when the instrument used has been previously validated)	
Did the study use objective measures of sleep? (Appraisal assessment: objective measures of sleep may provide assessments of sleep that are more	

internally valid, yet less subjectively valid, than self-reported instruments)	
Did this study measure more than one characteristic of sleep? (Appraisal assessment: studies generating data on more than one sleep characteristic are likely to offer a more comprehensive assessment of any relationship between sleep and pregnancy)	
Did the study apply any multivariable analyses capable of adjustment for potential confounders? (Appraisal assessment: studies that do not conduct multivariable statistical analyses are not able to adjust for potential confounding, and their unadjusted analyses may therefore be biased)	
In any multivariable analyses presented in this study, were the variables included for adjustment potential confounders, rather than likely mediators? (Appraisal assessment: even when studies use multivariable analyses to adjust for potential confounding, the misidentification of mediators as confounders may introduce additional bias as a result of the reversal paradox)	
Did the study compare pregnant women with different anatomical, physiological or hormonal changes during their pregnancy? (Appraisal assessment: studies comparing pregnant women with differing pregnancy-related changes may be able to provide further evidence of the role that such changes might play in the relationship between sleep and pregnancy)	
Are there any additional potential limitations associated with sampling, measurement or analysis not covered by any of the preceding critical appraisal questions? (Appraisal assessment: over and beyond the specific concerns and potential methodological issues addressed above, there remain a number of additional, potential errors in method	

that might undermine the quality/validity of the data and analyses undertaken)	

Reference: Oxman AD, Cook DJ, Guyatt GH. 1994. Users' guides to the medical literature. How to use an overview*? Journal of the American Medical Association*. **272**: 1367-1371.

Appendix 3.1 Precise wording for the derived variables used in UKHLS sample questionnaire(s) and item, with coding and sources, references.

Variable	Precise wording of UKHLS questionnaire items	Coding	Source/references
<u>Sociodemographic variables</u> ***Age group*** 16-23 24-31 32-39 40-48	*What is your* date of birth*?*	*In binary coding: ≤30 (referent) and >30.*	Quantile
Ethnicity-based DM risk Low risk(referent) Ethnic majorities	Do you come from, or have parents or grandparents from any of the following ethnic groups? *See next column.*	"White"	Labour force survey ethnicity classification Smith A. The new ethnicity classification in the Labour Force Survey. *Labour Market Trends.* 2002; **112:** 657-66

Variable	Precise wording of UKHLS questionnaire items	Coding	Source/references
High risk Ethnic minorities		"Asian", "Bangladeshi", "Pakistani", "Indian", "Middle east" , "Mixed black" , "Black African", "Black Caribbean" , "Mixed White and Black", "others".	
Educational qualifications ≥Degree	Can you tell me the highest educational or school qualification you have obtained? *See next column.*	"Degree", "Other higher degree".	Office for National Statistics 2010 [Online]. [Accessed 1.11.2016]. Available from: *https://www.ons.gov.uk/*
<Degree		"A-level" and "GCSE" and "Other qualification".	
Never		"No qualifications". In binary coding: ≥Degree and combine <Degree, Never (referent).	
Partnership status Partner	What is your legal marital status? *See next column.*	"Partner", "married".	
No Partner		"Single", "divorced", "Widowed".	

Variable	Precise wording of UKHLS questionnaire items	Coding	Source/references
Additional adults in household 0(referent)	What is the composition of household?	"Couple under, over pensionable age, no children" "Couple with 1 child" "Couple with 2 children" "Couple with 3 or more children"	Derived from household composition variable in UKHLS dataset. This classification follows the household composition classification for the Labour Force Survey (Office for National Statistics. *Labour Force Survey*. 2010). [Online]. [Accessed 1.11.2016]. Available from: *http://www.ons.gov.uk/ons/guide-method/method-quality/specific/labour-market/labour-market-statistics/index.html*

Variable	Precise wording of UKHLS questionnaire items	Coding	Source/references
Additional adults in household ≥1		"1 adult under pensionable age, no child" "1 adult, 1 child" "1 adult, 2 or more children" "2 adults, not a couple, both under pensionable age ,no children" "2 adults, not a couple, one or more over pensionable age, no children" "2 adults, not a couple, 1 or more children" "3 or more adults, no children, include. At least one couple" "3 or more adults, 1-2 children, include. At least one couple" "3 or more adults, >2 children, include. At least one couple" "3 or more adults, no children, exclude. Any couples" "3 or more adults, 1 or more children, exclude. Any couples	

Variable	Precise wording of UKHLS questionnaire items	Coding	Source/references
Additional couples in household 0(referent)	What is the composition of household?	**No couples in the household:** "1 adult, 1 child" "1 adult, 2 or more children" "2 adults, not a couple, both under pensionable age ,no children" "2 adults, not a couple, one or more over pensionable age, no children" "2 adults, not a couple, 1 or more children" "3 or more adults, no children, exclude. Any couples" "3 or more adults, 1 or more children, exclude. Any couples"	Derived from household composition variable in UKHLS dataset. This classification follows household composition classification in the Labour Force Survey (Office for National Statistics. *Labour Force Survey*. 2010). [Online]. [Accessed 1.11.2016]. Available from: *http://www.ons.gov.uk/ons/guide-method/method-quality/specific/labour-market/labour-market-statistics/index.html*
Additional couples in household ≥1		***Additional couples in household*** ≥1	
Parity Nulliparous(referent)	Relationships in the household? *Natural parent, step parent, foster parent, parent-in-law, none.*	***Parity*** Nulliparous(referent)	Relationships in the household? Natural parent, step parent, foster parent, parent-in-law, none.

Variable	Precise wording of UKHLS questionnaire items	Coding	Source/references
Multiparous		Multiparous	
Children in household 0 (referent)	What is the composition of household?	"1 adult under pensionable age, no child" "Couple under, over pensionable age, age, no children" "2 adults, not a couple, both under pensionable age ,no children" "2 adults, not a couple, one or more over pensionable age, no children" "3 or more adults, no children, include. At least one couple" "3 or more adults, no children, exclude. Any couples"	Derived from Household composition variable in UKHLS dataset. This classification follows household composition classification in the Labour Force Survey (Office for National Statistics. *Labour Force Survey*. 2010). [Online]. [Accessed 1.11.2016]. Available from: http://www.ons.gov.uk/ons/guide-method/method-quality/specific/labour-market/labour-market-statistics/index.html

Variable	Precise wording of UKHLS questionnaire items	Coding	Source/references
Children in household ≥1		"1 adult, 1 child" "1 adult, 2 or more children" "Couple with 1 child" "Couple with 2 children" "Couple with 3 or more children" "2 adults, not a couple, 1 or more children" "3 or more adults, 1-2 children, include. At least one couple" "3 or more adults, >2 children, include. At least one couple" "3 or more adults, 1 or more children, exclude. Any couples"	
Pre-existing health conditions No, None(referent)	Has a doctor or other health professional ever told you that you have any of these conditions? *See next column.*	No health conditions	

Variable	Precise wording of UKHLS questionnaire items	Coding	Source/references
Pre-existing health conditions Yes, ≥1		Health conditions including: Asthma, Arthritis, Congestive heart failure Coronary heart disease, Angina, Heart attack or myocardial infraction, Stroke Emphysema, Hyperthyroidism or an over-active thyroid, Hypothyroidism or an under-active thyroid, Chronic bronchitis, Any kind of liver condition, Cancer or malignancy, Diabetes, Epilepsy, High blood pressure, Clinical depression.	
Employment status High status	What is your employment status? *See next column.*	"Employee: Management and Professional", "Employee: and Intermediate" and "Employee: Small Employers and own account".	Office for National Statistics 2010 [Online]. [Accessed 1.11.2016]. Available from: *https://www.ons.gov.uk/*
Low status		"Employee: Lower supervisory and technical " and "Employee: Semi-routine, Routine and Never worked long term "	
Unemployed		"Unemployed", "Maternity leave", "Student" and "Long-time sick". In binary coding: combine High, low status, and Unemployed(referent).	

Variable	Precise wording of UKHLS questionnaire items	Coding	Source/references
Gestational Age First trimester	See chapter 3	≤ 12 weeks	WebMD updated in 2015. [Online]. [Accessed 1.11.2016]. Available from: *http://www.webmd.com/baby/tc/pregnancy-your-first-trimester#1*
Second trimester(referent)		13-27 weeks	
Third trimester		≥ 28 weeks	
Life style and health variables ***Diet*** **Dairy** (Usual type of milk consumed) Skimmed or soya (referent)	Can you tell me the main type of milk that you usually use? *See next column.*	"semi-skimmed milk", "skimmed milk", "soya milk"	
Not skimmed or soya		"whole milk", "any other sort of milk"	
Bread (type of bread eaten) (referent) "Brown" ,"Wholemeal", "wholegrain"	What type of bread do you eat most frequently? *See next column*.	"Brown" ,"Wholemeal", "wholegrain"	

Variable	Precise wording of UKHLS questionnaire items	Coding	Source/references
Bread (type of bread eaten Not brown or wholemeal or wholegrain		"White", "both brown and white", "other type of bread"	
Fruit (Days per week fruit eaten) ≥4(referent)	Including tinned, frozen, dried and fresh fruit, on how many days in a usual week do you eat fruit? *Never ,1 - 3 Days, 4 - 6 Days, Every day*	"4- 6 days", "every day"	American Heart Association updated in [Online]. [Accessed 1.11.2016]. Available from: *http://www.heart.org/HEARTORG/HealthyLiving/HealthyEating/Nutrition/About-Fruits-and-Vegetables_UCM_302057_Article.jsp#.WC4iTU1XV9A*
<4		"Never", "1 - 3 days"	
Fruit/Vegetables (Portions of fruit/ vegetables eaten) ≥4 (referent)	On a day when you eat fruit or vegetables, how many portions of fruit and vegetables in total do you usually eat? enter number of portions	≥4	American Heart Association AHA updated in 2013 [Online]. [Accessed 1.11.2016]. Available from: *http://www.heart.org/HEARTORG/HealthyLiving/HealthyEating/Nutrition/About-Fruits-and-Vegetables_UCM_302057_Article.jsp#.WC4iTU1XV9A*
<4		<4	

Variable	Precise wording of UKHLS questionnaire items	Coding	Source/references
Sport Habitual sport activity (0=None; 10=Very active) ≥5(referent)	On a scale of 0 to 10, with 0 being 'doing no sport at all' to 10 being 'very active through sport', where would you rank yourself?	(5-10)	Quantile
<5		(0-4)	
Smoking No(referent)	Did you smoke at all during this pregnancy, including before you were aware that you were pregnant? Yes or No	Not smoking	
Yes		Smoking	
BMI Not obese (referent)	-What is your current weight without clothes? -What is your Height without shoes? BMI calculated by divide weight in kilograms (kg) by height in metres (m).	<25kg·m^{-2}	WHO expert consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *The Lancet,* 2004;363: 157-163.
Obese and over weight		≥30kg·m^{-2} Obese , over weight ≥25 <30kg·m^{-2}	

Variable	Precise wording of UKHLS questionnaire items	Coding	Source/references
SF12PCS Physical health summary(SF12PCS score) Healthiest 50%	Derived variables SF-12 Physical Health component summary(scale 0-100)	>53(referent)	Tested and validated by Quality Metric Incorporated. The SF-12 is weighted and summed to provide easily interpretable scales for physical and mental health. Ware JE, Keller SD, Kosinski M. Sf-12: How to Score the Sf-12 Physical and Mental Health Summary Scales. *Quality Metric Incorporated 1998.*
Least healthy 50%		≤53	
SF12MCS Mental health summary (SF12MCS score) Healthiest 50%	Derived variables SF-12 Mental health component summary(scale 0-100)	>53(referent)	Tested and validated by Quality Metric Incorporated. The SF-12 is weighted and summed to provide easily interpretable scales for physical and mental health. Ware JE, Keller SD, Kosinski M. Sf-12: How to Score the Sf-12 Physical and Mental Health Summary Scales. *Quality Metric Incorporated 1998.*
Least healthy 50%		≤53	

Appendix 3.2 The United Kingdom Household Longitudinal Study (UKHLS)

The UKHLS forms part of the *Understanding Society* study which aims to identify social, economic and health changes in contemporary Britain at the individual and household level. These data can then be used to develop policy interventions that are intended to impact upon the well-being of the UK population as a whole. The *Understanding Society* study is sponsored by the UK's Economic and Social Research Council with additional support from various government departments including Education, Media, Health, and the Environment.

The UKHLS was established by the Institute for Social and Economic Research at the University of Essex in 2009 for the purposes of capturing vital information about social and economic behaviour and health to produce a snapshot of British society in the current era. It surveys participants from approximately 40,000 households in England, Scotland, Wales and Northern Ireland.

The high-quality data from the *Understanding Society* study benefits a range of different groups in various ways. The UKHLS data are analyzed by researchers such as economists, health researchers and social scientists in academic and non-academic institutions who use their findings to better understand changing patterns within British society and draw more accurate conclusions about these. The results are also used by British policy makers to make strategic decisions whilst voluntary, community and commercial organizations draw on these findings to inform the general public about how important socio-economic and health changes are likely to affect the lives and experiences of different communities within the UK.

The initial findings from the UKHLS were published in 2011, followed by the first full set of results in 2012. Three insight reports from the *Understanding Society* study have been published to date in 2014, 2015 and 2016.

Rationale for choosing UKHLS for use in this doctoral research

Given that the objective of this study is to identify sleep patterns in pregnancy and predictors for these, the *Understanding Society* study provides UKHLS datasets that are considered to be representative of contemporary UK society:

- Finding from the systematic review for this study (see Chapter 2) revealed the shortage of sleep research in the UK despite a national increase in the number of sleeping disturbances in the UK.
- The large number of study participants in *Understanding Society* provides the infrastructure for examining different categories within the population, allowing sleep patterns in pregnant women to be assessed among the population.
- The longitudinal design of the UKHLS includes questions about sleep characteristics such as sleep duration and perceived quality of sleep that can be used to identify the sleep patterns of participants. These sleep characteristics are derived from the Pittsburgh Sleep Quality Index (PSQI), a validated self- rating questionnaire which is widely used in the sleep studies to assess sleep quality and disturbances (Buysse et al., 1989).
- Various associations between sleep and socio-demographic characteristics, lifestyle and health predictors can be assessed.

UKHLS samples

The *Understanding Society* survey includes five samples and the sampling technique is illustrated in Figure 3.2.1.

General Population Sample (GPS)

The GPS consists of two parts. The Great Britain (GB) sample design is stratified and clustered, giving equal opportunity for participation in the three nations of England, Scotland and Wales. In the case of Northern Ireland (NI), a systematic simple random sample of household addresses was used.

General Population Comparison Sample (GPCS)

A random sub-sample was conducted for GPC and included in the analysis of the GPS.

From the 2,640 sample sectors selected in the GPS, 60% (1,584) included 18 GPS addresses and the other 40% included 17 GPS addresses and one GPC address. The members in these households were considered to be part of the GPC sample, regardless of their ethnicity.

Innovation Panel (IP):

The IP is used to examine the method of data collection and tools related to the main survey. Its sample design started with 2,760 households derived from 120 areas of England (Buck and McFall, 2011). It shares a similar design to the other samples and followed the same procedures in terms of how it was conducted.

British Household Panel Survey (BHPS)

The BHPS started in 1991 and was a random sample of the UK, excluding the Scottish Highlands and Islands. In 1999, boost samples from Scotland and Wales were included, followed by Northern Ireland in 2001. These alterations intended to improve the analysis of the data in these countries (Buck and McFall, 2011).The BHPS joined the *Understanding Society* study with effect from Wave 2, using the same questionnaire as the GPS. When these were unified, this strengthened the scientific value of the *Understanding Society* data.

Ethnic Minority Boost (EMB)

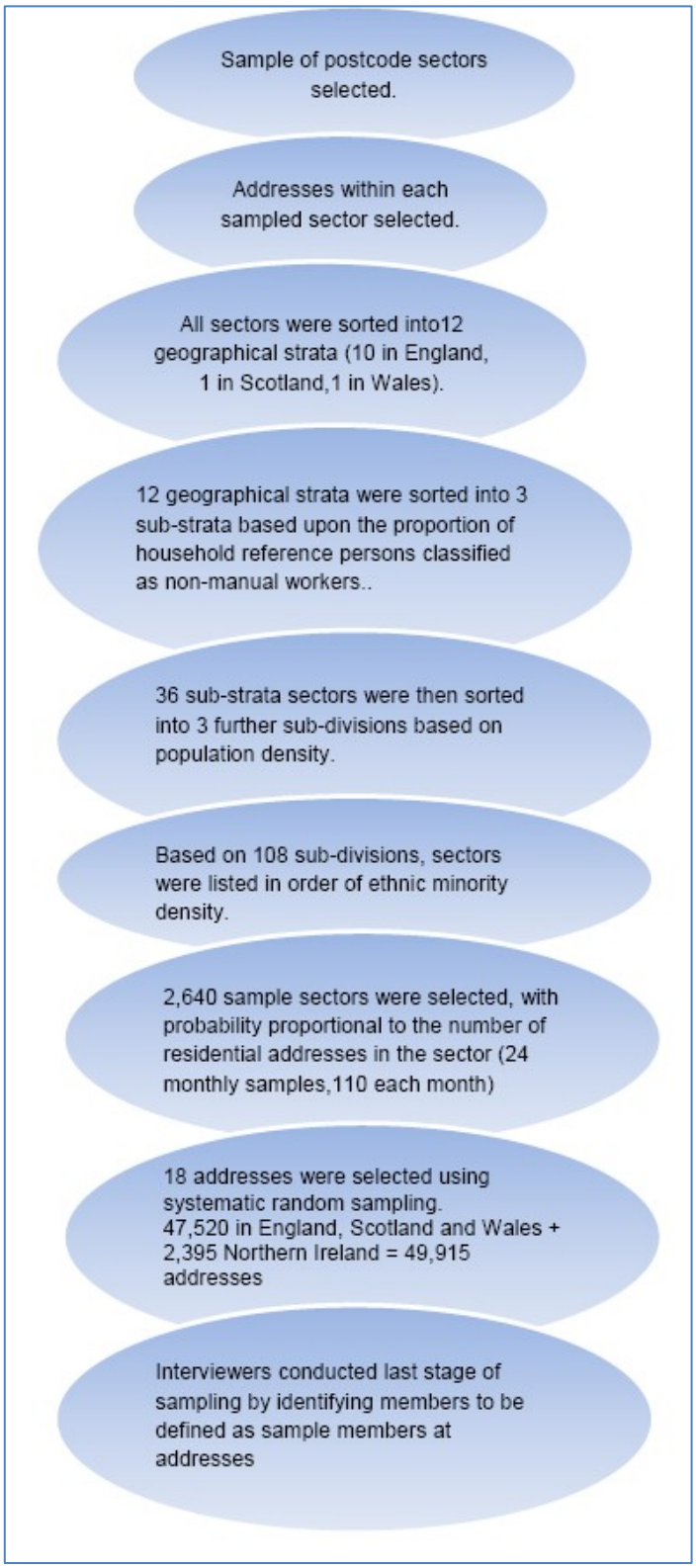
The aim of the EMB sample was to provide at least 1,000 adults from each of the five following groups: Pakistani, Indian, Bangladeshi, African and Caribbean. The sampling approach identified 3,145 postcode sectors with a relatively high density of the relevant ethnic minority groups. These sectors were then classified into four strata based on the number of ethnic minority households to be identified by sampling.

Some 771 postcode sectors (6 in Scotland, 7 in Wales, 758 in England) were selected for inclusion in the EMB sample and sampling differs across the sectors in order to obtain the expected number(Buck and McFall, 2011). EMB interviewees are asked extra ethnicity-related questions e.g. a harassment module was included in Wave 1.

Sample weighting

Sample weighting was designed to control unequal selection probability because some populations include small groups e.g. residents of Northern Ireland, or high proportion for non-response. For all-female sub-groups with certain characteristics, e.g. pregnant or over 50, sample weighting is not required due to less probability of bias.

Figure 3.2.1: sample design in UKHLS



Status of sample members

Three types of membership status exist in the samples used in *Understanding Society*: the Original Sample Members, Temporary Sample Members, and Permanent Sample Members.

1.Original Sample Members (OSMs)

These are members found at selected households in Wave 1. If an OSM gives birth to any children, they too become OSMs, and even if an OSM child moves house, he or she is followed to the new address. They remain potentially eligible sample members for the survey as long as they are living in the UK.

2.Temporary Sample Members (TSMs)

These are members who join the household of an OSM after the sample selection and first interview. TSMs remain eligible for interview as long as they remain co-residents in an OSM or PSM household.

3.Permanent Sample Members (PSMs)

These are TSMs who are followed for interview after they no longer co-reside with an OSM. Any TSM who is the father of an OSM child born after Wave 1 and found living with the child in the survey wave following the child's birth is considered to be a PSM. PSMs remain potentially eligible for interview as long as they are living in the UK.

Collection of UKHLS data

One adult household member, aged 16 or above, is designated at the initial time of data collection to complete the household questionnaire, which is expected to take some 15 minutes. In addition, each adult aged 16 or older participates in a face-to-face computer assessed personal interview (lasting 32 minutes) and a self-completion questionnaire (taking 8 minutes to complete). This questionnaire shifted from paper to computer in Wave 3. Young people, aged from 10 to 15 years of age, answer a youth self-completion questionnaire administered on paper. Information for younger children is provided by a parent in the household. Proxy interviews are used when adults are not able to be interviewed.

From Wave 3 onwards, telephone calls were made at the end of the fieldwork foreach sample month. The questionnaire instruments and survey materials have been translated into different languages to increase response rate (Buck and McFall, 2011).

Data collection time period

For each wave, data collection was administered over the course of a 24-month period, with these periods of time for each Wave overlapping, and the members being interviewed each year at the same time. During each spring of the year before starting the new main survey wave, data was collected from the IP members.

Wave 1 data was collected in the period from January 2009 to December 2011. Wave 2 began in January 2010 for those participants interviewed in the first month of Wave 1, finishing in January 2010. For those interviewed in December 2011, it finished in the following December. Leaving a 12-month gap between each Waves means that change can be captured over time.

Inclusion of biomarkers

Understanding Society began collecting biomarkers with a sample of adults from the GPS in Wave 2. A trained nurse visits the selected household and asks members to provide written consent before measuring height, weight, and blood pressure. A blood test includes lipid profile and glucose. Adding biomarkers to *Understanding Society* allows researchers to identify anthropometric and functional measures within households and how these measures change over time. The Economic and Social Research Council manages access to these samples (Buck and McFall, 2011)

For consenting participants, individual information is passed to the NHS to create a record in the Central Register. Consent also allows data to be linked to some administrative records e.g. the Higher Education Statistics Agency and the Department for Work and Pensions.

Advantages of UKLHS

Longitudinal panel datasets allow researchers to investigate change and the dynamics of individual behavior, meaning they are able to track elements, such as changes in the unemployment rate or in life circumstances or poverty persistence. It also allows them

to create better models to explain behavior, and to understand how current behaviors are influenced by past behaviours, and how prior aspirations and expectations can be related to subsequent outcomes.

Challenges of UKLHS

The real value of panel studies of this kind comes from following individuals and groups over a long period of time. However, often this is not possible because participants are not available for re-interview. This may be due to a range of factors. Participants may pass away or move abroad, making them ineligible for interview. Some participants may refuse to be interviewed or contact with them may be lost

Most institutions running longitudinal household panel studies hold introductory training courses addressed at both new and more experienced users covering a general description of the data as well as hands-on training sessions.

Planned content for *Understanding Society*

This study includes a very wide range of content, meaning it is not possible to repeat all questions for each wave. Instead, content is divided into modules which are included with varying frequency. The questionnaires have already been fully designed and surveys have either been completed or are in the process of being collected up to Wave 7.

A long-term content plan was developed following an extensive consultation on questionnaire content, prior to Wave 1. A further consultation with users on study content took place in 2013 prior to implementation of Waves 6-8 of the study. Input was received from a wide range of data users (including the UK Government, third-sector organizations and academic researchers), and after discussion, the Study's Scientific Advisory Committee and Governing Board, identified five priority topic areas, namely: income, wealth, consumption and expenditure; health wellbeing and health behaviors; employment; education; and the family.

Appendix 3.3 'Model Code' for the DAG summarised in (Figure 3.1)

```
Adults 1 @-0.976,-1.690

Age 1 @-2.592,-2.831

Children 1 @0.698,3.297

Couples 1 @-0.512,2.628

Education 1 @-2.012,-1.120

Employment 1 @2.206,4.153

Ethnicity 1 @-2.642,4.167

Gestational%20age 1 @2.902,-2.774

Parity 1 @0.010,-2.232

Partnership 1 @-1.606,1.929

Pre-existing%20health 1 @1.153,-2.873

Pregnant%2FNonpregnant 1 @2.239,0.404

Sleep 1 @4.021,0.404

Adults Children @-1.159,1.302 Couples @-1.242,0.718
Employment
@0.200,2.029 Parity @-0.678,-2.218 Pre-

existing%20health @- 0.587,-3.002

Pregnant%2FNonpregnant @1.004,-1.790 Sleep

@1.195,-1.747

Age Adults @-1.126,-3.059 Children @-2.418,0.704 Couples @-

2.393,1.345 Education @-2.518,-1.662 Employment @-

2.443,0.476 Parity @-1.324,-2.902 Partnership @-2.443,0.975

Pre-
```

existing%20health @-0.338,-3.515 Pregnant%2FNonpregnant @0.797,-3.686 Sleep @0.880,-3.914

Children Sleep @2.794,2.685

Couples Children @-0.114,3.112 Employment @0.142,4.053 Parity @-0.645,-0.436 Pre-existing%20health @-0.628,-0.650 Pregnant%2FNonpregnant @0.955,1.758 Sleep @2.479,2.670

Education Adults @-1.515,-1.904 Children @-1.822,0.918 Couples @-2.087,0.932 Employment @-0.040,2.115 Parity @-1.324,-2.873 Partnership @-2.186,0.105 Pre-existing%20health @-1.532,-3.472 Pregnant%2FNonpregnant @0.971,-1.163 Sleep @1.095,-1.249

Employment Pregnant%2FNonpregnant @1.891,2.343 Sleep @3.283,2.784

Ethnicity Adults @-2.650,0.675 Children @-0.521,4.238 Couples @-1.374,3.654 Education @-2.775,0.347 Employment @-0.388,5.107 Parity @-2.493,1.103 Partnership @-2.576,2.927 Pre- existing%20health @-2.501,1.545 Pregnant%2FNonpregnant @- 0.255,3.910 Sleep @2.173,5.022

Gestational%20age Sleep @3.499,-1.947

Parity Children @-0.073,1.060 Employment @0.880,1.858 Pre-existing%20health @0.449,-2.774 Pregnant%2FNonpregnant @1.178,- 1.747 Sleep @1.410,-2.275

Partnership Adults @-1.714,-0.294 Children @-0.910,3.611 Couples @-1.291,2.314 Employment @-1.101,4.666 Parity @-1.308,-

0.479 Pre-existing%20health @-0.777,-0.451

Pregnant%2FNonpregnant @0.258,1.958 Sleep

@1.924,2.870

Pre-existing%20health Employment @1.079,1.388

Pregnant%2FNonpregnant @1.800,-1.420 Sleep @2.380,-2.417

Pregnant%2FNonpregnant Sleep @2.695,-0.123

Appendix 3.4 Ethical Approval Letter

UK Data Service

Special Licence

Institute for Social and Economic Research

External
04 February 2014
Version: 04.00

T +44 (0)1206 872572
E susan@essex.ac.uk
ukdataservice.ac.uk

Special Licence – Institute for Social and Economic Research

Definitions

- Licence holder – the principal licence holder and associated parties to this licence specified in sections 1, 2, and 4
- Data depositor – Institute for Social and Economic Research
- Data – the collections detailed in section 8.2 of this licence
- Dispute arbitrator – ESRC

The data to which this Licence, known as a 'Special Licence', permits access are those of the data depositor and are held under 'Special Conditions', as specified in section 5 of the End User Licence (EUL).

This Special Licence specifies the conditions for access for statistical research purposes, the obligations of the researcher/s and the measures for protecting and respecting the confidentiality of statistical data.

The Special Licence grants the licence holder access solely for the purposes specified. The licence holder

- will take all necessary administrative, technical and organisational measures to ensure that the data are used only in the manner stated and for the research purposes specified
- will not process, disseminate or otherwise allow any of the data to be made available or used for any other purpose whatsoever and will remain bound by this obligation even after expiry or termination of the contract
- will not attempt to use these data after the expiry of the Licence
- will guarantee that none of these data are distributed to third parties
- will not attempt to identify by any means whatsoever, any individual statistical unit, nor will the licence holder claim to have done so
- will apply methods and standards specified in this licence for disclosure control for any outputs

Acceptance by the licence holder of the further conditions specified below is required before access to the data is granted

The Licence Holder is advised to read the Completion Notes at the end of the Licence before proceeding.

Special Licence – Institute for Social and Economic Research

Definitions

- Licence holder – the principal licence holder and associated parties to this licence specified in sections 1, 2, and 4
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- will apply methods and standards specified in this licence for disclosure control for any outputs

Acceptance by the licence holder of the further conditions specified below is required before access to the data is granted

The Licence Holder is advised to read the Completion Notes at the end of the Licence before proceeding.

1. PRINCIPAL LICENCE HOLDER

Principal licence holder's details

Name	Employing Organisation	Address of organisation	Position in organisation	Tel. No.	Email
Dr Amal Alghamdi	University of Leeds	Faculty of Medicine and Health University of Leeds Room 8.001e Worsley Building Leeds LS2 9JT	PhD student	0113 34(3 8623)	Ml11a 4aa@l eeds.a c.uk

2. RESEARCH TEAM

Details of each member of the team

Name	Employing Organisation	Address of organisation	Position in organisation	Tel. No.	Email
Dr George Ellison	University of Leeds	Faculty of Medicine and Health University of Leeds Room 8.001e Worsley Building Leeds LS2 9JT	Supervisor	0113 3433 876	g.t.h.el lison@ leeds. ac.uk
Dr Eleanor Scott	University of Leeds	Faculty of Medicine and Health University of Leeds Room 8.001e Worsley Building Leeds LS2 9JT	Supervisor	0113 3437 762	E.M.S cott@l eeds.a c.uk
Dr Graham Law	University of Leeds	Faculty of Medicine and Health University of Leeds Room 8.001e Worsley Building Leeds LS2 9JT	Supervisor	0113 3437 565	G.R.La w@lee ds.ac. uk
Nora Al Afif	University of Leeds	Faculty of Medicine and Health University of Leeds Room 8.001e Worsley Building Leeds LS2 9JT	PhD student	0113 3438 645	ml11n oa@le eds.ac .uk

3. EUL

The licence holder has registered with the UK Data Service and the registration and the EUL have been accepted

☑ (Tick to confirm)

4. RESPONSIBILITY for the licence holder's use of the data

4.1 ORGANISATION with the ultimate responsibility for the licence holder

Name of organisation	Address of organisation
The University of Leeds	Leeds LS2 9JT

4.2 ORGANISATION'S REPRESENTATIVE

The person with the authority to represent the organisation

Name	Organisation	Position in organisation	Tel. No.	Email
Roger Gair	University of Leeds	University Secretary	0113 343 4011	j.r.gair@adm.leeds.ac.uk

4.3 ORGANISATION employing the licence holder (where this is different to 4.1)

Name of organisation	Address of organisation
Same as for 4.1 (above)	

4.4 ORGANISATION'S REPRESENTATIVE

The person with the authority to represent the employing organisation

Name	Organisation	Position in organisation	Tel. No.	Email
Same as for 4.2 (above)				

5. FUNDING: Details of external funding that has been sought

5.1 Organisation funding the research project

Name of organisation	Address of organisation
The University of Leeds	Leeds LS2 9JT

5.2 Funding

The licence holder confirms that funding has been sought ☑ (tick to confirm)

Funding has been obtained: YES

6. SITE OF ACCESS

Name of organisation	Address of organisation
The University of Leeds	Room 8.001e, Worsley Building, Faculty of Medicine and Health, University of Leeds, Leeds LS2 9JT

7. DURATION OF ACCESS

Period of access specified must not exceed 2 years

From 15/03/2105 dd/mm/yy

To 15/03/2017 dd/mm/yy

(If it is necessary to extend the period of access, application must be made to the UK Data Archive prior to the expiry of the Licence)

8. TITLE OF RESEARCH PROJECT including UK Data Archive usage number

Sleep and pregnancy outcomes (**84718**)

8.1 Where research is part of a larger programme, please give details

This research forms part of ongoing research undertaken by the TIME (Temporal Influences on Metabolic Events) Research Group. Currently we are studying sleep and its influence on pregnancy and vice versa.

8.2 Title of the dataset(s) and the study number(s) to which access is required

Title of dataset	Study number
Understanding Society: Waves 1-4, 2009-2013: Special Licence Access	**SN: 6931** **Persistent identifier:** 10.5255/UKDA-SN-6931-4

9. PURPOSE FOR ACCESS

9.1 Details to include:

(i) A brief summary of up to 200 words describing the aims of the study/research project

Aim:

To identify

1. Patterns of sleep in pregnant women compared to the general population using latent class analysis and women identified as pregnant in Waves 1 and 4
2. Possible predictors of sleep patterns in the pregnant women (e.g. maternal age, education, multiple pregnancies, gestational age...etc)
3. Possible influences of different sleep patterns on maternal and foetal pregnancy outcomes (e.g. assisted delivery, birth weight, still birth, preterm delivery... etc)

(ii) Full description of the purpose/s for which the data are requested

It has previously been described that sleep is influenced by the trimester of pregnancy in which it is measured, due to hormonal, physiological, metabolic and anatomical causes. However in the open-access Understanding Society data set there is no variable available to identify the gestational age at which the sleep questionnaires were answered by pregnant women. In order to identify the gestational age (and generate a "month of gestation" derived variable, we have devised the following equation:

"month of gestation" = month of birth/year of birth minus month of interview/year of interview

Month of birth/ year of birth for babies of women who are pregnant in Wave 1 are found in the Wave 2 dataset; whilst those of women who are pregnant in Wave 4 will be found in the Wave 5 dataset (when this becomes available shortly).

The "month of gestation" derived variable will be used as:

1- a covariate in the latent class analysis to assist in predicting sleep patterns
2- an exposure when identify the sleep predictors for sleep patterns (clusters) in pregnancy
3- a confounder or competing exposure when examining the association between sleep patterns (clusters) and pregnancy outcomes

(iii) A justification as to why access to the special conditions version of the data is needed and why data available under the EUL is not sufficient for the purposes

In the open-access Understanding Society data set there is no variable available to identify the gestational age at which the sleep questionnaires were answered by pregnant women. In order to identify the gestational age (and generate a "month of gestation" derived variable, we have devised the following equation:

"month of gestation" = month of birth/year of birth minus month of interview/year of interview

Month of birth/ year of birth for babies of women who are pregnant in Wave 1 are found in the Wave 2 dataset (b_lchbm and b_alchby); whilst those of women who are pregnant in Wave 4 will be found in the Wave 5 dataset (when this becomes available shortly).

9.2 A description of the analyses that will be performed on the data

To identify variation in/clusters of sleep patterns in pregnancy we will use:

a) Data: pregnant women's data from Wave 1 and Wave 4
b) Variables (model predictors): sleep data + gestational age
c) Analysis: latent class analysis using LatentGold 4.5

To identify the predictors of sleep patterns we will use:

a) Data: pregnant women data from Wave 1 and Wave 4
b) Variables:
   - Outcomes sleep clusters (identified from the latent class analysis)
   - Exposures: gestational age, maternal age, maternal SES, household compositions...etc
c) Analysis: general linear regression modelling

To identify the association between sleep patterns and pregnancy outcomes we will use:

a) Data: pregnant women's data from Wave 1 and Wave 4
b) Variables:
   Exposure: sleep clusters (identified from the latent class analysis)
   Outcomes: maternal and foetal outcomes; caesarean delivery; birth weight; preterm delivery; still birth
   Analysis: general linear regression modelling (adjusted for: gestational age, presence of multiple pregnancies, alcohol and smoking ..etc)

10. USE OF THE DATA FOR COMMERCIAL GAIN

All signatories (other than the data depositor and the UK Data Archive) guarantee that these data will not be used for personal or commercial gain. The focus of the project is statistical research/analysis and the data will not be used for any other purpose.

[Statistics arising from the use of these data can be used for any purpose, subject to meeting the standards for disclosure control detailed in section 11]

11. PRODUCTS and PUBLICATIONS

11.1 Protecting confidentiality

The licence holder is aware that the microdata may allow individuals to be identified. Any outputs made available to anyone other than those named on the Licence, must meet the guarantee contained in the Code of Practice for Official Statistics and the Protocol on Data Access and Confidentiality, namely that no statistics are produced that are likely to identify an individual, unless specifically agreed with them.

The following rules will allow the guarantee to be kept in most cases. However, it is the responsibility of the licence holder and all signatories (other than the data depositor and UK Data Archive) to consider and protect against any other circumstances that might result in the disclosure of the identity of an individual.

11.2 Disclosure Protection

The licence holder will apply the supplied methods and standards below for disclosure control for any outputs released beyond the research team.

The licence holder will avoid small sample base numbers because they will be unreliable. For example, percentages based on small counts will have very wide confidence intervals.

Supplied methods and standards:

(i) Tables that contain very small sample numbers in some cells may be disclosive. The licence holder will ensure that tables do not report numbers or percentages in cells based on only 1 or 2

cases. Cells based on 1 or 2 cases should be combined with other cells or, where this is not appropriate, reported as 0 percent.

(ii) The licence holder will ensure that all tables report weighted values, where weights are available.

(iii) Tables and other outputs derived from data accessed through a Special Licence will not be published in a form where the level of geography would threaten the confidentiality of the data. Typically, outputs with a geography of region or greater can be considered safe.

Outputs with a geography between Local Authority and region can in some circumstances introduce disclosure risk. Where there is any doubt, the licence holder must contact the UK Data Archive to gain confirmation of the confidentiality of any outputs for publication with geography below region.

No outputs will be published with a geography below local authority.

(iv) Although most outputs from models or other statistical analysis will not be disclosive, the licence holder will ensure that individuals, households or organisations cannot be identified. In particular, results based on very small numbers should be avoided. Any result that refers to unit records, e.g. a maximum or minimum value should not be published. Models should not report actual values for residuals

(v) Graphical outputs should be based on non-disclosive data. The licence holder will take particular care not to report extreme outliers.

11.3 Intended outputs / publications arising from the use of these data

PhD theses (Alghamdi and Al Afif) and related academic publications in peer-reviewed journals.

11.3.1 The data depositor reserves the right to comment on statistical issues raised by publications and to scrutinise outputs before publication for disclosure control purposes. Where the data depositor so requires, the licence holder must supply the data depositor with a copy of any proposed publication, based wholly or in part on the data collections accessed, to enable the data depositor to consider it and comment as regards compliance with the conditions for disclosure protection and for changes to be made to the publication in the light of those comments.

The licence holder will make any [reasonable] changes that are required by the data depositor in order to make the proposed publication comply with these conditions.

11.3.2 The licence holder must supply to the UK Data Archive the bibliographic details of any published work based wholly or in part on the data collection/s accessed. Details are to be provided on publication.

12. MINIMUM INFORMATION REQUIRED

The licence holder confirms that access to the data is required in order to meet the aims of the project and that the access is proportionate and not excessive to the stated statistical purpose.

13. MATCHING or LINKING

Under this Licence, it is forbidden to match or attempt to match individual or household records to any other data source at the level of individual or household. Only area-level descriptors or other group-level classifications may be matched for analysis purposes.

14. DUPLICATION

The licence holder agrees that:

14.1 Any intended duplication of the data will only be for the purpose of making personal copies to aid their own research and analysis

14.2 No duplication of the data for any other purpose may take place.

15. EXPIRY OF ACCESS PERIOD

15.1 At the end of the access period, the licence holder agrees to destroy all copies of the data, including temporary copies, CDs, printed copies, personal copies, back-ups, derived datasets and all electronic copies.

15.2 The licence holder will ensure that the data are destroyed to the standards specified in the document *Microdata Handling and Security: Guide to Good Practice (link attached)*

15.3 After expiry of this Licence, the licence holder will sign and send to the UK Data Archive, a declaration to confirm that all copies of the data have been destroyed and to the required standards, or that the data have been returned to the UK Data Archive for destruction.

16. SECURITY OF THE DATA

The licence holder guarantees to preserve at all times the confidentiality requirements associated with the data and to meet the conditions specified in the EUL. Wrongful disclosure will attract penalties as detailed in section 17 below and outlined in the document *Microdata Handling and Security: Guide to Good Practice.*

Confidentiality requirements:

The licence holder will ensure that

16.1 Access to the data, any copies made of the data and the information contained in them is limited solely to the person who has signed this Licence and the research team, who have also signed the Special Licence.

16.2 The confidentiality of the data will be preserved in outputs and publications, as detailed in section 11.

16.3 The means of access to the data (such as passwords or pass-phrases) are kept secure and not disclosed by the Licence Holder or any member of the research team to any other individual, under any circumstances.

16.4 Data will only be accessed, in an institutional setting, via a stand-alone PC or a closely controlled LAN with restricted access. Access to the PC or LAN will be via password or pass-phrase.

16.5 Hard copies and backups of data are to be stored in a secure, access restricted filing cabinet

16.6 Stand-alone PCs and LANs, which have Internet access via broadband connection (and not through a secure organisational provider, e.g. JANET), will not have live Internet links while the data are in clear/unencrypted text on the machine. At such times the Internet will be disconnected and the broadband cable will be physically disconnected from the PC.

16.7 Stand-alone PCs and LANs, which have Internet access via dial-up telephone connection (and not through a secure organisational provider, e.g. JANET), will not have live Internet links while the data are in clear/unencrypted text on the machine.

16.8 Data requested under the Special Licence will only be accessed at a site that has security standards that meet the requirements outlined in the document *Microdata Handling and Security: Guide to Good Practice.*

16.9 Data will not be accessed at a private residence

16.10 The University of Essex and the data depositor reserve the right to conduct an on-site audit of the confidentiality and security procedures and practices for guaranteeing the security and confidentiality of the data covered by this Licence, or to require a report of such an audit.

16.10.1 For the purpose of conducting an audit, the University of Essex (or the UK Data Archive, on behalf of the University of Essex) or the data depositor may enter the premises where the data are stored and processed without notice at any reasonable time. The organisation with ultimate responsibility for the licence holder undertakes to allow the University of Essex or data depositor access for this purpose.

16.10.2 The data depositor further requires that the organisation with ultimate responsibility for the licence holder provides to the UK Data Archive, copies of any audits of these arrangements, conducted for the organisation or the licence holder, during the period of the Licence, including any audit implementation plans.

17. BREACH PROCEDURES

17.1 Any breach of any of the provisions of this Licence will result in the immediate termination of the licence holder's access to the data, the termination of the licence and the prohibition of any further access to the data depositor's data via the Special Licence. It will also lead to immediate termination of the services provided by the UK Data Archive data team, either permanently or temporarily (as stated in section 16 of the EUL)

17.2 The breach of any of the provisions of this Licence may result in sanctions being sought against the licence holder. These may include legal proceedings being taken by the data depositor for breach of obligations under statute or common law.

[Details of sanctions that may be sought can be found in the Completion Notes, section 2, 17.]

17.3 The licence holder is required to report promptly a breach of any of the terms of the Licence. Failure to disclose details is a fundamental breach of this Licence.

18. DISPUTE PROCEDURES

Any disputes arising from the use of the data and/or the terms of this licence will be resolved initially between the UK Data Archive, on behalf of the University of Essex and the principals to the agreement (the Licence holder and the organisation with ultimate responsibility for the Licence holder). Otherwise, outstanding issues will be referred to the dispute arbitrator.

19. AGREEMENT

19.1 The licence holder and, where the research project is undertaken by a research team, all members of the research team, agree/s to:

(i) comply with the terms and requirements of this Special Licence.

(ii) comply with any additional conditions that the data depositor may consider necessary before approving this Special Licence. Such conditions will be added to the Licence by the data depositor, at the time of approval, and notified to the licence holder by the UK Data Archive upon receipt of approval from the data depositor. Downloading the data by the Licence Holder will signify acceptance of such additional conditions.

(iii) continue to meet the terms of the End User Licence (EUL). Where there is disparity between the EUL and the Special Licence, the Special Licence will take precedence, unless identified explicitly in writing.

(iv) read the document *Microdata Handling and Security: Guide to Good Practice* and abide by the principles for use of the data, detailed therein.

19.2 The licence holder and, where the research project is undertaken by a research team, all members of the research team, understand/s:

(i) should circumstances require, the Licence may be terminated or suspended, access to the data terminated or suspended, or the terms of the Licence altered, by a member of the Data Team (as defined in the EUL) or by the data depositor. This may take immediate effect, or after a period of 30 days notice.

(ii) the principles of the Freedom of Information Act apply and nothing provided in this Licence is confidential to the licence holder or to the data depositor. To disclose the details of the Licence would not be a breach of any duty of confidence and therefore the details would be made available to the public on request and may be included as part of the metadata attached to any of the outputs arising from the access.

(iii) these data are provided in good faith and, to the best of the data depositor's knowledge and ability, are free of error at the time of supply. The data depositor and the UK Data Archive will not be responsible for any errors, omissions or mistakes contained in the users' dataset nor for any consequences or liabilities arising therefrom. The data depositor's liability shall be limited to re-supply of corrected materials.

19.3 The signatories believe that the Licence is compliant with the statements of principle in the Code of Practice for Official Statistics (the Code) and the specific requirements of the Protocol on Data Access and Confidentiality (PDAC). Where this Licence may appear to contradict the statements of principle in the Code or the specific requirements of the PDAC, the Code and the PDAC take precedence, unless explicitly stated.

Code of Practice for Official Statistics:

http://www.statisticsauthority.gov.uk/assessment/code-of-practice/index.html

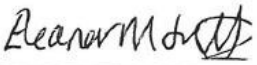
National Statistics Protocol on Data Access and Confidentiality:

http://www.ons.gov.uk/ons/guide-method/the-national-statistics-standard/code-of-practice/protocols/index.html

20. SIGNATURES

20.1 Licence holder and research team

Name of licence holder	Signature of licence holder	Date
Dr Amal Alghamdi		24-3-2015

Names of Research Team members	Signatures of Research Team members	Date
Nora Al Afif		24-3-2015
Dr George Ellison		24-3-2015
Dr Eleanor Scott		24-3-2015
Dr Graham Law		24-3-2015

20.2 ORGANISATION WITH RESPONSIBILITY FOR THE LICENCE HOLDER

The UNIVERSITY OF LEEDS (name of organisation) undertakes to accept ultimate responsibility for the licence holder's access to the data stated above

Name of organisation's representative	Signature of organisation's representative	Date
Roger Gair		24-3-2015

20.3 ORGANISATION WITH RESPONSIBILITY FOR THE LICENCE HOLDER (as employer) (complete where this is different to 20.2)

The .....(name of organisation) undertakes to accept responsibility for the licence holder's access to the data stated above, as the employing organisation.

Name of organisation's representative	Signature of organisation's representative	Date
Same as 20.2 (above)	Same as 20.2 (above)	

21. APPROVAL

21.1 UK Data Archive

The UK Data Archive, on behalf of the University of Essex, have screened the request and confirms that it meets the terms of the agreement between the data depositor and the University of Essex for access to these data.

Name of UK Data Archive representative	Signature of UK Data Archive representative	Date
M.A.WARD	M A Ward	13/4/15

21.2 Approval of the data depositor

The data depositor confirms that the access complies with any undertaking made at the time of collection or the scope of any consent given.

The data depositor authorises the provision of access to these data to the licence holder under the terms specified in this Special Licence, including any additional conditions imposed by the data depositor, as stated below:

Additional conditions of access:

Name of representative for the data depositor	Signature of representative for the data depositor	Date
Jakob Petersen	Digitally signed by Jakob Petersen DN: cn=Jakob Petersen, o, ou, email=jpeterb@essex.ac.uk, c=GB Date: 2015.04.13 15:30:41 +01'00'	

COMPLETION NOTES

1. General notes:

1. The Special Licence is to be used for access to data of the data depositor that are subject to special conditions and controlled access arrangements.
2. Approval to access the data is conditional upon the Licence Holder, any other named users and the 'responsible' organisation, agreeing to the terms and special conditions detailed in the Special Licence.
3. The data depositor retains the right of veto and may refuse access to the data requested by the Licence Holder. Such decision will be communicated to the Licence Holder by the UK Data Archive, together with the reason for the decision.
4. The Special Licence is to be completed by the Licence Holder, who will be the researcher requiring access to the data stated for a specific research purpose, for a time limited period. Where the researcher is part of a research team, the Licence Holder will be the head of the research team.
5. Parties to the Special Licence, who will be bound by the terms of the Licence, include:

   (i) Licence Holder

   (ii) Members of a research team, who must be identified and, in addition to the Licence Holder, will sign the Licence

   (iii) Organisation with the ultimate responsibility for the Licence Holder and any members of a research team (section 4 on the Licence and point 4 below)

   (iv) Employing organisation, where this is organisation is different to (iii)

   (v) The data depositor

6. Signatories to the Special Licence:

   (i) Licence Holder

   (ii) All members of a research team

   (iii) Representative for the organisation with ultimate responsibility for the Licence Holder and any research team (see point 4 below)

   (iv) The representative of the employing organisation, where this is organisation is different to (iii)

   (v) Representative for the UK Data Archive

   (vi) Representative for the data depositor

7. Names/details of organisations to be included on the Special Licence, in addition to those listed in section 5 above:

   (i) Where the research is being externally funded, the name of the funding organisation

8. All information is to be given in plain English and full explanations are to be given where unfamiliar terminology is included.
9. Details provided are to be full, coherent and concise.
10. Failure to provide adequate or comprehensive details will result in the Licence being returned to the applicant. This will delay the process and will also require the re-gaining of signatures to confirm the additional information provided.The Licence Holder will not make any changes to the format and content of the clauses of the Special Licence. Changes will be identified, will delay the process and

may result in the Special Licence being withdrawn

2. Guidance on individual sections:

SECTION	NOTES
1 Licence holder details	(i) The organisation to be entered is the licence holder's employer (ii) The addition of address and telephone number information is not mandatory.
2 Research team	Where access to the data is requested by a Research Team, the Special Licence is to be completed by the lead researcher who will be the licence holder. The name/s of the other member/s of the research team are to be entered in section 2.
3 The End User Licence (EUL)	Request for access to Special Licence data is conditional upon prior registration with UK Data Service and acceptance of the EUL.
4 Responsibility for the licence holder	(i) The organisation to be entered is that which has the ultimate responsibility for the licence holder's use of the data. This is not necessarily the organisation that employs the licence holder. (ii) The name to be entered is that of the person with the authority to represent that organisation: (Sections 4.2 & 20.2) See table below for further details * Supervised use of the data: Where the Licence Holder's use of the data is supervised, as may be the case with PhD students, the Supervisor is to be a member of the research team and their details included as requested in section 2.
5 Funding	Where the research is not subject to funding, enter 'N/A'.
6 Site of access	Special Licence data may not be accessed at a private residence. Data may only be accessed in an institutional setting, i.e. the site of the licence holder's employment, the site of the organisation with the ultimate responsibility for the licence holder, or the site of the funding or commissioning organisation.
7 Duration of access	The period of access stated should not be longer than the time required for conducting the research and producing outputs, with a maximum period of 2 years. Where it is necessary to extend the period of access, the Licence Holder should contact the UK Data Archive (the Archive), Support Services, in advance of the expiry of the period of access. Support Services will provide advice on the action to be followed.
8 The Research Project	(i) Where a research project does not have a usage number, the Licence Holder is to contact the Archive's Support Services, for guidance (ii) Details are to be included where a project is part of a larger programme or funded jointly by various organisations (iii) Access can only be requested to dataset/s that are currently available through the Archive catalogue and have a study number. Where the research project requires access to other data that are not

	in the catalogue, contact is to be made with the Archive for advice.
9 Purpose for access	Data held under the Special Licence are only to be accessed for statistical research purposes.
10 Use of the data for commercial purposes	The purpose for which the data are required must be statistical and the focus of the research, the resultant analysis. The prime focus for accessing the data must not be for the purpose of personal or commercial gain.
11 Products and Publications	(i) The licence holder agrees to ensure that disclosure control methodology, applied to outputs, is sufficient to ensure so that 'it would take a disproportionate amount of time, effort and expertise for an intruder to identify a statistical unit to others, or to reveal information about that unit not already in the public domain'. (Extract from the National Statistics Protocol on Data Access and Confidentiality) (ii) Where the data depositor requires sight of proposed outputs before publication, the data depositor will endeavour to comment and respond within one week of receipt. However, should circumstances require further discussion and investigation, the data depositor will notify the Archive with the minimum of delay and will be sensitive to licence holder's commitments and publication deadlines. (iii) Where the Licence Holder has any doubts about maintaining the confidentiality of the data in the outputs, contact is to be made with the Archive's Support Services, who will contact the data depositor for advice and guidance.
12 Minimum information required	Access to the data must be proportionate to the stated statistical purpose. As part of the approval process, the data depositor requires this assurance and will take into account the researcher/organisation benefiting from the access, the type of information being accessed, the method of access, the researcher's needs and the purpose for the research.
13 Matching or Linking	Where the Licence holder wishes to conduct a matching or linking exercise that would breach the terms of the Special Licence, the Licence Holder must contact the Archive before proceeding. The Archive will contact the data depositor for a decision.
14 Duplication	(i) The Licence Holder may take personal copies of the data to assist with the specified research and analysis. However, the Licence Holder is prohibited from taking copies for any other purpose. (ii) At the end of the period of access, all copies of the data, in whatever format made, must be destroyed. See section 15 below.
15 Expiry	At the expiry of access period, the Licence Holder must agree to destroy the data and all copies made in the manner specified in the document *Microdata Handling and Security: Guide to Good Practice.*
16 Security	Data may only be accessed according to the security conditions detailed in section 16 of the Special Licence. Licence holders must note the instructions in the document *Microdata Handling and Security: Guide to Good Practice* and are reminded that: (i) Data will be encrypted during transmission. However, when the

	licence holder accesses the data, it will appear as clear, plain unencrypted text in the format selected by the licence holder, i.e. SPSS, STATA or ASCII. At such times, the licence holder must ensure that, for PCs that have Internet access via broadband or telephone dial-up connection (and not through a secure organisational provider, e.g. JANET), the Internet is disconnected. For Broadband/internet connections, cables are to be physically disconnected from the PC. (ii) Where Internet access is through a 'secure organisational provider', it is not necessary to physically disconnect cables or disable internet systems. If there is any uncertainty as to whether an 'organisational provider' is 'secure', contact the Archive's Support Services with details of the system that is in place. (iii) Licence holders are reminded that data may not be accessed at a private residence. (iv) The data depositor and the University of Essex (or the Archive on behalf of the University of Essex) reserve the right to conduct an audit and to enter premises for this purpose. The licence holder is advised to bring this requirement to the attention of the individual with the authority to represent the organisation, before that individual and the licence holder sign the Licence.
17 Breach Procedures	The licence holder is reminded that a breach of any of the terms of this Licence must be reported promptly to the Archive. Failure to do so is a fundamental breach of the Licence. Sanctions that may be applied: 1. For a first offence, the penalty should be a minimum twelve-month non-discretionary suspension from access to any micro-data, applicable to the individual in question. It would generate a written warning to the institute. 2. An individual's second breach would, as a minimum, result in a suspension of access of two to five years, or permanently, on the individual, and would generate a written warning to the individual's institution. 3. If the individual has moved institutions between first and second breaches, the new institution will receive an advisory letter to include details of the 1st breach. 4. Any discretionary penalty may be decided, including permanent suspension for the individual or other staff in the relevant department, and/or pursuing in the Courts an action for breach of contract. 5. Where the breach is the result of an institution's wilful or negligent action, then a minimum penalty of a twelve-month non-discretionary suspension shall apply to the relevant department within the institution. Repeated breaches will result in a letter with discretionary penalties to the institution as a whole including suspension of all data access facilities for all the institution's staff and/or an action for breach of contract. 6. The consequences of any suspension of access (such as consequent inability to honour research contracts) will not be taken into consideration when applying minimum penalties or any of the Archive's (or, for ONS data, the National Statistician's) discretionary penalties.

	7. Any appeal will be to the Archive in the first instance and may be referred to the dispute arbitrator.
18 Dispute Procedures	The Archive acts as data custodian for the data deposited at the Archive by the data depositor. Therefore, where there is a dispute arising from the use of the data and/or the terms of the Special Licence, it will be resolved initially between the Archive the licence holder and the 'responsible' organisation.
19, 20 & 21 Agreement and Approval of the Special Licence	Please see the 'General Notes' above

*** Further information**

Responsibility for the Licence holder's use of the data

Commissioning / funding organisation	**Organisation's Representative**
GSS	Head of Profession
Government Department	Head of Directorate or Division responsible for statistical analysis and research
University	Either: (i) Chair of the University Ethics Committee (ii) Director of Research (iii) Head of Department
Local Authority / Other bodies	Either: (i) Head of Directorate or Division responsible to the organisation for statistical analysis and research (ii) Person with authority to enter the organisation into a contract and with institutional responsibility for the actions of licence holder (iv) Person with the authority to take ultimate responsibility for the use of the data, the actions of the licence holder, breach of the terms of the Licence and any sanctions arising therefrom, i.e. the person who signs the Special Licence in this capacity will have the responsibility to enter their institution into an agreement that carries penalties for misuse and breach of the terms of the Licence that will impact both upon the institution and the licence holder.

Appendix 4.1 Dagitty Model Code for the causal path diagram summarised in (Figure 4.1)

Adults 1 @-1.529,-1.171

Age 1 @-2.724,-2.949

BMI 1 @2.376,3.257

Bread 1 @1.914,-1.258

Children 1 @-0.405,3.232

Couples 1 @-1.082,3.107

Education 1 @-2.087,-0.487

Employment 1 @0.272,3.257

Ethnicity 1 @-2.660,4.152

Fruit 1 @1.914,-0.487

Gestational%20age 1 @0.474,-1.554 Health U @3.399,2.508

Lifestyle U @1.021,-0.014 Milk 1 @1.906,-2.042

Obstetric%20changes U @0.789,-3.157 Parity 1 @-1.035,-1.743

Partnership 1 @-1.768,2.771

Pre-existing%20health 1 @-0.270,-2.315

SF12 1 @3.822,1.707

Sleep 1 @4.169,0.757

Smoking 1 @1.941,1.956

Sport 1 @1.930,1.180

Vegetables 1 @1.930,0.346

Adults BMI @-0.397,2.473 Children @-1.608,1.130 Couples @- 1.895,0.881 Employment @-1.529,0.645 Health @-0.935,3.033 Lifestyle @-0.262,-0.114 Parity @-1.632,-1.780 Pre- existing%20health @-1.035,-0.549

Age Adults @-2.166,-1.221 BMI @-2.023,0.732 Children @- 1.975,2.187 Couples @-2.350,2.187 Education @-2.429,-0.910

Employment @-1.059,-1.905 Health @-0.703,3.614 Lifestyle @1.228,-3.088 Parity Partnership @-3.065,2.508 Pre- existing%20health @-0.835,-2.228 Sleep@3.267,-3.240

BMI Health @2.778,3.006 Sleep @4.419,3.503 Bread BMI @2.512,0.463 Sleep @3.763,-3.061

Children BMI @1.112,4.318 Employment @-0.174,3.257 Health @0.490,4.083 Lifestyle @-0.572,1.080 Sleep@1.510,1.417

Couples BMI @0.863,4.982 Children @-0.788,2.299 Employment @-0.796,2.112 Health @1.510,4.830 Lifestyle @-0.549,0.483 Parity @-1.385,0.520 Pre-existing%20health @-1.043,-0.151 Sleep @3.035,0.892

Education Adults @-1.871,-0.766 BMI @-0.309,2.585 Children @-1.871,1.403 Couples @-2.270,1.565 Employment @- 1.433,2.050 Health @-0.102,4.065 Lifestyle @-0.596,0.968

Parity @-2.158,-1.233 Partnership @-2.397,1.888 Pre- existing%20health @-0.939,-0.014 Sleep@0.830,1.389

Employment BMI @1.477,3.572 Health @1.717,3.337 Sleep @1.435,1.375

Ethnicity Adults @-3.081,-0.739 BMI @1.054,4.028 Children @-1.258,3.779 Couples @-1.704,3.543 Education @-2.833,0.159 Employment @-0.046,3.878 Health @2.807,4.127 Lifestyle @- 1.871,0.073 Parity @-1.913,0.090 Partnership @-1.959,3.455 Pre-existing%20health @-1.921,-0.255 Sleep @4.225,4.674

Fruit BMI @2.388,1.431 Health @3.026,-0.117 Sleep @3.556,- 3.223

Gestational%20age Obstetric%20changes @0.524,-2.466 Health SF12 Sleep @4.261,2.729

Lifestyle BMI @1.013,3.443 Bread @1.149,-1.544 Fruit @1.420,-0.412 Health @1.021,2.550 Milk @0.902,-2.203 Sleep @1.046,1.292 Smoking @1.045,2.373 Sport @1.021,1.391 Vegetables @1.372,0.359

Milk BMI @2.703,-0.158 Health @3.175,-0.297 Sleep @4.034,- 2.713
Obstetric%20changes BMI @0.292,2.702 Health @3.225,-2.231 Lifestyle @0.731,-1.513 Sleep @4.079,-3.682
Parity BMI @-0.214,1.316 Children @-1.337,0.384 Employment @-1.146,-0.064 Health @-0.305,3.862 Lifestyle @-0.564,- 0.151 Pre-existing%20health @-0.947,-2.203 Sleep @1.197,- 2.999
Partnership Adults @-2.063,0.682 Children @-0.620,2.075 Couples @-1.353,2.572 Employment @-0.748,1.913 Lifestyle @- 0.756,0.371 Parity @-1.648,-0.002 Pre-existing%20health @- 1.441,-0.450
Pre-existing%20health BMI @-0.278,2.324 Children @- 0.851,0.384 Employment @-0.564,1.080 Health @-0.653,2.716 Lifestyle @0.240,-1.358 Sleep @2.265,-2.415 SF12 Sleep @4.129,1.714

Smoking BMI @2.272,1.914 Health @2.595,1.154 Sleep@2.878,- 2.813
Sport BMI @2.338,1.831 Health @2.604,0.671 Sleep @2.562,- 0.877
Vegetables Health @3.035,0.532

Appendix 5.1: Precise wording for the derived variables used in UKHLS/GDM 'at risk' sample questionnaire items,with coding and sources,refrences.

Variable	Precise wording of UKHLS/GDM 'at risk' sample questionnaire items	Coding	Source/refrences
<u>Sociodemographic variables</u> ***Age group*** 16-23 24-31 32-39 40-48	**UKHLS:** What is your date of birth**?** **GDM 'at risk' sample:** Your date of birth?	In binary coding: ≤30 (referent) and >30.	Quantile

Variable	Precise wording of UKHLS/GDM 'at risk' sample questionnaire items	Coding	Source/refrences
Ethnicity-based DM risk Low risk(referent) Ethinic majorities	**UKHLS:** Do you come from, or have parents or grandparents from any of the following ethnic groups? *See categories in the next column.* **GDM 'at risk' sample:** Information about your ethnic group to select from the list? *See categories in the next column.*	"White"	Labour force survey ethnicity classification Smith A. The new ethnicity classification in the Labour Force Survey. *Labour Market Trends.* 2002; **112:** 657-66
Ethnicity-based DM risk High risk Ethinic manorities		"Asian", "Bangladeshi", "Pakistani", "Indian", "Middle east" , "Mixed black" , "Black African", "Black Caribbean" , "Mixed White and Black", "others".	

Partnership status Partner	**UKHLS:** What is your legal marital status? *See categories in the next column.* **GDM 'at risk' sample:** Choose from the list? *See categories in the next column.*	"Partner", "married".	

Variable	Precise wording of UKHLS/GDM 'at risk' sample questionnaire items	Coding	Source/refrences
No Partner(referent)		"Single", "divorced".	
Parity Nulliparous(referent)	**UKHLS:** Relationships in the household? *Natural parent, step parent, foster parent, parent-in-law, none.* **GDM 'at risk' sample:** Number of previous pregnancies? Number of live birth?		
Multiparous			
Pre-existing physical health conditions None(referent)	**UKHLS:** Has a doctor or other health professional ever told you that you have any of these conditions? *See categories in the next column.* **GDM 'at risk' sample:** Have you ever had any of the following? *See categories in the next column.*	No physical health conditions Diabetes	

Variable	Precise wording of UKHLS/GDM 'at risk' sample questionnaire items	Coding	Source/refrences
Pre-existing physical health conditions One or more		**UKHLS physical health conditions including:** Asthma, Arthritis, Congestive heart failure, Coronary heart disease, Angina, Heart attack or myocardial Infarction, Stroke, Emphysema, Hyperthyroidism or an over-active thyroid, Hypothyroidism or an under-active thyroid, Chronic bronchitis, Any kind of liver condition,Cancer or malignancy, Epilepsy, High blood pressure. **GDM 'at risk' physical health conditions including:** Asthma, Epilepsy, High blood pressure, Sickle cell anaemia, Hyperthyroidism, Liver disease, Kidney disease, Antiphospholipid.	

Variable	Precise wording of UKHLS/GDM 'at risk' sample questionnaire items	Coding	Source/refrences
Pre- existing psychological health conditions None(referent)	**UKHLS:** Has a doctor or other health professional ever told you that you have any of these conditions? *See next column.* **GDM 'at risk' sample:** Have you ever had any of the following? *See next column.*	No mental health conditions	
One or more		**UKHLS mental health conditions including:** Depression **GDM 'at risk' mental health conditions including:** Anxiety, Depression, History of self harm, Postnatal depression.	

Variable	Precise wording of UKHLS/GDM 'at risk' sample questionnaire items	Coding	Source/refrences
Gestational Age First trimester	**UKHLS:** (See chapter 3) **GDM 'at risk' sample:** based on the ID number for study sample which between 1-193 were collected during 19 weeks at first antenatal clinic visit which is the second trimester. ID number over 168 were collected at ≥32 weeks (third trimester)	≤12 weeks	WebMD updated in 2015 *http://www.webmd.com/baby/tc/pregnancy-your-first-trimester#1*
Second trimester (referent)		13-27 weeks	Second trimester (referent)
Third trimester		>27 weeks	Third trimester

<u>Life style and health variables</u> ***Smoking*** No (referent)	**UKHLS:** Did you smoke at all during this pregnancy, including before you were aware that you were pregnant? Yes or No **GDM 'at risk' sample:** Have you ever smoked? Yes or No When did you stop smoking? Date.	Not smoking	***Smoking*** No (referent)

Variable	Precise wording of UKHLS/GDM 'at risk' sample questionnaire items	Coding	Source/refrences
Yes		Smoking	
Alcohol consumption No (referent)	**UKHLS:** Did you drink alcohol during pregnancy? Yes or No **GDM 'at risk' sample:** Do you drink alcohol? Yes or No	Not drinking	
Yes		Drinking	
GDM risk No risk (referent)	**UKHLS:** If identifies as low risk ethnicity and answers "No" to "Have you ever had DM"? **GDM 'at risk' sample:** If identifies as low risk ethnicity and GDM risk assessment and previous pregnancy complications indicated No previous GDM.	GDM Free, neither ethnicity risk nor previous GDM	

Variable	Precise wording of UKHLS/GDM 'at risk' sample questionnaire items	Coding	Source/refrences
Risk but GDM-free (high risk ethnicity, ever had GDM)	**UKHLS:** If identifies as high risk ethnicity and answer "Yes" to "Have you ever had DM"? **GDM 'at risk' sample:** If identifies as high risk ethnicity and GDM risk assessment and previous pregnancy complications indicated previous GDM.		

Variable	Precise wording of UKHLS/GDM 'at risk' sample questionnaire items	Coding	Source/refrences
GDM diagnosed	**UKHLS: See details in (chapter 5)** Having DM? Have you ever had DM? "No Do you still have DM? "Yes" **GDM 'at risk' sample:** Type of DM and OGTT result Fasting glucose mmol/L ≥5.6 2 hours glucose mmol/L ≥7.8		UK National Institute for Clinical Excellence (NICE) update guidance 2015. https://www.nice.org.uk/guidance/ng3/chapter/1-Recommendations#gestational-diabetes-2

Appendix 5.2 Dagitty Model Code for the causal path diagram summarised in (Figure 5.1)

```
Age 1 @0.036,0.004

Alcohol 1

@0.636,0.350 BMI U

@0.715,0.397

Ethnicity 1 @0.033,0.919

Family%20diabetes U @0.071,0.401

GDM%20risk%2Fdiagnosis 1

@0.876,0.628

Gestational%20age 1 @0.419,0.882

Health U @0.134,0.088

Lifestyle U

@0.516,0.121 Parity 1

@0.240,0.440

Partnership 1 @0.203,0.311

Phys%2FPsych%20health 1 @0.344,0.173

Previous%20GDM 1 @0.348,0.451

Previous%20macrosomia U

@0.345,0.312 Sleep 1

@0.998,0.403

Smoking 1 @0.630,0.210

Age BMI @0.826,-0.083 Family%20diabetes @0.022,0.251
GDM%20risk%2Fdiagnosis @0.831,-0.051 Health
@0.106,0.035 Lifestyle @0.444,-0.005 Parity
@0.049,0.380 Partnership @0.080,0.325 Sleep @0.690,-
0.056.
Alcohol BMI @0.677,0.323 GDM%20risk%2Fdiagnosis
@0.738,0.234 Sleep @0.708,0.190

BMI GDM%20risk%2Fdiagnosis @0.787,0.456 Sleep @0.748,0.251
Ethnicity BMI @0.575,0.932 Family%20diabetes
@0.033,0.590 GDM%20risk%2Fdiagnosis @0.655,0.972
```

Health @0.012,0.198 Lifestyle @0.469,0.890 Parity
@0.067,0.495 Partnership @0.045,0.444 Sleep
@0.888,1.123.
Family%20diabetes BMI @0.360,0.709
GDM%20risk%2Fdiagnosis
@0.274,0.821 Heath @0.060,0.207 Lifestyle @0.244,-0.023
Parity
@0.138,0.438 Partnership @0.116,0.348 Sleep @0.297,0.866

GDM%20risk%2Fdiagnosis Sleep @0.942,0.581

Gestational%20age GDM%20risk%2Fdiagnosis @0.698,0.813
Lifestyle
@0.394,0.384 Sleep @0.866,0.972

Health BMI @0.764,-0.092 GDM%20risk%2Fdiagnosis
@0.076,0.958 Lifestyle @0.410,0.040 Parity @0.126,0.336
Partnership
@0.143,0.209 Phys%2FPsych%20health @0.280,0.109
Previous%20GDM
@0.304,0.321 Previous%20macrosomia @0.296,0.207 Sleep
@0.628,- 0.056

Lifestyle Alcohol @0.600,0.206 BMI @0.724,0.121
GDM%20risk%2Fdiagnosis @0.497,0.477 Sleep @0.676,0.079
Smoking
@0.588,0.144

Parity BMI @0.333,0.645 GDM%20risk%2Fdiagnosis
@0.234,0.715 Lifestyle @0.221,0.038
Phys%2FPsych%20health @0.238,0.224 Previous%20GDM
@0.287,0.459 Previous%20macrosomia @0.268,0.313 Sleep
@0.298,0.732

Partnership BMI @0.426,0.522 GDM%20risk%2Fdiagnosis
@0.126,0.789 Lifestyle @0.248,0.014 Parity @0.196,0.370
Phys%2FPsych%20health @0.253,0.176 Previous%20GDM
@0.247,0.446 Previous%20macrosomia @0.285,0.267 Sleep
@0.157,0.861

Phys%2FPsych%20health BMI @0.469,0.362
GDM%20risk%2Fdiagnosis
@0.468,0.539 Lifestyle @0.373,0.112 Sleep @0.477,0.534

Previous%20GDM BMI @0.500,0.511 GDM%20risk%2Fdiagnosis
@0.453,0.878 Lifestyle @0.388,0.246 Sleep @0.578,0.570
Previous%20macrosomia BMI @0.486,0.428
GDM%20risk%2Fdiagnosis
@0.457,0.642 Lifestyle @0.392,0.159 Sleep @0.593,0.550

Smoking BMI @0.686,0.234 GDM%20risk%2Fdiagnosis
@0.789,0.186 Sleep @0.689,0.141

Appendix 5.3: Ethical Approval Letter (GDM Study)

NHS
Health Research Authority
NRES Committee Yorkshire & The Humber – Bradford

Yorkshire & Humber REC Office
Millside
Mill Pond Lane
Meanwood
Leeds
LS6 4RA

Telephone: 0113 30 50128
Facsimile: 0113 85 56191

06 June 2012

Dr Etienne Ciantar
Academic SpR in Obstetrics & Gynaecology
Leeds Teaching Hospitals NHS Trust
Academic Unit of Obstetrics & Gynaecology
D Floor, Clarendon Wing
Leeds General Infirmary
LS1 3EX

Dear Dr Ciantar

Study title: **A pilot study to assess the duration and quality of sleep in pregnant women with diabetes and how this relates to pregnancy outcomes and glycaemic control.**
REC reference: **12/YH/0156**

Thank you for your letter of 31 May 2012, responding to the Committee's request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Ethical review of research sites

NHS sites

The favourable opinion applies to all NHS sites taking part in the study, subject to management permission being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Non-NHS sites

Conditions of the favourable opinion

The favourable opinion is subject to the following conditions being met prior to the start of

the study.

Management permission or approval must be obtained from each host organisation prior to the start of the study at the site concerned.

Management permission ("R&D approval") should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements.

Guidance on applying for NHS permission for research is available in the Integrated Research Application System or at http://www.rdforum.nhs.uk.

Where a NHS organisation's role in the study is limited to identifying and referring potential participants to research sites ("participant identification centre"), guidance should be sought from the R&D office on the information it requires to give permission for this activity.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of approvals from host organisations

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
Covering Letter		05 March 2012
Covering Letter		14 May 2012
Covering Letter		31 May 2012
Letter from Sponsor		22 February 2012
Other: CV - Dr. Etienne Ciantar		05 March 2012
Participant Consent Form	2	14 May 2012
Participant Information Sheet: Pre-gestational diabetes	3	31 May 2012
Participant Information Sheet: Gestational diabetes	3	31 May 2012
Protocol	1	05 March 2012
Questionnaire: Berlin Questionnaire		
Questionnaire: Pittsburgh Sleep Quality Index	1	
REC application	3.1	21 February 2012
Referees or other scientific critique report	1	14 December 2011
Response to Request for Further Information		14 May 2012
Response to Request for Further Information		31 May 2012

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

After ethical review

Reporting requirements

The attached document *"After ethical review – guidance for researchers"* gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Notification of serious breaches of the protocol
- Progress and safety reports
- Notifying the end of the study

The NRES website also provides guidance on these topics, which is updated in the light of changes in reporting requirements or procedures.

Feedback

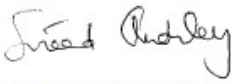
You are invited to give your view of the service that you have received from the National Research Ethics Service and the application procedure. If you wish to make your views known please use the feedback form available on the website.

Further information is available at National Research Ethics Service website > After Review

12/YH/0156	**Please quote this number on all correspondence**

With the Committee's best wishes for the success of this project

Yours sincerely



pp Dr Ian Woollands
Chair

Email: sinead.audsley@nhs.net

Enclosures: "After ethical review – guidance for researchers"

Copy to: *Dr Derek Norfolk, Leeds Teaching Hospitals Trust*
Ms Anne Gowing, Leeds Teaching Hospitals NHS Trust

Appendix 6.1 Ethical consideration: confirmation of the advice provided by the School of Medicine Research Ethics Committee Chair (Dr Roger Parslow) regarding the use of forum-based data.

Fwd: Ethics Query

---------- Forwarded message ----------
From: **Roger Parslow**
<R.C.Parslow@leeds.ac.uk> Date: 17 May 2016 at 11:46
Subject: RE: Ethics Query
To: George Ellison <G.T.H.Ellison@leeds.ac.uk>

Hello George,

If the data is in the public domain then I think you just need to be guided by common sense and an appropriate approach to the research and its interpretation. It doesn't need to go through ethics.

Regards Roger

From: George Ellison [mailto:g.t.h.ellison@leeds.ac.uk]
Sent: 13 May 2016 10:09
To: Roger Parslow <R.C.Parslow@leeds.ac.uk>
Subject: Ethics Query

Dear Roger,

One of my PhD students is examining online forums generated by pregnant Mums where they discuss sleep-related issues...

The data are in the public domain, but I think we would like to get ethical clearance for this work - is there a brief approach we could use to obtain Chairs action (if appropriate) to avoid putting you to unnecessary extra work?

Just thought I'd

ask... Best, G

George TH Ellison PhD DSc

Appendix 6.2: An alphabetical list of abbreviations, and a list of 'emoticons', appearing within excerpts from forum posts cited in the present study, together with interpretations of what each is likely to represent, undertaken by the authors.

Abbreviation	Interpretation
dd	darling daughter; dear daughter
dnt	do not
dr	doctor
lol	laugh out loud
n	and
nhs	National Health Service (UK)
spd	symphysis pubis dysfunction
tri 1	trimester 1
tri 3	trimester 3

Emoticon	Interpretation
:(	unhappy; miserable; sad
:)	happy; funny; humorous
;)	humorous or wry wink
:0	astonishment; shock

Appendix 7.1 The presentation and diagnosis of Pregnancy-Associated Sleep Disorder (Revised version of the ICSD; AASM, 2001, pp.297-300)

Pregnancy-Associated Sleep Disorder (780.59-6)

Synonyms and Key Words: Pregnancy-associated excessive sleepiness, pregnancy-associated insomnia.

Essential Features:

Pregnancy-associated sleep disorder *is characterized by the occurrence of either insomnia or excessive sleepiness that develops in the course of pregnancy.*

The sleep disorder associated with pregnancy usually is biphasic. It typically begins with excessive sleepiness and can progress to severe insomnia. In rare instances, nightmares, sleep terrors, and postpartum psychosis may occur.

Associated Features: Pregnancy-associated sleep disorder is often associated with lack of concentration, irritability, apathy, and moodiness. Hypertension, proteinuria, glycosuria, ketonuria, anemia, and morning sickness can be associated with pregnancy. Some women also develop lower-back pain, which can exacerbate the sleep problems.

Course: The first trimester is commonly associated with sleepiness and complaints of tiredness that can precede realization of pregnancy. Total sleep time increases during the first trimester, and patients will frequently nap. Sleep normalizes in the second trimester, but toward the end of the second trimester, the frequency of awakenings increases. The latency to sleep, the number of awakenings, and sleeplessness increase to above normal amounts in the third trimester. These sleep problems may be accounted for by the patient's inability to find a comfortable sleep position, back pain, urinary frequency, and fetal activity. Sleep disruption persists after delivery, with nocturnal childcare being an important contributing factor, but gradually declines in the late postpartum period.

Predisposing Factors: None known.

Prevalence: Occurs in most pregnant women. Sleep terrors and postpartum psychosis are rare.

Age of Onset: Pregnant women of any age.

Sex Ratio: Occurs only in women.

Familial Pattern: None known.

Pathology: None known. The sleepiness that occurs during the first trimester is presumably related to hormonal and biochemical changes of pregnancy. The insomnia during the final trimester, however, is probably due to discomfort, bladder distention, and fetal movement.

Complications: In the initial phase of this disorder, patients may be cognitively impaired due to sleepiness. It has been suggested that postpartum psychosis may be in some way related to the sleep-stage changes that occur in late pregnancy and immediately after delivery. Though sleep-stage fluctuations disappear within a few weeks following delivery in most cases, in some women, the fluctuations may persist for several months or longer.

Various pathologies associated with complications of pregnancy (e.g., toxemia of pregnancy, can increase the severity of the sleep disorder).

Polysomnographic Features: The first trimester of pregnancy is associated with increased sleep time. Towards the end of the second trimester and continuing into the last trimester, the number of awakenings increases. Sleep latency and awake time after sleep onset also increase. As the pregnancy approaches term, stage 4 sleep declines. In one study, four of seven women had a complete loss of stage 4 sleep during late pregnancy.

The excessive sleepiness may be evident on multiple sleep latency testing, with a mean latency below 10 minutes.

Two dramatic changes in sleep occur following delivery: (1) REM sleep decreases markedly, then normalizes over the next two weeks and (2) stage 4 sleep begins to come back to previous levels.

Other Laboratory Test Features: If pregnancy is suspected in a patient presenting with symptoms of excessive sleepiness, pregnancy testing should be performed.

Differential Diagnosis: In its early phase, pregnancy-associated sleep disorder must be differentiated from other disorders of excessive sleepiness. It is not uncommon that the sleep problems are noticed before the patient realizes she is pregnant. Pregnancy testing can provide confirmation. In the third trimester, this condition must be differentiated from other disorders of initiating and maintaining sleep. Polysomnographic evidence of sleep apnea, periodic limb movements, or other abnormal sleep events may be necessary to substantiate sleep disorders other than those associated with normal pregnancy.

Diagnostic Criteria: Pregnancy-Associated Sleep Disorder (780.59-6)

A. The patient has a complaint of either insomnia or excessive sleepiness.
B. The sleep disturbance begins and is present during pregnancy.
C. Polysomnographic monitoring demonstrates either of the following:
   1. Frequent arousals and reduced sleep efficiency
   2. A prolonged habitual sleep period
D. A multiple sleep latency test demonstrates a mean sleep latency of less than 10 minutes.
E. No other medical or mental disorder accounts for the primary symptom.
F. No other sleep disorder is present that could account for the symptoms.

Minimal Criteria: A plus B.

Severity Criteria:

Mild: Mild insomnia or mild sleepiness, as defined on page 23.
Moderate: Moderate insomnia or moderate sleepiness, as defined on page 23.
Severe: Severe insomnia or severe sleepiness, as defined on page 23. Parasomnias such as nightmares or sleep terrors may be present.

Duration Criteria:

Acute: 7 days or less.
Subacute: More than 7 days but less than 1 month.
Chronic: 1 month or longer.

Bibliography:

Errante J. Sleep deprivation or postpartum blues? Top Clin Nurs 1985; 6: 9–18.

Fast A, Shapiro D, Ducommun EJ, Friedmann LW, Bouklas T, Floman Y. Low-back pain in pregnancy. Spine 1987; 12: 368–371.

Karacan I, Heine W, Agnew HW, Williams RL, Webb WB, Ross JJ. Characteristics of sleep patterns during late pregnancy and the postpartum periods. Am J Obstet Gynecol 1968; 101: 579–586.

Karacan I, Williams RL, Hursh CJ, McCaulley M, Heine MW. Some implications of the sleep pattern of pregnancy for postpartum emotional disturbances. Br J Psychiatr 1969; 115: 929–935.

Postpartum periods ;obEditorial;cb. Am J Obstet Gynecol 1968; 101: 579–586.

Appendix 7.2 The original wording of any items (and any related answer categories/options) corresponding to emerging thematic codes, identified from repeated close-reading and thematic content analysis of the n=30 sleep instruments and custom sleep item sets examined for this review.

Instrument	1.Sleep timing (at what time fell asleep* and at what time woke up)/naps Precise wording
4 (BNSQ)	The questions should address the last three months. Other time periods may be used if necessary. 13. When do you usually go to bed (to sleep)? a) On weekdays: at. _____ b) On days off: at. _____ 14. When do you usually wake up? a) On weekdays: at. _____ b) On days off: at. _____ The questions should address the last three months. Other time periods may be used if necessary. 13. When do you usually go to bed (to sleep)? a) On weekdays: at. _____ b) On days off: at. _____ 14. When do you usually wake up? a) On weekdays: at. _____ b) On days off: at. _____

Instrument	1.Sleep timing (at what time fell asleep* and at what time woke up)/naps Precise wording
7(GSDS)	Take a nap a scheduled time (Number of days per week) that suits you best. 0 means no days during the course of a week, 7 means every day during the course of a week.
17 (Mindell-CSIS)	Usual bedtime during the week :_____am / pm Usual bedtime on weekends :_____am / pm Usual waketime during the week :_____am / pm Usual waketime on weekends :_____am / pm Do you take naps? Yes / No If yes: If you nap, how many times per day?_____If you nap, how many times per week? _____ How long do these naps usually last?_____minutes If no: Would you nap, if you could (e.g., didn't have to work or care for other children)? Yes / No

18(MEQ)	For each question, please select the answer that best describes you by circling the point value that best indicates how you have felt in recent weeks. 1. Approximately what time would you get up if you were entirely free to plan your day? [5] 5:00 AM–6:30 AM (05:00–06:30 h) [4] 6:30 AM–7:45 AM (06:30–07:45 h) [3] 7:45 AM–9:45 AM (07:45–09:45 h) [2] 9:45 AM–11:00 AM (09:45–11:00 h) [1] 11:00 AM–12 noon (11:00–12:00 h) 2. Approximately what time would you go to bed if you were entirely free to plan your evening? [5] 8:00 PM–9:00 PM (20:00–21:00 h) [4] 9:00 PM–10:15 PM (21:00–22:15 h) [3] 10:15 PM–12:30 AM (22:15–00:30 h) [2] 12:30 AM–1:45 AM (00:30–01:45 h) [1] 1:45 AM–3:00 AM (01:45–03:00 h) 10. At approximately what time in the evening do you feel tired, and, as a result, in need of sleep? [5] 8:00 PM–9:00 PM (20:00–21:00 h) [4] 9:00 PM–10:15 PM (21:00–22:15 h) [3] 10:15 PM–12:45 AM (22:15–00:45 h) [2] 12:45 AM–2:00 AM (00:45–02:00 h) [1] 2:00 AM–3:00 AM (02:00–03:00 h)

21 (PSD)	Went to bed last night at----- Light out at----------

Instrument	1.Sleep timing (at what time fell asleep* and at what time woke up)/naps Precise wording
	Finally woke at ------
22 (PSQI)	1. During the past month, what time have you usually gone to bed at night? BED TIME _____ 3. During the past month, what time have you usually gotten up in the morning? GETTING UP TIME _____ _____
23 (SHQ)	On weekdays/workdays I usually go to bed at _____ On weekdays/workdays the earliest time in the last 2 weeks I've gone to bed _____ And the latest time was at _____ In the evening I usually start feeling sleepy at _____ On weekdays I wake up at _____ My usual weekend/days off bedtime is at _____ On weekends I wake up at _____ The clock times that I wake up during the night are I take a nap_____times per week. After a nap I feel :_____refreshed_____sleepy/groggy.

24(SDQ)	132.Adaytime nap worsen my nighttime sleep 134.After anap ,I feel less sleepy in the daytime. Never, Rarely, Sometimes, Usually, Always
27 (SIGHDRS)	When have you been falling asleep and waking up over the past week?

Instrument	2.Sleep duration (how long asleep)* Precise wording
2(AIS)	This scale is intended to record your own assessment of any sleep difficulty you might have experienced. Please, check (by circling the appropriate number) the items below to indicate your estimate of any difficulty, provided that it occurred at least three times per week during the last month. Total sleep duration 0 sufficient 1 slightly insufficient 2 Markedly insufficient 3 very insufficient or didn't sleep at all
4 (BNSQ)	The questions should address the last three months. Other time periods may be used if necessary. 12. How many hours of sleep each night? I sleep around_____hours each night. 20. How many hours of sleep do you get per night (how many hours you would have slept if you could sleep as long as you need)? I need_____hours and_____minutes of sleep per night.
13 (Kaneita-CSIS)	sleep status during the previous month: sleep duration "insufficient" or "very insufficient" *short sleep duration (SSD, <7 h)
16(Micheli-CSIS)	During the past month, how many hours do you sleep per day?

Instrument	2.Sleep duration (how long asleep)* Precise wording
17 (Mindell-CSIS)	Usual amount of sleep on weekdays_____hours_____minutesUsual amount of sleep on weekend days_____hours_____minutes 14. In general, in the past two weeks, do you feel you have been getting _____a. too much sleep? _____b. sufficient sleep? _____c. too little sleep?

Instrument	**2.Sleep duration (how long asleep)*** **Precise wording**
18(MEQ)	For each question, please select the answer that best describes you by circling the point value that best indicates how you have felt in recent weeks. 1. Approximately what time would you get up if you were entirely free to plan yourday? [5] 5:00 AM–6:30 AM (05:00–06:30 h) [4] 6:30 AM–7:45 AM (06:30–07:45 h) [3] 7:45 AM–9:45 AM (07:45–09:45 h) [2] 9:45 AM–11:00 AM (09:45–11:00 h) [1] 11:00 AM–12 noon (11:00–12:00 h) 2. Approximately what time would you go to bed if you were entirely free to plan yourevening? [5] 8:00 PM–9:00 PM (20:00–21:00 h) [4] 9:00 PM–10:15 PM (21:00–22:15 h) [3] 10:15 PM–12:30 AM (22:15–00:30 h) [2] 12:30 AM–1:45 AM (00:30–01:45 h) [1] 1:45 AM–3:00 AM (01:45–03:00 h) 10. At approximately what time in the evening do you feel tired, and, as a result, in needof sleep? [5] 8:00 PM–9:00 PM (20:00–21:00 h) [4] 9:00 PM–10:15 PM (21:00–22:15 h) [3] 10:15 PM–12:45 AM (22:15–00:45 h) [2] 12:45 AM–2:00 AM (00:45–02:00 h) [1] 2:00 AM–3:00 AM (02:00–03:00 h)

Instrument	2.Sleep duration (how long asleep)* Precise wording
19 (Neau-CSIS)	usual number of hours of sleep per night?
21 (PSD)	Went to bed last night at----- Light out at---------- Finally woke at ------ How many day time naps did you take today? (if none,write 0) give times for each Start----end----start----end------
22 (PSQI)	Q4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.) A4. HOURS OF SLEEP PER NIGHT _____
23 (SHQ)	On weekdays/workdays I usually go to bed at _____ On weekdays/workdays the earliest time in the last 2 weeks I've gone to bed And the latest time was at _____ In the evening I usually start feeling sleepy at _____ On weekdays I wake up at _____ My usual weekend/days off bedtime is at _____ On weekends I wake up at _____ To feel my best I need_____hours of sleep. The clock times that I wake up during the night are _____

Instrument	2.Sleep duration (how long asleep)* Precise wording
24(SDQ)	In answering the questions, consider each question as applying to the past six months of your life, unless you have been told differently by the person who gave you this booklet. 153. How many hours of sleep do you get at night, not including time spent awake in bed? 1.) Less than 4 hrs. 2.) Four to 5 hrs. 3.) Six hrs. 4.) Seven hrs. 5.) Eight or more
25(SQS)	My sleep hours are enough Rarely, Sometimes, Often, Almost always
27 (SIGHDRS)	When have you been falling asleep and waking up over the past week? How many hours on average have you been sleeping in a 24-hour period in the past week, including naps? Is that a normal amount for you? What is the longest you've slept in a 24-hour period last week?
29 (VSHSS)	Examining sleep over the previous 3 nights. Responses are recorded along a 100mm line with 0 indicating that the sleep behaviour or quality is not present, and 100 indicating that it is consistently experienced. Did not a waken ----------was awake 10 hours Had no sleep----------Had 10 hours' sleep No sleep during the day yesterday ----------slept 10 hours during the day Did not sleep yesterday morning----------slept off on yesterday morning Did not sleep yesterday evening----------slept off on yesterday evening Had enough sleep----------Did not have enough sleep

Instrument	3.Sleep latency (how long to get to sleep)* Precise wording
2(AIS)	This scale is intended to record your own assessment of any sleep difficulty you might have experienced. Please, check (by circling the appropriate number) the items below to indicate your estimate of any difficulty, provided that it occurred at least three times per week during the last month. 1-Sleep Induction (time it takes you to fall asleep after turning-off the lights) 0 No problem 1 slightly delayed 2 Markedly delayed 3 very delayed or didn't sleep at all
3(BIS)	During the past month, how many days a week has it taken you more than 30 minutes to fall asleep after the light was switched off? (number of days per week) that suits you best. 0 means no days during the course of a week, 7 means every day during the course of a week.
4 (BNSQ)	The questions should address the last three months. Other time periods may be used if necessary. 2. How long (average number of minutes) do you lie awake in bed before going to sleep (after the light is off)? a) On weekdays it takes about_____minutes before I fall asleep b) On days off, it takes about_____minutes

Instrument	3.Sleep latency (how long to get to sleep)* Precise wording
9(ISQ)	During the past month did you have – 1-Difficulty falling asleep Never,Don't know,Rarely,Sometimes,Frequently,Always How long has the sympomps lasted?
13(Kaneita-CSIS)	difficulty in initiating sleep sometimes", "often" or "always"
14(LSEQ)	**How would you describe the way you currently fall asleep in comparison tousual?** 1. More difficult than usual ----------Easier thanusual 2. Slower than usual ----------More quickly than usual 3. I feel less sleepy than usual ----------More sleepy thanusual
15(Marques-CSIS)	"In your lifetime, have you ever had a period of one month or more when you were sleeping poorly (difficulty fallingasleep)
17(Mindell-CSIS)	How long does it usually take you to fall asleep?_____hours_____minutes 26. Do you feel you currently have a sleep problem? Yes / No If you have a sleep problem, which of the following items describe your specific sleep difficulty: (You may check more than one) _____a. falling asleep
19(Neau- CSIS)	the notion of capacity to get asleep (yes/no)
21 (PSD)	Minutes until fell asleep----------

Instrument	**3.Sleep latency (how long to get to sleep)*** **Precise wording**
22 (PSQI)	2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night? NUMBER OF MINUTES _____
23 (SHQ)	The amount of time it usually takes to fall asleep is _____ On weekdays I wake up at _____
24(SDQ)	I have trouble getting to sleep at night Never, Rarely, Sometimes, Usually, Always
25(SQS)	The following survey is to know the quality of sleep you had for the last one month. read the questions and check the closest answer. I have difficulty falling asleep Rarely, Sometimes, Often, Almost always
27 (SIGHDRS)	Have you had any trouble falling asleep at the beginning of the night? (Right after you go to bed, how long has it been taking you to fall asleep?) How many nights this week have you had trouble falling asleep? (yes/no)
28(Ursavas-CSIS)	Difficulty in falling asleep a Likert Scale of 0–4 [0 = never, 1 = rarely (less than once a month), 2 = sometimes (less than once a week), 3 = often (at least once a week) and 4 = always (almost every night)]

Instrument	3.Sleep latency (how long to get to sleep)* Precise wording
29 (VSHSS)	Examining sleep over the previous 3 nights.Responses are recorded along a 100mm line with 0 indicating that the sleep behaviour or quality is not present, and 100 indicating that it is consistently experienced. Fell asleep immediately ----------Did not fall asleep
30(WHIIRS)	1. Did you have trouble falling asleep? 0) 'No, not in past 4 weeks', (1) 'Yes, less than once a week', (2) 'Yes, 1 or 2 times a week', (3) 'Yes, 3 or 4 times a week', and (4) 'Yes, 5 or more times a week'.

Instrument	4.Sleep medication Precise wording
4 (BNSQ)	7. Have you been taking sleeping pills (which you have been prescribed) during the last three months? 1. Never or less than once a month 2. Less than once a week 3. 1 to 2 days of the week 4. 3 to 5 days a week 5. Every day or almost every day Which (n) sleeping pill (s): _____
7(GSDS)	How often in the past week did you: 18. Use herbal product to help you get to sleep. 19. Use an over-the-counter sleeping pill to help you get to sleep. 20.Use a prescription sleeping pill to help you get to sleep (Number of days per week) that suits you best. 0 means no days during the course of a week, 7 means every day during the course of a week.
15(Marques-CSIS)	"Did you take medication because of sleeping poorly?"(yes/no)
22 (PSQI)	Not mentioned whether before pregnancy or not: 7. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")? Not during the past month_____

	Less than once a week_____ Once or twice a week_____ Three or more times a week_____

Instrument	**5. Number of 'awakenings' (times fully awake after falling to sleep)*** **Precise wording**
2(AIS)	This scale is intended to record your own assessment of any sleep difficulty you might have experienced. Please, check (by circling the appropriate number) the items below to indicate your estimate of any difficulty, provided that it occurred at least three times per week during the last month. AWAKENINGS DURING THE NIGHT 0 No problem 1 Minor problem 2 Considerable problem 3 Serious problem or did not sleep at all
3(BIS)	2.During the past month, how many days a week have you been awake for more than 30 minutes between periods of sleep? (number of days per week) that suits you best. 0 means no days during the course of a week, 7 means every day during the course of a week.

4 (BNSQ)	The questions should address the last three months. Other time periods may be used if necessary. 3. How often have you woken at night during the last three months? 1. Never or less than once a month 2. Less than once a week 3. 1 to 2 days of the week 4. 3 to 5 days a week 5. Every night or almost every night 4. If you tend to wake up at night, how many times do you usually wake up during the night (for the last three months)? 1. Usually tend not to wake up at night 2. Once per night 3. 2 times 4. 3 to 4 times 5. At least five times per night 5. How often have you woken too early without being able to fall asleep again during the last three months? 1. Never or less than once a month 2. Less than once a week 3. 1 to 2 days of the week 4. 3 to 5 days a week 5. Every day or almost every day
7(GSDS)	How often in the past week did you: 2.Wake up during your sleep period

Instrument	5. Number of 'awakenings' (times fully awake after falling to sleep)* Precise wording
	3.Wake up too early at the end of sleep period (Number of days per week) that suits you best. 0 means no days during the course of a week, 7 means every day during the course of a week.
8(ISI)	Please rate the current (i.e,last 2 weeks)severity of your insomnia problem: Difficulty staying asleep None Mild Moderate Severe very
9(ISQ)	During the past month did you have 3-Frequent awakenings from sleep Never,Don’t know,Rarely,Sometimes,Frequently,Always How long has the sympomps lasted?

Instrument	5. Number of 'awakenings' (times fully awake after falling to sleep)* Precise wording
10 (IRLSSGRS)	4. Overall, how severe is your sleep disturbance from your RLS symptoms? (4) Very severe (3) Severe (2) Moderate (1) Mild (0) None
13(Kaneita-CSIS)	difficulty maintaining sleep (DMS) answered “sometimes”, “often” or “always”
15(Marques-CSIS)	(yes/no): “In your lifetime, have you ever had a period of one month or more when you were sleeping poorly (difficulty falling asleep, waking up many times during the night or waking up too early in the morning and unable to go back to sleep?”).
17(Mindell-CSIS)	1. Do you wake up in the middle of the night?Yes / No If yes: On average, how many times a night do you wake?_____times How many nights a week do you wake during the night? _____ 26. Do you feel you currently have a sleep problem? Yes / No If you have a sleep problem, which of the following items describe your specific sleep difficulty: (You may check more than one) _____c. frequent awakenings throughout the night
19(Neau-CSIS)	Waking up in the middle of the night or early morning? (yes or no)?

Instrument	5. Number of 'awakenings' (times fully awake after falling to sleep)* Precise wording
21 (PSD)	After falling asleep,woke up this many time during the night 0 1 2 3 4 5 or more. Total number of minutes awake----------. Woke to use the bath room. 0 1 2 3 4 5 or more. Awakened by noises/child/bedpartner. 0 1 2 3 4 5 or more. Awakened due to discomfort or physical complaint. 0 1 2 3 4 5 or more. Just woke. 0 1 2 3 4 5 or more.
22 (PSQI)	5. During the past month, how often have you had trouble sleeping because you … b) Wake up in the middle of the night or early morning Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

Instrument	5. Number of 'awakenings' (times fully awake after falling to sleep)* Precise wording
23 (SHQ)	INSOMNIA: (check the choices that are true for you) _____When I wake up during the night, I have trouble going back to sleep.
24(SDQ)	In answering the questions, consider each question as applying to the past six months of your life, unless you have been told differently by the person who gave you this booklet. 4. I wake up often during the night Never, Rarely, Sometimes, Usually, Always
25(SQS)	The following survey is to know the quality of sleep you had for the last one month. read the questions and check the closest answer. 2.I wake up while sleeping. 3.I have difficulty getting back to sleep once I wake up in middle of the night. 7.I never go back to sleep after awakening during sleep. Rarely, Sometimes, Often, Almost always
27 (SIGHDRS)	During the past week, have you been waking up in the middle of the night? IF YES: Do you get out of bed? What do you do? (Only go to the bathroom?) How many nights this week have you had that kind of trouble?
28(Ursavas-CSIS)	Frequent awakening with difficulty in falling asleep once again? a Likert Scale of 0–4 [0 = never, 1 = rarely (less than once a month), 2 = sometimes (less than once a week), 3 = often (at least once a week) and 4 = always (almost every night)].

Instrument	5. Number of 'awakenings' (times fully awake after falling to sleep)* Precise wording
29 (VSHSS)	Examining sleep over the previous 3 nights.Responses are recorded along a 100mm line with 0 indicating that the sleep behavior or quality is not present, and 100 indicating that it is consistently experienced. Had no trouble with disturbed sleep ----------Had a lot of trouble disturbed asleep Didn't wake at all ----------was awake off and on all night
30(WHIIRS)	2. Did you wake up several times at night? (0) 'No, not in past 4 weeks', (1) 'Yes, less than once a week', (2) 'Yes, 1 or 2 times a week', (3) 'Yes, 3 or 4 times a week', and (4) 'Yes, 5 or more times a week'.

5.1 - Duration of 'awakenings' (for how long awake, on average)*

*These together should provide the data to calculate 'sleep efficiency'

Total sleep time = Time in bed(Minutes) -Minutes to fall asleep-Minutes awakening

*These together should provide the data to calculate 'sleep efficiency'

Total sleep time = Time in bed(Minutes) -Minutes to fall asleep-Minutes awakening

Sleep efficiency: Total sleep time /Time in bed X 100

85% as normal and really good sleep efficiency is above 90%.

Instrument	**5.1 Duration of 'awakenings' (for how long awake, on average)*** **Precise wording**
17 (Mindell-CSIS)	1. Do you wake up in the middle of the night? Yes / No If yes: On average, how long do you remain awake?_____hours_____minutes
21(PSD)	After falling a sleep,woke up this many time during the night 0 1 2 3 4 5 or more. Total number of minutes awake.-------
24(SDQ)	In answering the questions, consider each question as applying to the past six months of your life, unless you have been told differently by the person who gave you this booklet. **154. How long is your longest wake period at night?** 1.) Less than 5 min. 2.) Six to 19 min. 3.) 20 to 59 min. 4.) One to 2 hrs. 5.) More than 2 hrs.
27 (SIGHDRS)	When you get back in bed, are you able to fall right back asleep? How long do you stay awake?

Instrument	5.2 Timing of awakenings (at what time do these start to/occur) Precise wording
2(AIS)	This scale is intended to record your own assessment of any sleep difficulty you might have experienced. Please, check (by circling the appropriate number) the items below to indicate your estimate of any difficulty, provided that it occurred at least three times per week during the last month. FINAL AWAKENING EARLIER THAN DESIRED 0 No problem 1 Minor problem 2 Considerable problem 3 Serious problem or did not sleep at all

4 (BNSQ)	The questions should address the last three months. Other time periods may be used if necessary. 3. How often have you woken at night during the last three months? 1. Never or less than once a month 2. Less than once a week 3. 1 to 2 days of the week 4. 3 to 5 days a week 5. Every night or almost every night 4. If you tend to wake up at night, how many times do you usually wake up during the night (for the last three months)? 1. Usually tend not to wake up at night 2. Once per night 3. 2 times 4. 3 to 4 times 5. At least five times per night 5. How often have you woken too early without being able to fall asleep again during the last three months? 1. Never or less than once a month 2. Less than once a week 3. 1 to 2 days of the week 4. 3 to 5 days a week 5. Every day or almost every day
7(GSDS)	How often in the past week did you:

Instrument	**5.2 Timing of awakenings (at what time do these start to/occur)** **Precise wording**
	3.Wake up too early at the end of sleep period (Number of days per week) that suits you best. 0 means no days during the course of a week, 7 means every day during the course of a week.
13 (Kaneita-CSIS)	early-morning awakening (EMA)? "sometimes", "often" or "always"
15(Marques-CSIS)	yes/no): "In your lifetime, have you ever had a period of one month or more when you were sleeping poorly (difficulty falling asleep, waking up many times during the night or waking up too early in the morning and unable to go back to sleep?").
17(Mindell-CSIS)	1. Do you wake up in the middle of the night?Yes / No If yes: On average, how many times a night do you wake?_____times How many nights a week do you wake during the night? _____
19(Neau-CSIS)	Waking up in the middle of the night or early morning? (yes or no)?

Instrument	5.6 Timing of awakenings (at what time do these start to/occur) Precise wording
21 (PSD)	After falling a sleep,woke up this many time during the night 0 1 2 3 4 5 or more. Total number of minutes awake----------. Woke to use the bath room. 0 1 2 3 4 5 or more. Awakened by noises/child/bedpartner. 0 1 2 3 4 5 or more. Awakened due to discomfort or physical complaint. 0 1 2 3 4 5 or more. Just woke. 0 1 2 3 4 5 or more
22 (PSQI)	5. During the past month, how often have you had trouble sleeping because you … b) Wake up in the middle of the night or early morning Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

Instrument	5.2 Timing of awakenings (at what time do these start to/occur) Precise wording
23 (SHQ)	INSOMNIA: (check the choices that are true for you) _____When I wake up during the night, I have trouble going back to sleep. _____I wake up in the morning long before I have to.
24(SDQ)	In answering the questions, consider each question as applying to the past six months of your life, unless you have been told differently by the person who gave you this booklet. **154. How long is your longest wake period at night?** 1.) Less than 5 min. 2.) Six to 19 min. 3.) 20 to 59 min. 4.) One to 2 hrs. 5.) More than 2 hrs.
25(SQS)	The following survey is to know the quality of sleep you had for the last one month. read the questions and check the closest answer. 3.I have difficulty getting back to sleep once I wake up in middle of the night. Rarely Sometimes Often Almost always
27 (SIGHDRS)	During the past week, have you been waking up in the middle of the night? IF YES: Do you get out of bed? What do you do? (Only go to the bathroom?) When you get back in bed, are you able to fall right back asleep?

Instrument	**5.2 Timing of awakenings (at what time do these start to/occur)** **Precise wording**
30(WHIIRS)	3. Did you wake up earlier than you planned to? (0) 'No, not in past 4 weeks', (1) 'Yes, less than once a week', (2) 'Yes, 1 or 2 times a week', (3) 'Yes, 3 or 4 times a week', and (4) 'Yes, 5 or more times a week'.
Instrument	**6. Coughing/snoring/breathing difficulties (including wooziness following bouts of what are likely to be OSA)** **Precise wording**
1 (ASAC)	Category 2: History of Apparent Airway Obstruction during Sleep Two or more of the following are present (if patient lives alone or sleep is not observed by another person, then only one of the following need be present): a. Snoring (loud enough to be heard through closed door) b. Frequent snoring c. Observed pauses in breathing during sleep d. Awakens from sleep with choking sensation e. Frequent arousals from sleep

4 (BNSQ)	The questions should address the last three months. Other time periods may be used if necessary. 16. Do you snore when you sleep? (ask others if you are not sure) 1.Never or less than once a month 2.Less than once a week 3.1 to 2 days of the week 4.3 to 5 days a week 5.Every night or almost every night 17. How is your snoring? (ask others how snoring sounds) 1.I do not snore 2.I snore regularly and deeply 3.I snore even, but quite high 4.I snore even, but very high (others in the room next door can hear me snore) 5.I snore very loudly and unevenly (i.e. with breathing pauses which snoring is not heard, and to times with very high snoring with gasping for air) 18. Have you experienced breathing stops (apnoea) during sleep? (Have others noticed that you stop breathing during sleep)? 1.Never or less than once a month 2.Less than once a week 3.1 to 2 days of the week 4.3 to 5 days a week 5.Every night or almost every night 19. If you snore at least 1-2 times per week, how many years have you been snoring? (ask others if you do not know)I have snored for about_____years. I was about_____years old when I started to snore.

5 (BSQ)	1. Do you snore? - a. Yes - b. No - c. Don’t know If you snore: 2. Your snoring is: - a. Slightly louder than breathing - b. As loud as talking - c. Louder than talking - d. Very loud – can be heard in adjacent rooms 3. How often do you snore? - a. Nearly every day - b. 3-4 times a week - c. 1-2 times a week - d. 1-2 times a month - e. Never or nearly never 4. Has your snoring ever bothered other people? - a. Yes - b. No - c. Don’t Know 5. Has anyone noticed that you quit breathing during your sleep?

Instrument	6. Coughing/snoring/breathing difficulties (including wooziness following bouts of what are likely to be OSA) Precise wording
	- a. Nearly every day - b. 3-4 times a week - c. 1-2 times a week - d. 1-2 times a month - e. Never or nearly never
11 (Izci-CSIS)	Snoring frequency and breathing pauses are rated before pregnancy and during the last month on a five-point Likert scale, corresponding to 'never', 'rare' (1–2 nights per month), 'occasional' (1–2 nights per week), 'often' (3 nights per week), 'frequent or always' (more than three nights per week) and 'do not know'.
16(Micheli-CSIS)	-How often do you snore during your sleep? non-snorers (never/rarely), occasional snorers (sometimes/often), and severe snorers (frequently/always)

Instrument	6. Coughing/snoring/breathing difficulties (including wooziness following bouts of what are likely to be OSA) Precise wording
17(Mindell-CSIS)	3. During the past two weeks, did you snore? Yes / No If yes: If you snore, have people said you snore loudly and disruptively? Yes / No Do you snore throughout the night? Yes / No Do you snore every night? Yes / No If you snore, how long has this occurred? _____ months _____ years 4. Have you awakened feeling short of breath or with a choking feeling? Yes / No 5. In the past two weeks, did your breathe through your mouth Yes / No while sleeping, more than through your nose? 6. Has anyone observed pauses in your breathing while you were sleeping during the past two weeks? Yes / No

Instrument	6. Coughing/snoring/breathing difficulties (including wooziness following bouts of what are likely to be OSA) Precise wording
22 (PSQI)	5. During the past month, how often have you had trouble sleeping because you e) Cough or snore loudly Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____ If you have a room mate or bed partner, ask him/her how often in the past month you have had… a) Loud snoring Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____ b) Long pauses between breaths while asleep Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

Instrument	6. Coughing/snoring/breathing difficulties (including wooziness following bouts of what are likely to be OSA) Precise wording
23 (SHQ)	WHAT MY SLEEP IS LIKE (check the choices that are true for you) _____I have been told that I snore very loudly. _____Sometimes a person cannot sleep in the same room, because of my snoring. _____I have been told that I stop breathing when I sleep. _____I have been told that I gasp or snort when I sleep.
24(SDQ)	20. I snore in my sleep 21. I am told I snore loudly and bother others 22. I am told I stop breathing ("hold my breath") in sleep 23. I awake suddenly gasping for breath, unable to breathe 141. My snoring or my breathing problem is much worse if I sleep on my back 142. My snoring or my breathing problem is much worse if I fall asleep right after drinking alcohol 143. My snoring or my breathing problem is much worse when I have an allergy or infection in the nose, throat, or chest Never, Rarely, Sometimes, Usually, Always
26 (SBSAQ)	The STOP-BANG criteria and questions are as follows: S = Snoring. Do you snore loudly (louder than talking or loud enough to be heard through closed doors)? O= Observed apnoea. Has anyone observed you stop breathing during your sleep?

Instrument	6. Coughing/snoring/breathing difficulties (including wooziness following bouts of what are likely to be OSA) Precise wording
28(Ursavas-CSIS)	Women were asked about insomnia, snoring and witnessed apnoea. a Likert Scale of 0–4 [0 = never, 1 = rarely (less than once a month), 2 = sometimes (less than once a week), 3 = often (at least once a week) and 4 = always (almost every night)]

Instrument	**7.Presence of bed-partner** **Precise wording**
17(Mindell-CSIS)	Do you share a bedroom with your partner? _____Yes _____No
20(Nielsen-CSIS)	If spouses were present in the room, they were asked to verify any occurrences of dream-associated behaviours
21(PSD)	Awakened by noises/child/bedpartner (circle/times) 0 1 2 3 4 5 or more
22(PSQI)	10. Do you have a bed partner or room mate? No bed partner or room mate _____ Partner/room mate in other room _____ Partner in same room, but not same bed _____ Partner in same bed _____ If you have a room mate or bed partner, ask him/her how often in the past month you have had… a) Loud snoring b)Long pauses between breaths while asleep c) Legs twitching or jerking while you sleep d) Episodes of disorientation or confusion during sleep e) Other restlessness while you sleep; please describe

24(SDQ)	15.At night my sleep disturbs my bed partner's sleep. Never, Rarely, Sometimes, Usually, Always
28(Ursavas-CSIS)	Women were asked about witnessed apnoea, and these responses were graded on a Likert Scale of 0–4 [0 = never, 1 = rarely (less than once a month), 2 = sometimes (less than once a week), 3 = often (at least once a week) and 4 = always (almost every night)].

Instrument	8.Overall sleep 'quality' Precise wording
3(BIS)	6.During the past month, how many days a week have you been dissatisfied with your sleep? (number of days per week) that suits you best. 0 means no days during the course of a week, 7 means every day during the course of a week.
4 (BNSQ)	6.How well have you slept during the last three months? 1. Well 2. pretty well 3. neither good nor bad 4. pretty bad 5. bad
7(GSDS)	How often in the past week did you: 10.Feel satisfied with the quality of your sleep (Number of days per week) that suits you best. 0 means no days during the course of a week, 7 means every day during the course of a week.
8(ISI)	2. How satisfied /dissatisfied are you with your current sleep pattern? 0 to 4 (0=very satisfied,4=very dissatisfied)
9(ISQ)	4-Feeling that your sleep is not sound? Never,Don't know,Rarely,Sometimes,Frequently,Always How long has the symptoms lasted?

Instrument	8.Overall sleep 'quality' Precise wording
17(Mindell-CSIS)	24. How would you rate your sleep? _____a. highly unsatisfactory _____b. unsatisfactory _____c. neither satisfactory or unsatisfactory _____d. satisfactory _____e. highly satisfactory
21 (PSD)	Sleep Quality (place a mark somewhere along the line) Very bad----------verygood
22 (PSQI)	6. During the past month, how would you rate your sleep quality overall? Very good _____ Fairly good _____ Fairly bad _____ Very bad _____

Instrument	9. (sleep inertia or lack of it) Alertness on awakening Precise wording
3(BIS)	4.During the past month, how many days a week have you felt that you have not had enough rest after waking up? (number of days per week) that suits you best. 0 means no days during the course of a week, 7 means every day during the course of a week.
4 (BNSQ)	8. Do you feel more tired than usual when you wake up in the morning? 1. Never or less than once a month 2. Less than once a week 3. 1 to 2 days of the week 4. 3 to 5 days a week 5. Every day or almost every day

Instrument	9. (sleep inertia or lack of it) Alertness on awakening Precise wording
5 (BSQ)	6. How often do you feel tired or fatigued after your sleep? - a. Nearly every day - b. 3-4 times a week - c. 1-2 times a week - d. 1-2 times a month - e. Never or nearly never 7. During your waking time, do you feel tired, fatigued or not up to par? - a. Nearly every day - b. 3-4 times a week - c. 1-2 times a week - d. 1-2 times a month - e. Never or nearly never
7(GSDS)	How often in the past week did you: 4.Feel rested upon awaking at the end of sleep period. (Number of days per week) that suits you best. 0 means no days during the course of a week, 7 means every day during the course of a week.
9(ISQ)	5- Feeling that your sleep is unrefreshing Never,Don't know,Rarely,Sometimes,Frequently,Always How long has the sympomps lasted?

Instrument	9. (sleep inertia or lack of it) Alertness on awakening Precise wording
16(Micheli-CSIS)	–How fresh do you feel when you wake up in the morning, independently of the hours you have slept?
17(Mindell-CSIS)	26. Do you feel you currently have a sleep problem? Yes / No If you have a sleep problem, which of the following items describe your specific sleep difficulty: (You may check more than one) _____f. non-restorative sleep or “unrefreshing” sleep
21 (PSD)	Alertness on final awakening(place a mark somewhere along the line) Very sleepy----------very alert
22 (PSQI)	9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done? No problem at all _____ Only a very slight problem _____ Somewhat of a problem _____ A very big problem _____

Instrument	**10. Daytime sleepiness** **Precise wording**
1(ASAC)	One or more of the following are present: a. Frequent somnolence or fatigue despite adequate “sleep”. b. Falls asleep easily in a non-stimulating environment (e.g., watching TV, reading, riding in or driving a car) despite adequate “sleep”
3(BIS)	5.During the past month, how many days a week have you been so sleepy/tired that it has affected you at school/work or in your private life? (number of days per week) that suits you best. 0 means no days during the course of a week, 7 means every day during the course of a week.

Instrument	**10. Daytime sleepiness** **Precise wording**
4 (BNSQ)	9. Feeling extremely tired during the day 1. Never or less than once a month 2. Less than once a week 3. 1 to 2 days of the week 4. 3 to 5 days a week 5. Every day or almost every day 10. Have you during the last three months been plagued by an irresistible urge to sleep while you were atwork? 1. Never or less than once a month 2. Less than once a week 3. 1 to 2 days of the week 4. 3 to 5 days a week 5. Every day or almost every day 11. Have you during the last three months has been plagued by an irresistible urge to sleep time? 1. Never or less than once a month 2. Less than once a week 3. 1 to 2 days of the week 4. 3 to 5 days a week 5.Every day or almost every day

Instrument	**10. Daytime sleepiness** **Precise wording**
5 (BSQ)	8. **Have you ever nodded off or fallen asleep while driving a vehicle?** - a. Yes - b. No *If yes:* 9. **How often does this occur?** - a. Nearly every day - b. 3-4 times a week - c. 1-2 times a week - d. 1-2 times a month - e. Never or nearly never

Instrument	**10. Daytime sleepiness** **Precise wording**
6 (ESS)	Use the following scale to choose the most appropriate number for each situation: 0 = would never doze 1 = slight chance of dozing 2 = moderate chance of dozing 3 = high chance of dozing SITUATION CHANCE OF DOZING Sitting and Reading _____ Watching TV _____ Sitting, inactive in a public place (e.g. a theatre or meeting)_____As a passenger in a car for an hour without a break _____ Lying down to rest in the afternoon when circumstances permit _____ Sitting and talking to someone _____ Sitting quietly after a lunch without alcohol _____ In a car, while stopped for a few minutes in the traffic _____

Instrument	**10. Daytime sleepiness** **Precise wording**
7(GSDS)	How often in the past week did you: 6.Feel sleepy during the day 9.feel tired and fatigued during the day 11.feel alert and energetic during the day 15.fall asleep at unscheduled time (Number of days per week) that suits you best. 0 means no days during the course of a week, 7 means every day during the course of a week.
8(ISI)	3. To what extent do you consider your sleep problem to interfere with your daily functioning (e.g. daytime fatigue, ability to function at work/daily chores, concentration, memory, mood, etc) 0 to 4 (0=not at all interfering, 1=ALittle,2=somewhat,3=Much ,4=Very Much Interfering)
9(ISQ)	During the past month: 12.have your sleep difficulties made tou feel fatigued? 13.how sleepy do you feel during the day? Not at all,A little bit,Moderately,Quite a bit ,Extremely.

17(Mindell-CSIS)	22. In the last two weeks, how much of a problem have you had with sleepiness during the day (feeling sleepy, struggling to stay awake during the day)? _____a. none _____b. slight _____c. moderate _____d. considerable _____e. very great 26. Do you feel you currently have a sleep problem? Yes / No If you have a sleep problem, which of the following items describe your specific sleep difficulty: (You may check more than one) _____e. excessive daytime sleepiness 28. How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your usual way of life in recent times. Even if you have not done some of these things recently try to work out how they would have affected you. Use the following scale to choose the most appropriate number for each situation: 0 = would never doze 1 = slight chance of dozing 2 = moderate chance of dozing . 3 = high chance of dozing Situation Chance of dozing a. Sitting and reading _____ b. Watching TV _____ c. Sitting, inactive in a public place

Instrument	10. Daytime sleepiness Precise wording
	(e.g., a theater or a meeting) _____ d. As a passenger in a car for an hour without a break _____ e. Lying down to rest in the afternoon when circumstances permit _____ f. Sitting and talking to someone _____ g. Sitting quietly after a lunch without alcohol _____ h. In a car, while stopped for a few minutes in traffic _____
22 (PSQI)	8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity? Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____
26 (SBSAQ)	The STOP-BANG criteria and questions are as follows: T = Tiredness. Do you often feel tired, fatigued, or sleepy during the daytime?

Instrument	11. Pre-conception sleep pattern(before pregnancy) Precise wording
17(Mindell-CSIS)	27. Do you feel you had a sleep problem prior to becoming pregnant? Yes / No (answer only if you are pregnant) If you clearly remember having a sleep problem prior to pregnancy, which of following items describe your specific sleep difficulty: (You may check more than one) _____a. falling asleep _____b. staying asleep _____c. frequent awakenings throughout the night _____d. early morning awakenings without being able to return to sleep _____e. excessive daytime sleepiness _____f. non-restorative sleep or “unrefreshing” sleep _____g. sleep paralysis or dream-like images _____h. restless legs _____i. sleepwalking
19 (Neau-CSIS)	A comparison of actual sleep during pregnancy and what this was like previously.
27 (SIGHDRS)	What were your usual hours of going to sleep and waking up, before this began? When have you been falling asleep and waking up over the past week?
28(Ursavas-CSIS)	Pregnant women were asked to report their symptoms prior to pregnancy and during the third trimester.