The spatial analysis of diagnosed Chronic Kidney Disease in Nigeria: A case study of Edo State

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ABSTRACT

The thesis explores the severity of diagnosed chronic kidney disease (CKD) with particular reference to its impact in Edo state, Nigeria. There has been a scarcity of studies on the prevalence and spatial patterns of CKD in developing countries even though the costs of treatment at the late stage of the disease are extremely expensive and the inevitable outcome for the vast majority of sufferers is renal failure. CKD is a growing problem in Nigeria, presenting challenges to the nation's health and economy. This thesis presents an analysis of 442 patients with CKD referred to the renal department at the University of Benin Teaching Hospital, Nigeria, which is currently the only fully functioning CKD treatment centre in Edo state. The research study evaluates the factors that are associated with the severity of CKD in Edo State as well as the temporal and spatial trends of diagnosed CKD across the state.

The results of this thesis highlights the spatial distribution of diagnosed CKD and evaluates the likely predictors for the severity of CKD at the time of diagnosis in Edo State by examining the socio-demographic and known biological risk factors such as diagnosed hypertension, and diabetes. It also highlights the areas of concern regarding the spatial distribution of diagnosed CKD within the state. Although there are attempts at raising the awareness of CKD across the study area, many patients are still being diagnosed at the last stage of the disease. This means that there is the probability that many cases are left undetected until it is too late.

The findings derived from this research study would be helpful both in the policy-making decisions that pertain to the health sector and the development of a healthcare accessibility model for CKD patients that could be beneficial in the location of new healthcare centres.

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ACRONYMS

CKD: Chronic kidney disease

EPO: Erythropoietin

ERA-EDTA: European Renal Association - European Dialysis and Transplant Association

ESRD: End-Stage Renal Disease

GFR: glomerular filtration rate

GIS: Geographical Information System

GWR: Geographically weighted regression

IFKF: International Federation of Kidney Foundation

INEC: Independent National Electoral Commission

ISN: International Society of Nephrology

KDE: Kernel Density Estimation

KDOQI: Kidney Disease Outcomes Quality Initiative

LADKTR: Latin American Dialysis and Kidney Transplant Registry

LSCP: Location set covering problem

MAUP: Modifiable areal unit problem

MCLP: Maximal covering location problem

MSIS: Multi-Source Information System

NACPP: National AIDS Control and Prevention Program

NAN: Nigerian Association of Nephrologists

NHANES: National Health and Nutrition Examination Survey

NHS: National Health Service

NKF: National Kidney Federation

NMCP: National Malaria Control Program

NPC: National Population Commission

REIN: Renal Epidemiology and Information Network

RRT: Renal Replacement Therapy

SCr: Serum creatinine

SIGNe: Système d'Information Géographique pour la Néphrologie

SKI: Sheffield Kidney Institute

SMR: Standardised morbidity rate

UNDP: United Nations development programme

Web-GIS: Web-based Geographic Information System

WHO: World health organisation

WKD: World Kidney Day

Chapter 1 Introduction

In many affluent countries, chronic diseases such as diabetes are showing significant increases in prevalence, posing considerable burdens on those who suffer from them and their carers, and increasing costs of healthcare systems. Chronic kidney disease (CKD) is another condition showing the same trends as diabetes. However, the disease is much less well known than diabetes. This disease can remain undetected until a late stage, when the health interventions involve dialysis and kidney transplants.

There has been a scarcity of studies by health geographers on the prevalence and spatial patterns of such chronic diseases in developing countries. This is particularly the case with CKD, for which the costs of late stage treatment are extremely expensive and the inevitable outcome for the vast majority of sufferers is renal failure.

The rise in the incidence and prevalence of CKD in both developed and developing countries has resulted in a renewed interest in global CKD prevention because many countries now regard CKD as a public health threat (Arogundade and Barsoum, 2008). In all countries, it is important to diagnose the disease early, however, for poorer countries, early diagnosis is essential to prevent mortality, as the majority of sufferers cannot afford the cost of treatment at the last stage of the disease.

1.1 Chronic Kidney Disease (CKD) in Nigeria

The actual data on the prevailing health status of Nigeria is currently inconclusive because there are no current or accurate registries or a health database to monitor the various diseases or health deficiencies that contribute to the nation's burden of disease.

Notwithstanding, a health issue that has become a growing problem in Nigeria is the prevalence of CKD. However, the exact prevalence rate of CKD in Nigeria is not known. Hospital based data in Nigeria has been used to estimate that the prevalence of CKD among annual medical admissions was between 2% and 4% (Akinsola et al., 2004), however, according to another report in 2007, the estimation of the annual medical admissions was placed between 10% and 12% (Kidney Consultants International, 2007).

Similar to other developing countries, Nigeria does not have a reliable register or database to show the current impact of CKD on its population. This therefore makes it difficult to verify the reported statistics on CKD rates within the country. Studies have shown that the commonest causes of CKD in Nigeria are chronic

glomerulonephritis[1], Type 2 diabetes[2], hypertension, and obstructive uropathy[3] (Akinsola et al., 1989; Alebiosu and Ayodele, 2005; 2006).

In Nigeria, the majority of those with CKD die because of lack of funds and access to adequate healthcare. This has been compounded by the fact that within the current healthcare system, the financial burden for the treatment of CKD is the sole responsibility of the patient, as the cost of treatment is not subsidised by the government, nor is there any health insurance policy available to cover the cost of treatment. According to previous studies, the majority of patients are diagnosed at the final stage of the disease when the cost of treatment is very expensive, usually beyond the financial capacity of the average citizen (Arogundade and Barsoum, 2008; Ulasi and Ijoma, 2010). According to a medical report by a Nephrology agency in Nigeria, the average yearly costs of kidney management for stage 5 CKD patients is 2,401,340 naira, which is approximately £11,000 (Kidney Consultants International, 2007). However, the country's average household annual net income is estimated at N126,895, which is approximately £500 (Oseni and Winters, 2009). Given the high cost of treatment for the last stage of CKD, it is clear that majority of the

[1] Chronic glomerulonephritis is the advanced stage of a group of kidney disorders that results in the inflammation and progressive destruction of internal kidney structures called glomeruli.
[2] Type 2 diabetes is a disease caused by insufficient insulin production or lack of responsiveness to insulin, resulting in high blood glucose levels
[3] Obstructive uropathy is a structural or functional hindrance of normal urine flow, sometimes leading to renal dysfunction

patients are unable to either begin or continue treatment, once diagnosed with the disease (Arije et al., 2000; Bamgboye, 2003).

The problems posed by CKD on the population and the economy of Nigeria point to the need for interventions such as the creation of a National Kidney Foundation and a functional National Health Insurance Scheme aimed at the prevention and early treatment of CKD in the country (Bamgboye, 2003). However, there is currently no government-funded/aided national prevention programme for CKD within the country (Arogundade and Barsoum, 2008). In order to combat the disease, the main route taken by the Nephrology society in the country is to raise awareness of CKD among the public using events organised during World Kidney Day (WKD) programme that began in 2006, however, this has not effectively improved the management of the disease within the country (discussed in chapter five).

1.2 Why is this research study original?

Although there have been studies researching the prevalence and impact of CKD, there are currently few published research studies by health geographers which have focused on the spatial variability in the prevalence and impact of CKD. Furthermore, no such study has been carried out within a developing country. Therefore, the originality of this study lies in the spatial analysis of CKD using geographical information systems (GIS) in the study of chronic kidney disease within Nigeria. This would equally contribute to an understanding of

the spatial impact of CKD in other African settings as no such study has been carried out on the prevalence of CKD within any African country. It is therefore hoped that this research study will contribute to the improvement in managing CKD within the study area in particular and the country in general.

1.3 Contribution to the academic field of knowledge

In recent years, medical researchers have studied the increasing prevalence of chronic diseases such as hypertension, diabetes, and chronic kidney disease. However, the contributions of health geographers to the study of these chronic diseases especially within developing countries have been rather limited. Therefore, it is hoped that the main findings of this study will contribute to the field of health geography by applying a spatial perspective to the study of the available CKD dataset from a developing country that had previously been only made available to medical researchers particularly in the absence of a national CKD registry.

1.4 Study Area

The study area for this research study was Edo state, which is one of the 36 states in Nigeria located in the Niger-delta region of the country.

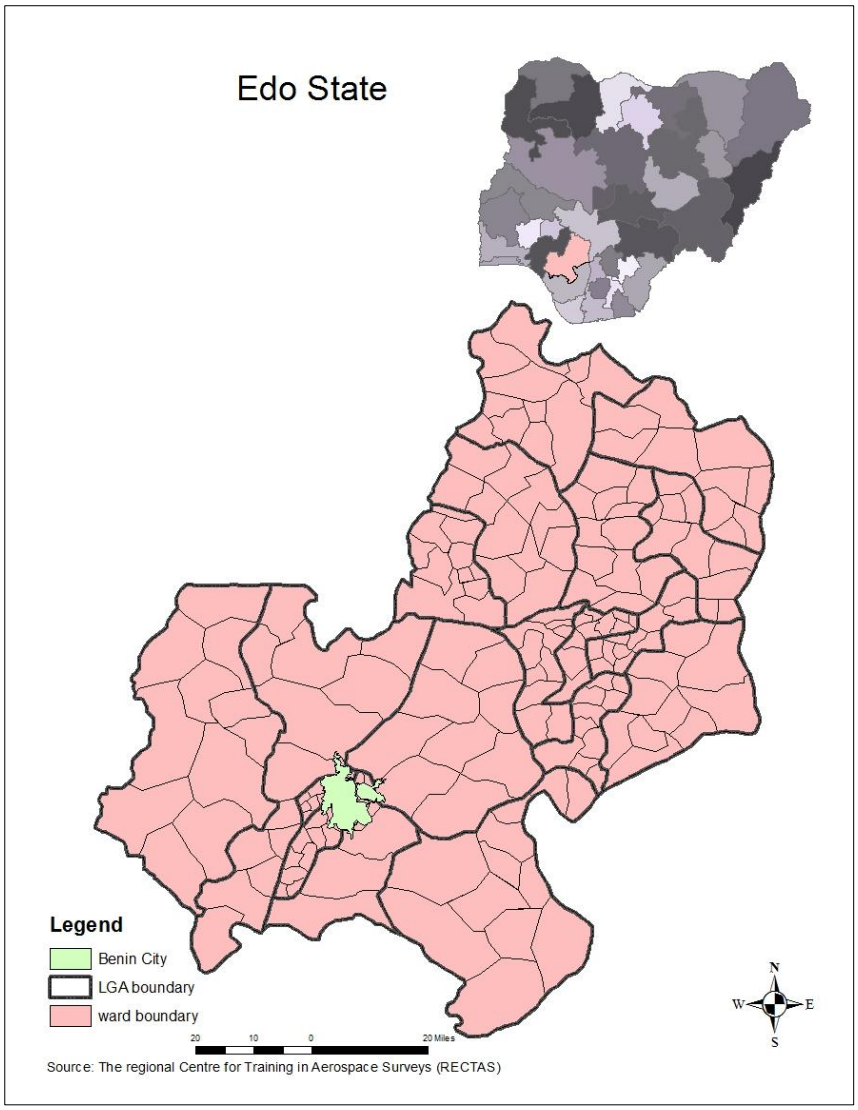

Figure 1.1 : The study area including an inset map of Nigeria, which shows the location of Edo state

Edo State shares boundaries with Delta state on the South, Ondo state on the West, Kogi state on the Northeast and the state's capital is Benin City. There are eighteen local government areas (LGAs) in Edo State with an average of 10 political wards in each LGA. In total, there are 193 wards within the state. The wards are currently the smallest unit of health services delivery in the state and the country in general.

The population within Edo state can be regarded as having a diverse population structure because of the many ethnic groups within the state. The main ethnic groups in Edo State are the Binis, Afemais, Esans, Owans, and Akoko Edos. According to a report (Edo State Government, 2009), the Bini speaking people who occupy seven out of the 18 Local Government Areas of the state constitute 57.54% while others include Esan (17.14%), Afemai comprising of Etsako (12.19%), Owan (7.43%), and Akoko Edo (5.70%). However, the Igala-speaking communities exist in Esan South-East, Igbira related communities in Akoko and Afemai Areas as well as Urhobos, Izons, Itsekiris and Yoruba communities in Ovia North-East and Ovia South-West Local Government Areas especially in the borderlands.

Edo State was chosen as my study area because it is my home state and because of the established access to the management body of the nephrology department for the hospital where I collected the CKD data used in the study.

1.5 Aim of the research study

Due to the problem of late diagnosis of CKD among the general population, this research aims to examine the factors that are likely to contribute to the early or late diagnosis of CKD in patients in Nigeria. Using secondary data (i.e. data from health records of CKD patients), it attempts to identify any variation(s) among the factors associated with CKD patients and determine if it can be regarded as an influential factor on the severity of CKD at the time of diagnosis. This could help

contribute to the development of interventions that are more effective in the prevention and management of the disease. The study also investigates the accessibility of patients with CKD to healthcare to determine the efficiency of the health service available to CKD patients in the area. The results could identify any accessibility issues relating to the number of CKD patients that are being treated by the hospital. At the moment, there is only one healthcare service that treats CKD in the state and this is the University of Benin Teaching Hospital (UBTH). As a result, UBTH was where CKD data was collected and used for this research study. The study involved the analysis of CKD patients diagnosed from 2006 to 2009. The reason for selecting CKD patients from this study period is because the global awareness programme for Kidney disease termed "World Kidney Day" first started in 2006 and Nigeria is among the African nations that has been participating in the awareness programme since 2006 (ISN, 2006). That year marked the turning point in the awareness of CKD as this programme has led to an increase in the number of charity organisations that are affiliated with kidney awareness within the country. These charities along with the Nigerian Association of Nephrologists (NAN) routinely carry out these awareness programmes every year since 2006. It is therefore hoped by the Nigerian Association of Nephrologists and the affiliated charities that there would be a steady improvement in the number of early diagnosis of CKD within the population. The year 2009 marked the end of the study period as this was the year I proceeded with the data

collection for my research study. Therefore, at the beginning of this research study, I had hoped that this study period would produce the highest possible number of diagnosed cases. However, in the course of carrying out this study, this did not prove to be the case because there was no significant increase in the number of diagnosed CKD cases especially for patients that were diagnosed at the earlier stages (discussed in chapter five).

1.5.1 **Research Questions**

The analysis presented in this thesis addresses the following research questions:

1. Is there an association between socio-demographic factors and the severity of CKD at first presentation?
2. Is there a relationship between the severity of CKD at first presentation in Edo state and known biological risk factors of CKD?
3. What factors are likely to lead to the late diagnosis of CKD among patients in Edo State?
4. What is the trend of diagnosed CKD within Edo state?
5. What is the spatial pattern of diagnosed CKD cases within Edo state?
6. Is the prevalence and distribution of CKD in the state appropriately serviced by the available CKD healthcare service?

It is hoped that this research will provide the platform for modelling national CKD future risk and projected distribution based on national census data and maps as well as the future application of GIS technology and expertise on national CKD data.

1.6 Structure of the Thesis

The thesis is organised into eight chapters outlined below:

Chapter 2 begins with the theoretical framework of the thesis. This is followed by a brief explanation of the functions of the kidney, description of CKD, the causes, the symptoms, and treatment of the disease. The chapter also reviews literatures from the most relevant fields of research. These include research studies on chronic kidney disease and its associated risk factors, studies on spatial epidemiology with particular references to the spatial distribution of CKD as well as the application of geographical information systems (GIS) in the study of health outcomes particularly within developing countries where detailed datasets are not readily available.

In **chapter 3**, the research design, data collection process, and methods selected are discussed. The limitations of the available datasets are also discussed within this chapter. Given the limitations associated with the available datasets, a pragmatic approach was used in determining the methods that appeared best suited to address the research questions outlined above. An overview of the chosen statistical and spatial methods included within the study is briefly discussed. The chapter concludes with a brief discussion on other methods that were considered but not applied in the study.

In **chapter 4**, the CKD dataset used in the study is evaluated. This can be described as the *preliminary analysis* chapter as it involves the descriptive analysis of the variables within the dataset. The outcome

of the preliminary analysis provides a profile of diagnosed CKD patients represented within the dataset.

Chapter 5 focuses on answering the first four research questions outlined above. The findings within this chapter are primarily derived using statistical analyses. It attempts to determine the factors associated with the severity of CKD at the time of diagnosis and also evaluates the trend of diagnosed CKD within the study period. The results are discussed and the justification for taking research further is briefly outlined.

Chapter 6 focuses on the spatial analyses of the CKD dataset with the aim of answering the fifth research question. It involves determining the rates of diagnosed CKD across the study area in order to identify areas with high rates of diagnosed CKD and areas with low rates or absence of diagnosed CKD. The problems experienced in carrying out the analyses, how they were resolved, along with the findings of these spatial analyses are discussed.

In **chapter 7**, which is regarded as the final analysis chapter, the accessibility to CKD healthcare service within the study area is examined. It involves the use of travel time models to explore the efficiency of the current structure of healthcare for CKD patients within the study area as well as evaluate potential scenarios that could improve the CKD healthcare service in the area.

Chapter 8 is the concluding chapter, which summarises the findings of the research study. The limitations of the research study, the

implications of the findings and the recommendations for further studies are also discussed.

Chapter 2 Evaluating CKD from a geographical perspective

2.1 Introduction

Scientific studies indicate that there are more occurrences of kidney disease than had been previously thought (Collins et al., 2006). Among these kidney diseases, chronic kidney disease (CKD) has been found to be widely prevalent in the general population (Coresh et al., 2007a). The number of patients with CKD is increasing and is anticipated to rise further (Mahon, 2006). Some of this increase has been attributed to better healthcare services, which resulted in better diagnosis (Peres et al., 2010) along with population growth which has also resulted in an increase in the number of older people who have a higher risk of developing CKD (Stevens et al., 2010). Worldwide, it is estimated that over 1.1 million patients with the final stage of CKD require maintenance dialysis, and this number is increasing at a rate of 7% per year (Paraskevas et al., 2010). Efforts are therefore being made by nephrologists to increase the awareness of CKD prevalence among the general public. This is because although the disease is less well recognised than other chronic diseases such as diabetes and cancer by the general public, its impact is being regarded as a growing threat in both rich and poor countries (Harman, 2009). One such effort is the initiation of the "World Kidney Day" programme, which aims to address the problem of poor awareness of CKD thereby enabling the general public to take better care of their kidneys and seek treatment early to avoid preventable complications. The programme was first launched in 2006 and is held on the second Thursday of March each

year as a joint initiative of the International Society of Nephrology (ISN) and the International Federations of Kidney Foundation (IFKF). The programme is marked by a number of events designed to raise awareness among the general public as well as among medical professionals (discussed further in chapter five).

This chapter begins with the theoretical framework of the thesis. The second segment of the chapter provides an overview of the kidney and its functions within the body. The definition of CKD and the various stages of CKD, the symptoms that are associated with the disease, the likely causes of the disease, and how the disease is currently managed are then discussed. The third segment of the chapter discusses the various socio-demographic variables that are currently associated with health outcomes especially CKD related outcomes. The fourth segment examines the international prevalence of CKD as well as the prevalence in Nigeria. The fifth section of this chapter reviews the application of Geographical Information System (GIS) within the African health sector, taking into account the advantages of spatial evaluation in healthcare particularly the use of GIS as a method to spatially evaluate health outcomes within the African health sector. This section attempts to evaluate the benefits of the utilisation of GIS within the African setting given the limited yet essential resources required in effective healthcare management. The final section reviews the utilisation of GIS in the study of CKD in order to highlight the advantages of spatial analysis using GIS in CKD research and management.

2.2 Theoretical framework

This research aims to examine the factors that are likely to contribute to the early or late diagnosis of CKD in patients in Nigeria. Therefore, access to available CKD healthcare within the state will be examined in order to determine if it conforms with the inverse care law (Hart, 1971). This law proposes that healthcare services are distributed inversely to population health needs and mainly operates where medical care is exposed to market forces. When Hart initially described the inverse care law in 1971, he was mainly concerned with the effects of market forces on healthcare in the British National Health Service (NHS). This was due to existing demands on the private sector, to provide solutions to healthcare delivery problems (Watt, 2002). Hart argued that under no circumstances would any market move its investment from where it is most lucrative to where there is a greater need and as such a market based approach will not be effective in providing a rational and effective healthcare system (Hart, 2001; 2006). It can therefore be argued that inequality is a major feature in any society where market forces determine an individual's access to healthcare. This suggests that those with the greatest healthcare needs often receive the least adequate healthcare and this pattern of inequality can be driven by profit (Fiscella and Shin, 2005). Since the inverse care law is still present in the NHS 'where financial barriers to care have been largely removed', it can be said that 'other processes are at work' (Watt, 2002, p. 252). These processes are likely to be present in other countries as the inverse care law has been found

to be present in the provision of healthcare in other countries although healthcare is generally regarded as a human right, unsuited to trade (Hart, 2006). It can be argued that the limited access and affordability of treatment by people in low socio-economic status areas is a common factor associated with the presence of the inverse care law (Bishai et al., 2007; Furler et al., 2002; Ross, 2005). Evidence indicates that patients with low socioeconomic status are more likely to become ill (and to do so earlier) than patients from more affluent groups, but their communities are less attractive to doctors (Carlisle and Johnstone, 1996; Hart, 2006). This can be attributed to the poor living standard of people within these communities, which has lasting consequences on their social and biological health (Hart, 2006). Therefore, as affluent groups within any society accumulate 'the public-health benefits of effective clinical interventions, the effect of evidence-based medicine' will be to increase health inequality, which is consistent with the presence of the inverse care law (Watt, 2002, p.253).

When Hart proposed the inverse care law in 1971, he did not use his own data for the inverse care law but he did draw on the findings of others to support it. This included a study by Ann Cartwright (1967) that consisted of 1370 randomly sampled adults in representative areas of England and their 552 doctors, which Hart used while investigating the evidence of 'selective redistribution of care' between the middle class and the working class (Hart, 1971, p. 407). He suggested that her findings indicated that the 'better-endowed, better-equipped, better-

staffed areas of the service draw to themselves more and better staff, and more and better equipment' and this led to an accumulation of better facilities in more affluent and equally healthier areas (Hart, 1971, p. 408). The inverse care law therefore has implications for healthcare access and outcomes for less affluent members of the society because they are less likely to gain access to adequate healthcare.

Much evidence has been collected in favour of the inverse care law since 1971 (Cooper, 2010). Many of the studies providing evidence of the inverse care law focused on specific health outcomes such as healthcare access (Kruger et al., 2011), consultation length (Furler et al., 2002), quality of service (Mercer and Watt, 2007), likelihood of diagnosis, and referrals to secondary and tertiary healthcare services (Baird et al., 2008).

2.2.1 **The inverse care law and access to care in Nigeria**

Since the postulation of the inverse care law, one of the factors that have been associated with the law in many societies is the issue of access to healthcare. Access to healthcare can be defined as "the ability to secure a specified range of services at a specified level of quality, subject to a specified maximum level of personal inconvenience and costs, whilst in the possession of a specified level of information" (Goddard and Smith, 2001 p. 1151). Therefore, accessing available healthcare does not only refer to geographical accessibility, it equally includes affordability of the health service and

awareness of the healthcare services available to the individual or community.

In Nigeria, the provision of healthcare is currently managed by the three tiers of Government (Acho, 2005; Akhtar, 1991). The federal government's role involves coordinating the affairs of the university teaching hospitals, which provide tertiary[4] healthcare while the state government manages the general hospitals (secondary healthcare) and the local government focuses on primary healthcare. Furthermore, Nigeria does not currently offer free healthcare to patients; patients are expected to pay for any healthcare service that they receive. There are also privately owned healthcare facilities within the country but none of them are classified as tertiary hospitals. The payment for treatment within the public and private healthcare system has continued to raise the issue of inequalities in the access to healthcare and the utilisation of health services by all socio-economic groups (Onwujekwe, 2005). Due to the high population in urban areas and the fact that the cost of treatment within the Nigerian healthcare system is paid by patients and/or family members, healthcare providers tend to locate their facilities in urban areas where they can improve the demand for their health service(s). This is because the urban areas have a higher population than the rural areas therefore the urban areas are likely to have more health cases than the rural areas and also there is the likelihood that more people in urban areas can afford the cost of

[4] Tertiary healthcare are specialised consultative health care and patients are usually referred from primary and secondary healthcare centres

treatment. This could explain why all the tertiary hospitals and most secondary hospitals are located in urban areas. For example, according to a report on the number of registered healthcare facilities in Edo state, all the tertiary hospitals are located in urban centres in the state and 59.2% of all privately owned hospitals and clinics are located within Benin City despite the fact that Benin City has a population of 1125058, which is approximately 35% of the total population in the state (Edo State Government, 2009). In addition, a study that examined the deprivation index within the LGAs in Nigeria, indicated that within Edo state, six of the LGAs (approximately 25% of the population), which are predominantly rural areas, had a high index of above 121 for areas that are more than one hour away from the nearest health facility (Ojo et al., 2010).

It should be noted that although the urban areas have a higher population than their rural counterparts, an aggregate of the total population living in rural areas are higher than the total population living in urban areas. For example, in Edo state, Benin City has approximately 35% of the total population in the state while the remaining notable urban areas namely Irrua, Ekpoma, Auchi, and Uromi have a combined population of approximately 10.4%, which means that approximately 54.6% of the population resides in rural areas (Nigerian Population commission, 2006). Therefore, it can be argued that within the current healthcare structure in the country, only the smallest proportion of the population access tertiary care as these are located in urban cities. This is because the larger proportion live in

rural areas and most of the rural population are too poor to pay for the service and even if they could afford the treatment, there is the absence of an efficient transportation system (Ipingbemi, 2008), which makes it difficult to access tertiary care facilities that are located in urban areas. Evidence from past censuses conducted within the country indicates that over 70 percent of rural dwellers are within the low socioeconomic groups (NPC, 2005). This suggests that rural dwellers appear to have a limited access to specialist care and laboratory support for the much needed screening and diagnosis of chronic illnesses (Ogunbiyi, 2011). It can be argued that access to healthcare supports the evidence of the inverse care law because the cost of available treatment could be too high for many rural dwellers. Therefore, strategies to overcome this inverse care provision should be put in place within the healthcare system, such as subsidising cost of treatment, increasing the number of doctors within disadvantaged areas, provision of incentives for doctors in rural areas, and strengthening health promotion and community health services in disadvantaged areas (Furler, 2002). Furthermore, there is evidence that the socio-economic status and region-specific knowledge about healthcare access positively affects a patient's health outcome in Nigeria (Agee, 2010). In September 2004, a revised national health policy for Nigeria derived from the National Health Policy and Strategy[5] promulgated in 1988 had as its long term goal to provide the

[5] The National Health Policy and Strategy of 1988, emphasized Primary Health Care as the

entire population with adequate access, not only to primary health care but also to secondary and tertiary services through a well-functioning referral system (Federal Ministry of Health, 2004; Ogunbiyi, 2011). The policy also aims to ensure an "equitable distribution of human resources for healthcare delivery between urban and rural areas, including difficult terrain, such as mountainous, riverine, and inaccessible areas of the country" (Federal Ministry of Health, 2004 p. 31). However, there has not been any noted change within the Nigerian healthcare structure since the introduction of the revised policy in 2004. Studies have indicated that there is unequal access to healthcare within the country, which suggests that distance to improved healthcare and the total cost of seeking health care need to be reduced to enhance access to improved health services by various socio-economic groups in the country (Antai et al., 2010; Awoyemi et al., 2011; Omonzejele, 2010).

In summary, it can be argued that the literature on access to healthcare in Nigeria appears to support the presence of the inverse care law within the Nigerian health sector because in the provision of healthcare services, the market forces are the main forces in operation. This is particularly evident in the provision of specialised care because market forces have greatly influenced the distribution of specialised healthcare services than the need of the population. Evidence suggests that these healthcare services are provided where they are likely to be

profitable rather than on the basis of need alone and this could have an impact on the access to healthcare within the country. Given the current literature on access to healthcare within Nigeria, this study considers whether an inverse care law can be observed in the provision of CKD healthcare for CKD patients by evaluating whether the access to available healthcare could have influenced the spatial distribution of diagnosed CKD patients within the state.

The rest of this chapter will discuss the functions of the kidney, and the causes, symptoms, and treatment of chronic kidney disease. The chapter also reviews research literatures on CKD that relates to addressing the research questions outlined at the beginning of the thesis (see section 1.5.1).

2.3 The Kidney

The kidneys are vital organs that keep the blood clean and chemically balanced. They are located just below the rib cage, on each side of the spine (see Figure 2.1). The kidneys weigh about 0.1 kg each and process approximately 200 litres of blood daily to remove waste products as well as excess water from the body (Mercer and Watt, 2007). These waste products include urea, creatinine[6], potassium, sodium, phosphorus and fluids (Kidney Consultants International, 2007). This becomes urine, which flows to the bladder. A failure of

[6] **Creatinine** is a breakdown product of creatine phosphate (which is a molecule that serves as a high-energy phosphate that is formed from certain amino acids) in the muscles, usually produced at a fairly constant rate by the body depending on the mass of the muscle.

the kidneys could therefore lead to many negative complications and could gradually affect the other organs of the body.

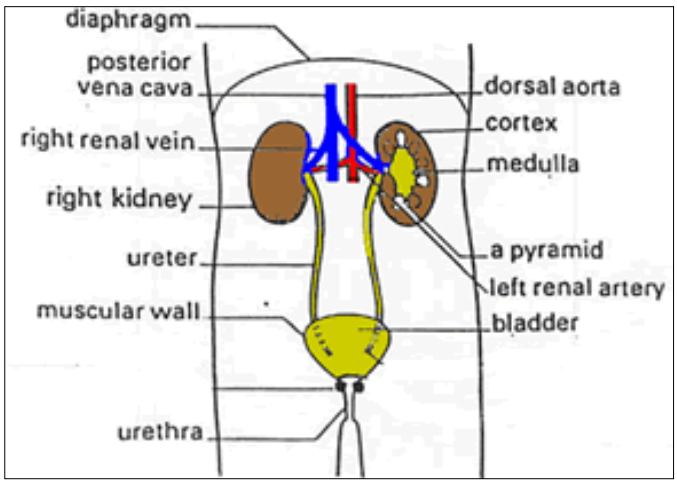

Figure 2.1: The human Kidney

Source: BURRELL, JOHN (2010) Click4biology (online) http://Click4biology.info/

2.3.1 Functions of the kidney

Apart from the removal of waste products and excess fluids from the body, the kidney performs a number of functions that are vital for a healthy body. These include the following (Kidney Consultants International, 2007; Peter, 2007):

1. They help to reabsorb useful substances like glucose and protein into the body in precise levels needed for the body to function properly.
2. They produce hormones that help various organs carry out their specific functions. Healthy kidneys make hormones including renin and angiotensin, which regulate how much sodium and fluid the body keeps, and how well the blood

vessels can expand and contract. This process helps control blood pressure.

3. They help to produce red blood cells, and maintain healthy bones. Healthy kidneys produce a hormone known as erythropoietin (EPO), which is carried in the blood to the bone marrow where it stimulates the production of red blood cells. These cells carry oxygen throughout the body.
4. They help to produce vitamin D, which maintains the health of bones. Healthy kidneys produce a hormone called calcitriol, which maintains the right levels of calcium and phosphate in the blood and bones.

In summary, "*the kidneys function as excretory, biosynthetic*[7]*, and metabolic organs, vital for maintaining normal physiology"* (Peter 2007, p. S2)

2.4 Chronic Kidney Disease (CKD)

Chronic kidney disease (CKD) is a gradual loss of kidney function, usually taking months, or years to develop. In 2002, the National Kidney Federation's (NKF) Kidney Disease Outcomes Quality Initiative (KDOQI) Work Group developed a staging system to define CKD according to the presence or absence of kidney damage and level of kidney function. The increased severity of CKD is divided into five stages (see Table 2.1) with the fifth stage categorised as a

[7] **Biosynthetic**: is a chemical reaction that occurs in cells of living organisms whereby the substance acted upon by an enzyme are converted to more complex products.

total or near-total loss of kidney function, which results in a patient requiring some form of renal replacement therapy such as dialysis or a kidney transplant. The stages of CKD are determined by a measurement of the kidney's function known as glomerular[8] filtration rate (GFR) (NKDEP, 2009; Poggio et al., 2006).

Table 2.1 Stages of Chronic Kidney Disease

Stage	Description	GFR* mL/min/1.73m^2
1	Slight kidney damage with normal or increased filtration	More than 90
2	Mild decrease in kidney function	60-89
3	Moderate decrease in kidney function	30-59
4	Severe decrease in kidney function	15-29
5	Kidney failure requiring dialysis or transplantation	Less than 15

Source: http://www.kidney.org/professionals/kdoqi/guidelines_ckd/p4_class_g1.htm

Anyone with a GFR < 60 mL per minute per 1.73 m^2 for more than 3 months is classified as having CKD and this represents a loss of 50% or more of the adult level of normal kidney function (Peter, 2007; National Kidney Foundation, 2002).

2.4.1 Symptoms of CKD

As the kidneys perform so many functions for the body, chronic kidney disease can affect the body in different ways. Therefore, symptoms tend to vary greatly. Symptoms of chronic renal disease are characterized by a combination of many of the following factors (Murphy et al., 2009; Murtagh et al., 2007; NKDEP, 2009):

1. Fatigue and weakness (from anaemia - shortage of red blood cells) or accumulation of waste products in the body)
2. Loss of appetite, also nausea and vomiting

[8] **Glomerular** : A tiny structure in the kidney that filters the blood to form urine

3. Swelling of the legs and puffiness around the eyes due to fluid retention
4. Itching, easy bruising, and pale skin (from anaemia)
5. Headaches, numbness in the feet or hands, disturbed sleep, altered mental status, and restless legs syndrome
6. High blood pressure, chest pain due to inflammation around the heart
7. Shortness of breath from fluid in lungs
8. Bleeding (poor blood clotting)
9. Bone pain and fractures

2.4.2 **Causes of CKD**

There are a number of factors that can lead to the development of CKD, including diseases of the kidneys themselves; however, the major risk factors are diabetes and hypertension (Peter, 2007). Other noted risk factors include; chronic glomerulonephritis, toxic nephropathy, obesity, HIV infection, sickle cell disease, heroin abuse, amyloidosis [9] , chronic kidney infections, certain cancers, and obstructive uropathy[10] e.g. kidney stones, clogging and hardening of the arteries (atherosclerosis) that lead to the kidneys thereby causing a condition called ischemic nephropathy (Pranay, 2007). In order to identify how CKD could develop in an individual, a few of the listed risk factors are briefly discussed below.

A number of studies have identified diabetes as one of the main risk factors for CKD. This covers countries including the USA (Collins et al., 2005; Vassalotti et al., 2010), Latin American countries (Dirks et

[9] **Amyloidosis:** A condition in which a protein-like material builds up in one or more organs, this material cannot be broken down and interferes with the normal function of that organ.

[10] **Obstructive uropathy:** is the obstruction of normal urine flow, sometimes leading to the disturbance in the functioning of the kidney

al., 2006), countries in sub-Saharan Africa (Mbanya et al., 2010), and China (Zhang et al., 2008). Diabetes is a disease characterized by high glucose levels which are usually associated with insulin deficiency, which causes complications to the kidneys and nerves and also increases the risk for heart disease (Herman, 2007). There are currently three main tests used to measure the level of the blood glucose in a person in order to identify higher than normal glucose level in that individual. These tests are relatively cheap and simple to carry out. Therefore, an early diagnosis of diabetes could help reduce the possibility of developing kidney complications and potentially CKD.

Hypertension is a disease classified by an abnormally elevated blood pressure. It is a known risk factor for heart disease (such as stroke and heart failure) and kidney disease (Carretero and Oparil, 2000). Currently, the diagnosis of hypertension is dependent on the measurement of blood pressure (Hemmelgarn et al., 2006). Again, an early detection and management of hypertension in an individual could reduce the possibility of developing CKD.

Chronic glomerulonephritis is a progressive inflammatory disease that leads to the destruction of the glomeruli of the kidney, which gradually results in the loss of kidney function (Kalyuzhina and Kalyuzhin, 2004; Sadjadi, 2007). Due to the gradual progression of the disease, it is usually detected during a routine medical test such as urine test to detect blood and protein but the disease is usually

confirmed with a kidney biopsy (Sadjadi, 2007). As a result, cases may not be detected early, which could lead to complications, including CKD. Should the disease be left undetected for too long, it could lead to a more advanced stage of CKD when it is finally diagnosed. In poor countries, it should be noted that a kidney biopsy is an expensive and potentially risky surgical procedure.

Toxic nephropathy is a general term that describes kidney damage caused by toxins that were either ingested or originated within the body thereby leading to a disruption in the function of the kidneys (Wali and Henrich, 2002). Many industrial and environmental chemicals have been shown in experimental studies to be toxic to the kidneys (WHO, 1991). When toxic nephropathy is not treated early, it could result in the development of CKD. The use of traditional/herbal treatments along with self-medication has been known to contribute to the development of toxic nephropathy in many patients particularly in African and Asian communities (Imai and Matsuo, 2008; Jha and Chugh, 2003a). A number of these medications, which are usually unregulated by the health authorities, are found to have compounds that may be contaminated with drugs or heavy metals (Bagnis et al., 2004).

Past studies have shown that patients are likely to take traditional treatment before visiting a health centre for treatment and some are known to take traditional treatments and modern medications simultaneously (Ezegwui, 2010; Jombo et al., 2010; Omorodion,

1993). The use of these traditional/herbal treatments along with self-medications is known to contribute to the development of toxic nephropathy in most patients (Imai and Matsuo, 2008).

Toxic nephropathy on the kidneys is usually diagnosed as an underlying cause of kidney failure during a thorough examination of the patient's medical history. This means that the development of CKD in a patient who has toxic nephropathy is sometimes determined by the severity of the toxin's damage to the kidney. There are indications that the influence of toxic nephropathy on the development of CKD in an individual is under-estimated, as the CKD cases might not be tested for toxic nephropathy at the time of CKD diagnosis (Brewster and Perazella, 2004; Simon, 1999; Soderland et al., 2010).

2.4.3 **Treatment of CKD**

There is currently no cure for CKD but it can be managed in order to slow the progression of the disease by treating underlying causes and contributing factors, complications, and by replacing lost kidney function. A patient with stage 1 CKD is classified as having some evidence of kidney disease with normal kidney function. In patients with Stage 2 CKD, their kidney function is classified at 60-90% (see Table 2.1). Most patients with stages 1 and 2 CKD just need a routine test each month to monitor the function rate of their kidneys and in most cases, they may also require a special diet. However, some of these patients may need further investigation due to other risk factors that are present such as hypertension and diabetes that equally require

treatment, which could result in more complications if left untreated. Although these tests can be regarded as a simple routine test within developed countries like the UK, in poorer countries, the cost could be unaffordable to most of the patients.

It should be noted that most patients at the first four stages require medical treatments that typically involve drugs and most cases a special diet. Patients diagnosed at stage 3 CKD have a similar treatment to patients with stages 1 and 2, but with more frequent monitoring. Patients diagnosed at the fourth stage of CKD require about three tests each month in order to monitor the functioning capacity of their kidney. Although the functioning capacity of the kidney at this stage is rather low (approximately 15%-30%), evidence shows that the disease can be appropriately managed without it deteriorating to the final stage (El Nahas, 2005). Patients with stage 5 CKD are classified as having the last stage of the disease, which means that their kidneys are functioning at less than 15%. Patients at this stage require some form of kidney replacement treatment, as their kidneys are no longer functioning properly on their own. At this point, renal replacement therapy (RRT) is the recommended maintenance treatment.

Renal replacement therapies take over a portion of the function of the failing kidneys to remove the fluid and waste. There are three types: kidney transplantation, haemodialysis, and peritoneal dialysis.

Kidney transplantation involves taking a kidney from a donor and implanting it. In haemodialysis, the patient's blood is pumped through a dialysis machine to remove waste products and excess fluids; this procedure is done weekly although three times a week is regarded as the standard recommendation (Locatelli et al., 2005). Peritoneal dialysis uses the patient's own body tissues inside of the belly to act as a filter. The abdomen is filled with special solutions that help remove toxins. This form of dialysis can be performed at home, but must be done every day (NKF-K/DOQI, 2001).

2.4.3.1 *Treatment of CKD patients at the University of Benin Teaching Hospital (UBTH)*

According to the nephrologists at the renal unit in UBTH, once a patient has been diagnosed with CKD, the patient would have to undergo mandatory health investigations to monitor the progress of the disease at certain intervals. Each investigation costs approximately nine thousand naira (N9000). Those who are diagnosed at early stages of the disease (such as stages 1- 3) may require approximately one mandatory investigation per month. A patient diagnosed at stage 4 is expected to have a mandatory investigation every two weeks. A patient diagnosed with stage 5 CKD is expected to have a mandatory investigation every week and also have dialysis sessions. The nephrologists at the hospital indicated that three dialysis sessions per week are the optimal number of dialysis sessions required. However, this has not been possible, as most patients cannot afford the cost. They disclosed that the cost of each dialysis session is approximately

twenty thousand naira (N20000), therefore a patient with stage 5 CKD is expected to spend approximately sixty nine thousand naira (N69000) per week. The difference in the cost of managing the disease varies significantly across the different stages of the disease and the cost is exceptionally high among stage 5 cases. This means that each month, a patient diagnosed with the first three stages of CKD spends N9000, and a patient diagnosed at stage 4 spends N18000, while a stage 5 CKD patient spends N276000. Since healthcare costs are the full responsibilities of the patient or their family, it has been observed that most stage 5 CKD patients that require dialysis sessions often go for the "*No Treatment*" option because the cost of treatment is too expensive. The recently introduced National Health Insurance Scheme in Nigeria does not cover CKD patients, which rules out the option of relying on the use of the health insurance to cover the treatment of the disease (Ulasi and Ijoma, 2010).

2.5 Socio-demographic determinants of health and its association with CKD

Socio-demographic trends have had an effect in the spread of diseases within the human population. Presently, most demographers and epidemiologists are convinced of the close association between human demography and infectious diseases (Cohen, 1999). A number of studies have also carried out research studies on the relationship between demographical factors and non-infectious disease and in most cases there has been a significant association obtained from the results

(Duthé and Pison, 2008; Goldman, 2001; Guralnik et al., 1993; Ukraintseva and Yashin, 2003).

2.5.1 **Sex and health**

There is a substantial body of evidence of differences between males and females in a wide range of health outcomes (MacIntyre et al., 1996). Whilst male life expectancy is shorter, females have poorer health through life than men (Macintyre, 1993; Verbrugge, 1989; Haavio-Mannila, 1986). This has been disputed stating that these studies often fail to take into account factors such as the gendered distribution of social roles, age, and morbidity measures (MacIntyre et al., 1996; Verbrugge, 1976; Wingard et al., 1989).

In relation to access to health care, there have been indications of discrimination. Women's accessibility to healthcare might be dependent upon variables such as their status in the specific culture and society to which they belong (MacCormack, 1988; Berhane et al., 2002), their position in the labour force, and in several cases, their ethnicity (Puentes-Markides, 1992; Kim et al., 2007). There is evidence of sex discrimination in the diagnosis of various diseases particularly chronic disease like hypertension (Basu et al., 2010), heart disease (Bönte et al., 2008) and CKD (Ulasi, 2008). This has mainly been attributed to the biased approaches in the diagnosis of these diseases in men and women.

There is evidence of higher prevalence of CKD among the male population than female population (Jones et al., 1998; Jungers et al.,

1996). However, it has been argued by Perrone and his colleagues (1992) that the higher prevalence of CKD amongst males could be attributed to the use of a single cut-off serum creatinine (SCr) value for both males and females although these SCr values do not equate with similar Glomerular filtration rates (GFR). The measurement of the serum creatinine is regarded as a simple test that is used as an indicator of renal function. However, this test is not suitable for detecting early-stage kidney disease as a rise in blood creatinine level is only observed with marked damage to functioning nephrons (Peake and Whiting, 2006). Perrone and his colleagues argued that because the SCr levels vary depending on age, sex, muscle mass, and diet, therefore, what would be regarded as "normal" serum levels can drastically mask reduced kidney function. This could lead to problems in identifying actual CKD patients from the general population as most female patients may be denied early referral if the approach to their diagnosis is based on applying SCr level to guide referral, rather than calculated GFR. This results in males being diagnosed earlier, and referred for treatment earlier. Their argument has been supported by similar studies that identified the problems associated with using a single cut-off serum creatinine value in the diagnosis of CKD (Peake and Whiting, 2006; Shephard et al., 2010).

2.5.2 **Age and health**

Age is a significant indicator of many health outcomes, as there is a general perception that older age groups have a higher risk of poor health because they are more prone to diseases. Older age groups are

at risk of diseases such as heart disease (Lloyd-Jones et al., 1999; Seeman et al., 1993) and cancer (Carter et al., 1999; Parkin et al., 2001).

Similarly, there are indications that the youngest and oldest age groups are more at risk than other age groups to certain diseases. For example, children younger than two years old and those above the age of sixty-five years are at a higher risk of developing influenza complications that could cause severe illness or death (WHO, 2009).

In relation to kidney diseases, there are indications that suggest that the kidney functions decline with age (Garg et al., 2004) which increases the risk of developing CKD. This is supported by O'Hare et al (2006; 2007), who indicated that the risk of CKD appeared to increase with age. However, the disease has been known to affect young children (Atkinson et al., 2010; Mak and Bakris, 2010; Michael and Gabriel, 2003; Olowu, 2003). Vassalotti et al (2010) have argued that people aged 55 and above are more at risk while others have argued that younger age groups are equally at risk especially in developing countries (Naicker, 2010a). This could be attributed to lower life expectancies in most developing countries (Mathers et al., 2004). As a result, there will be less CKD cases registered among the older population within developing countries than the number of CKD cases registered among the older population in developed countries.

2.5.3 **Marital status and health**

For both infectious and chronic diseases, there is evidence of an association between marital status and health outcomes (Kaplan and Kronick, 2006). Studies have indicated a positive correlation between being married and experiencing good health (LaHorgue, 1960; Ross and Wu, 1996; Verbrugge and Wingard, 1987). This positive relationship has been supported by research suggesting an association between being single (having never married) and lower life expectancy (Kaplan and Kronick, 2006; Blazer, 1982; Oechsli, 1975). Widowhood may also be an important predictor of mortality among the elderly population (Johnson et al., 2000; Welin et al., 1992).

Shortridge and James (2010) suggested that marital status has an impact on the health outcome of CKD patients as married patients had better outcomes. They argued that this might be attributed to the support of the spouses of the married CKD patients. Bruce et al (2010) found that the prevalence of CKD was lower among people who were married. In addition, being married was associated with better access to renal transplantation compared to those who were never married or were widowed (Khattak et al., 2010). Bapat et al (2008) found that marital status was significantly associated with accepting renal replacement therapy by CKD patients. They argued that most CKD patients who accepted the required form of treatment were more likely to be married, suggesting that the patients' spouses were a form of social support for the patients that enabled them to accept and respond better to treatment.

Nevertheless, it is still not clear how marital status combine with other factors to impact on the development and progression of CKD in individuals at risk of the disease (Bruce et al., 2009).

2.5.4 Education, occupational status, and health

Education and occupational status are regarded as important measures for determining the socio-economic status of an individual with education being the most frequently-used measure because it does not usually change after young adulthood (Kaplan and Keil, 1993).

The positive association between education and health is well established (Ross and Wu, 1996). The well-educated have better health than the poorly educated, as indicated by high levels of self-reported health and physical functioning and low levels of morbidity, disability, and mortality (Feldman et al., 1989; Guralnik et al., 1993; Gutzwiller et al., 1989; Liu et al., 1982; Winkleby et al., 1992).

Whilst some suggest that there is a significant association between the levels of education and the prevalence of CKD (Tarver-Carr et al., 2002; Young, 2010; Singh et al., 2009), however, Bruce and his colleagues (2010) found no significant association between the prevalence of CKD and educational levels within their study of the Jackson area in Mississippi, USA. The general consensus is that the educational level of a person is highly correlated with their socio-economic status (SES), and that there is a significant association between the prevalence of CKD and those with low SES (Crews et al., 2010; Young, 2010).

There has been evidence that suggests that individuals with higher occupational status are less likely to develop a poor health outcome than those with a lower occupational status (Kunst et al., 1998). This has been attributed to their accessibility to better resources such as higher education, higher income, job security, and sense of control (Carroll et al., 1996; Charlton and White, 1995; Kunst et al., 1998). In addition, job related stress has a negative impact on the health outcome of an individual (Yarnell, 2008) although its impact appears to vary across the occupational classes.

There is some evidence linking occupational hazards to health outcomes including the development of CKD. Occupational diseases include silicosis[11] in miners and asthma in workers at plastic making industries as well as among painters and artisan (Dryson et al., 1995; Torres et al., 2010). Studies have indicated that exposure to silicon-containing compounds such as sand, cement, coal, and rocks, may be related to CKD developing among manual workers handling these materials (Nuyts et al., 1995; Steenland et al., 1990; Stratta et al., 2001). The exposure results in gradual damage to the kidney, eventually leading to the development of CKD. CKD risks were higher among agricultural workers (Cerdas, 2005; Trabanino et al., 2002), attributed to long-term exposures to heavy metals in agricultural insecticides or pesticides (Trabanino et al., 2002). As discussed in section 2.4.2, the effects of the exposure of these toxic

[11] Silicosis is a respiratory disease caused by inhaling silica dust

compounds are classified as toxic nephropathy and when they are not diagnosed and treated early, they lead to the development of CKD in the individual.

2.5.5 **Ethnicity and health**

Before evaluating the association between ethnicity and health, there is the need to clarify the term "ethnicity". The term has been loosely used to classify various racial groups particularly within nations that have a multi-racial population such the United States of America, the United Kingdom, and Australia. However, the concept of ethnicity is not just associated with racial groups but it is equally associated with culture, religion, language, and nationality (Betancourt and Lopez, 1993; Omi and Winant, 1994). Ethnicity within a local context tends to refer to people with similar cultures usually based on kinship or tribal affiliation. These groups can be classified as local ethnic groups as they precede state, or national affiliations.

Numerous studies have associated poorer health with minority ethnic or racial groups in their study areas (Crocker et al., 2009; Winkleby et al., 1998). Although there are racial and ethnic differences in the causes and prevalence of certain diseases such as sickle cell disease, other studies have questioned whether there is any significance in using race or ethnicity to identify factors that contribute to health or disease (Burchard et al., 2003; Collins, 2004; Cooper et al., 2003). They argued that although these variables should not be discarded, the correlation between these variables and health is rather weak and

attention should be moved beyond these weak relationships in order to get to the root causes of health and disease, whether they are hereditary, environmental or both.

In spite of these arguments, there have been studies that found a higher prevalence of certain diseases among certain ethnic groups (Mbanya et al., 2010; Schena, 2000; Zhang and Rothenbacher, 2008). One of such disparities is the higher prevalence of CKD among those of African (Atkinson et al., 2010; Kramer et al., 2008) and Asian descent (Domrongkitchaiporn et al., 2005; Ong-Ajyooth et al., 2009; Schena, 2000).

Although these studies included minority ethnic groups so as to identify the ethnic groups that registered a higher CKD prevalence, it was interesting to note that not all the ethnic groups present within some study areas were included in order to give a more reliable result. Interestingly, studies within the USA focused on certain racial/ethnic groups such as the African-Americans, Hispanic Americans, and the Caucasians (Alves and Lewis, 2010; Crews et al., 2010; Mehrotra et al., 2008). However, few research studies included the Asians and the Native American ethnic groups (Hall et al., 2005; Norris and Agodoa, 2005) even though these ethnic groups are part of the minority groups within the country. Within the UK, it was interesting to note that where ethnicity data were available, most of the ethnic groups present were included within the studies of the association of ethnicity and CKD (Dreyer et al., 2009). Such ethnic groups included the African

ethnic groups (i.e. Black African, Black Caribbean, Black British, and mixed Black), Asian (south Asian e.g. Indian, Sri Lankan; East Asian e.g. Chinese and Japanese), and White (British, Irish, other European Caucasians). Most studies however, reclassified these ethnic groups into fewer groups for ease of analyses.

Although the authors identified ethnicity as a determinant of the health outcome, they suggested that the socio-economic status of the study population had a significant impact on the outcome of the results. These suggestions appear to support the arguments disputing the significance found between ethnicity and health outcomes. These authors argued that racial or ethnic differences in health are more likely to reflect differences in people's experiences from birth onward, based on the relatively advantaged or disadvantaged position in society of the race or ethnic group of the families into which they are born (Burchard et al., 2003; Collins, 2004).

2.5.6 **Religion and health**

Religion can be viewed as participation in the institutionally sanctioned beliefs and activities of a faith group (Koenig et al., 2001), which gives meaning to one’s life, illness, and death, and this usually exists both within and outside of traditional religious systems (Puchalski and Romer, 2000). The relationships between religion and health have been studied extensively. This ranges from the association between religion and good physical health (Krause, 2002) to its association with mental health (Schieman et al., 2006) and with

mortality (Hummer et al., 1999). The search for an association between religion and health may be found in various disciplines including public health, medicine, psychiatry, nursing, biology/physiology, sociology, psychology, ethics, and history (Krause, 2010).

Associations between religion (or practicing faith) and health are predominantly positive (McCullough et al., 2000; Powell et al., 2003; Seybold and Hill, 2001). More studies have been found to focus on the association of religion and mental health than on physical health (Lee and Newberg, 2005), such as the association between religion and depression (Ellison, 1995; Miller et al., 1997). There have been studies on the association between religion and chronic disease such as breast cancer (Van Ness et al., 2003) and infectious diseases such as HIV (Jenkins, 1995; Trinitapoli and Regnerus, 2006). These studies indicated that there was a significant association between religion and these patients with these diseases as they found that the patients' religious beliefs enabled them to find a renewed sense of purpose in life. In the past decade, studies have evaluated the association of religion with CKD. Ko et al (2007) explained the relationship between religion and the quality of life of CKD patients that were undergoing haemodialysis and found that as the patients' health declined, their religious beliefs became stronger. All of these studies focused on the association of religion and the patients' recovery or survival rather than the causes. Currently, there are no published studies on the association between the prevalence of CKD and religious practices.

Notwithstanding, some have questioned the quality of these research inferences (Sloan and Bagiella, 2001), while others have pointed out that the benefits or costs of religion may vary depending on the indicator of religious involvement (Krause and Wulff, 2004; Pargament, 2002).

2.6 Evaluating the spatial prevalence of CKD

The burden of CKD as a health problem is not just felt by the patients and their carers or family members but also by the health-care system that is currently in place. The general consensus of nephrologists both globally and locally is that early identification of patients with CKD may allow health-care systems to implement effective interventions (Bosa, 2006; de Lusignan et al., 2005; Dirks et al., 2006; Stevens et al., 2007; Iseki et al., 2003). These interventions would be aimed at decreasing the progression and eventually the morbidity and mortality from the disease among the population.

Although the actual number of people with CKD cannot be determined as the first and second stages of CKD are not detected easily, the prevalence of stages 3-5 of CKD in the UK is estimated between 5% and 8.5% (de Lusignan et al., 2005; Stevens et al., 2007).

In the UK, there are indications that early nephrology referrals have resulted in an improvement in the survival rates of CKD patients (Jones et al., 2006; Richards et al., 2008). Screening the whole population for CKD was not found to be a cost-effective strategy (Boulware et al., 2003; Stevens et al., 2007). Screening of *at risk*

populations has however been found to be effective in recognizing undiagnosed CKD (KEEP, 2005; Stevens et al., 2007). According to El Nahas (2005), CKD does not affect all sectors of the population equally, with higher prevalence in the elderly, patients of South Asian, African, and Afro-Caribbean origin and the socially disadvantaged. Therefore, he argued that an effective screening programme has to be in place to adequately identify CKD patients within the population. Although the risk of developing the last stage of CKD among those classified as *at risk* population was low (Hallan et al., 2006b). Diabetic renal disease was the single most common cause of renal failure accounting for 24% of all diagnosed CKD cases (Tomson, 2010).

Screening for CKD usually involves a urine test to identify the presence of blood, which is used to detect the presence of CKD. However, a laboratory blood test, which involves determining the estimated glomerular filtration rate (eGFR) from serum creatinine has generally been accepted as a better method (Jones et al., 2006; Richards et al., 2008; Stevens et al., 2007). The computerized reporting of the eGFR was widely introduced throughout the National Health Service (NHS) in April 2006 following recommendations of part II of the National Service Framework for Renal Disease (Department of Health, 2005) and the Joint Royal College guidelines on the identification, management and referral of patients with chronic kidney disease (Vanholder, 2006). Given the computerized reporting of the eGFR within the UK, it is easy to see why the screening of high

risk patients using eGFR has effectively identified patients with CKD within the UK.

The population prevalence of CKD in Australia was estimated at 11.5% (95% CI, 9.42-14.1), which was approximated at 1.4 million adults (White et al., 2010). The CKD prevalence in Australia was comparable to a study that estimated the CKD prevalence in Norway at 10.2% (Hallan et al., 2006a). A national report indicated that 1 in 9 adults over age 25 years had at least one clinical symptom that suggested the presence of CKD in the individual (Kidney Health Australia, 2011).

The prevelence of CKD within the United States has been found to have increased over the past two decades (Coresh et al., 2007b). This could be attributed to the increasing health problems or risk factors commonly associated with CKD such as diabetes and hypertension (Lu et al., 2008; Ito et al., 2008). According to a report by the National Health and Nutrition Examination Survey (NHANES), it was estimated that 13% of the US adult population had CKD (Coresh et al., 2007b). The country currently lacks a complete and efficient surveillance programme that captures and monitors the impact of CKD in the population however, there are plans to put that programme in place as the system could support efforts toward prevention, earlier detection, and implementation of optimal disease management strategies (Saran et al., 2010). This can likely result in increased awareness of CKD, thereby decreasing the rates of CKD progression,

lowered mortality from the disease, and ultimately reducing resource utilisation currently spent in managing the disease.

Although research studies has shown that CKD is more prevalent in people of African and Asian decent as opposed to other ethnic groups (El Nahas, 2005; Kramer et al., 2008; Ong-Ajyooth et al., 2009), there has been a steady rise in the disease in Latin America (Cusumano and González Bedat, 2008). The prevalence of CKD in Latin America has an annual growth of 6.8% since 2003 (Cusumano and González Bedat, 2008). The rise of the disease has been attributed to a number of factors. These include; increase in the life expectancy at birth within the region resulting in a growth in the older population over 65years (UNDP, 2006), an increasing prevalence of diabetes in most Latin countries (Cusumano et al., 2009), fast lifestyle changes associated with migration from rural to urban areas that could result in being inactive and overweight (CEPAL, 2005). Diabetes remained the primary cause of CKD, and the highest CKD incidences were reported in Puerto Rico (65%), Mexico (51%), Venezuela (42%), and Colombia (35%) (Cusumano et al., 2009). A number of suggestions have been put forward to address the rise in the prevalence of CKD in Latin America. These include; careful data collection and screening for risk factors (Dirks et al., 2006). Other suggestions include the initiation of public awareness campaigns by reaching out to primary care physicians and the general public, and the inclusion of CKD patients and the progression of their disease in a database, in order to identify those at risk of developing the worst outcome (Cusumano and

González Bedat, 2008). However, there is still the problem of insufficient data on the prevalence of the risk factors associated with CKD progression as well as the distribution of these risk factors, which are very important when developing public health policies and programmes. Attempts at addressing this problem are ongoing. This was attempted by 11 countries, which have either implemented or developed national CKD detection programmes recommended by the Latin American Dialysis and Kidney Transplant Registry (LADKTR) committee in 2005 in order to raise public health awareness about the burden of CKD (Dirks et al., 2006).

Asia now accounts for 60% of the world's population with many of the eastern Asian countries experiencing an increase in life expectancy, notably in China, Japan, South Korea, and Taiwan, where birth rates have been on a decline over the last 30years (United Nations, 2007). These changes have resulted in the development of a rapidly aging population in Asia where chronic diseases such as diabetes and hypertension have become common and this has also resulted in the prevalence of CKD within the past 10years (Imai and Matsuo, 2008).

Factors that could be responsible for high prevalence in Asia, include Chronic glomerulonephritis - the leading risk factor of CKD in China accounting for 47.3% of all CKD cases (Zhang et al., 2008) and the second leading risk factor in Japan with 25.6% (Imai and Matsuo,

2008). In China and Japan, haematuria[12] accounts for 3.5% (Zhang et al., 2008) and 9.0% (Imai et al., 2007) of the population with CKD respectively. Proteinuria[13] accounts for 4·1% of the population in Japan (Imai et al., 2007) 7·9% in Taiwan (Wen et al., 2008) and 0·5% in China (Zhang et al., 2008). Another risk factor that would account for the high prevalence of CKD is the presence of toxic nephropathy caused by nephrotoxic[14] herbal medicines which is also common throughout Asia (Imai and Matsuo, 2008). According to reports from Japan, Korea, and China, the proportion of adults with CKD ranges between 8.7% - 18.7% (Imai and Matsuo, 2008; Iseki et al., 2003). India with a population exceeding one billion, has been projected to become the main reservoir of chronic disease (Srinath Reddy et al., 2005) with 25% - 40% of these expected to develop CKD (Modi and Jha, 2006).

Studies carried out on the awareness of CKD among the general public in Japan and Taiwan have shown that CKD awareness is generally low even among CKD patients. Reports show that only 3.5% and 7.9% in Taiwan and China respectively are aware of the disease (Imai and Matsuo, 2008; Wen et al., 2008). One of the problems faced by Asia is the low number of nephrologists especially in the southeastern parts of the continent (Sitprija, 2003). For example, Cambodia and Laos do not have any nephrologists while

[12] haematuria is the presence of blood in the urine
[13] proteinuria means too much protein in the urine. This may be a sign of kidney damage
[14] Nephrotoxic refers to something that is toxic to the kidney

Burma has only 10 and Indonesia only 43 (Imai and Matsuo, 2008). Therefore, the general consensus on reducing the rate of progression of CKD has been to improve the awareness of the disease amongst the general public as well as educate the health practitioners (Imai and Matsuo, 2008; Iseki et al., 2003). Screening for the disease has also been suggested as the best method for targeting the disease at its early stage as well as targeting high-risk patients e.g. those with diagnosed risk factors such as diabetes, hypertension, and family history of CKD (Imai and Matsuo, 2008; Iseki et al., 2003). This is because the earlier stages of CKD can be effectively managed and the progression of the disease can be halted or slowed. Although there are no registers or current data on the incidence of CKD in some of the Asian countries especially those in southern Asia (such as Bangladesh, India, and Pakistan), attempts have been made by developing the Asian forum of CKD initiatives, which was implemented in 2007 by Asian nephrologists. Their aim is to get Asian medical colleagues together to clarify the status of CKD in the Asian region and exchange information. They expect that future collaborative studies could be performed to compare the CKD incidence and prevalence in Asian countries (Iseki et al., 2003). A progress report on the outcome of this forum indicated that there has been an improvement in collaborative studies between developed and developing Asian countries (Tsukamoto et al., 2009). However, there is room for improvement because the collaborative studies were usually done between two countries when the forum aims to have collaborative studies among

multiple countries in order to develop an international registry of CKD patients among multiple Asian countries and establish a network on the CKD Initiative in Asia.

The actual prevalence of CKD within Africa is currently unknown and this is attributed to the unavailability of a reliable register of the disease in African countries. The delivery of renal care within African countries has been classified as really challenging because the ratio of nephrologists to the general population in Africa is likely the lowest in the world (Katz et al., 2011). The highest rate is found in Egypt with 6.5 nephrologists per million persons, compared to 23.1 nephrologists per million persons within the USA (Katz et al., 2011; Rosenberg, 2007). There are indications that there are no nephrologists in many African countries (El Matri, 2007; Katz et al., 2011).

Within Nigeria, where this research is situated, similar strategies like the general consensus reached by the LADKTR committee in Latin America and the Asian forum of chronic kidney disease initiatives on reducing the prevalence of CKD are currently being put into practice. These include carrying out routine screening (Bosa, 2006) and intensifying the awareness of CKD among the general public. However, little has been done about the implementation of a CKD register. I believe that in the interim, a model could be created for the management of renal health by combining renal health programmes such as CKD awareness campaigns and screening sessions with an established national health prevention programme. Currently no

attempt has been made at creating such a model that can be combined with nationally recognised prevention programmes such as the National Malaria Control Program (NMCP) and the National AIDS Control and Prevention Program (NACPP), as both programmes are well established and could be used as a platform in raising CKD awareness among the public.

Due to the absence of a reliable CKD register within African countries, the primary challenge of combating the disease is to determine the prevalence of CKD both within African countries and within the continent in order to provide evidence that CKD is a public health problem (Katz et al., 2011).

This challenge can be classified as a multi-dimensional task. Issues such as the practical screening test to use, the location of screening centres for easy access by the population at risk, as well as the development of healthcare policies for the efficient management of CKD cases, are all important factors. The reality is that there are not sufficient resources for healthcare in many developing countries, especially for expensive treatment such as RRT. This emphasises the need to detect CKD at an early stage when the cost of intervention and treatment are cheaper. As suggested by Rizvi and his colleagues (2005), an effective framework to manage CKD diagnosis would have to be created in order to efficiently identify patients at risk of CKD and to enable early intervening strategies aimed at preventing the disease.

2.6.1 **Impact of renal replacement therapy (RRT)**

It has been estimated that more than a million patients have undergone Renal Replacement Therapy (RRT) worldwide and this is expected to reach 2.2 million by the year 2030 (El Nahas and Bello, 2005; Naicker et al., 2005; Snyder and Collins, 2009). RRT, which consists of dialysis or kidney transplant represent very expensive procedures for stage 5 CKD patients and this, has financial implications on not only the patient but also on the health care system. According to a report by the ERA-EDTA [15] Registry (2010), the prevalence of renal replacement therapy in 2008 for the whole of Europe was estimated at 221,538 patients, which came to a total of 881 pmp[16]. RRT was first introduced in the United Kingdom in 1946 (Turner, 2004) and it has become an established surgical procedure. The assumed rate of patients needing RRT has risen progressively to about 110 pmp per annum (The Renal Association, 2007). According to the UK Renal Registry's report, by the end of 2008, 47,525 adult patients were receiving RRT in the UK and there is an annual increase in RRT prevalence of approximately 4.4% (Tomson, 2010).

van Woerden et al (2007) examined the effect of gender, age and geographical location on the population's prevalence of RRT in Wales. They showed that out of the 2434 patients on RRT, the RRT age-specific prevalence rate peaked at around 70 years with a rate of

[15] ERA-EDTA refers to the European Renal Association - European Dialysis and Transplant Association
[16] PMP= Per Million Population

approximately 1790 pmp. The study showed significant variation in the provision of RRT by gender, age, and the prevalence rates of RRT for various geographical locations in Wales. However, a higher significance was found in gender and age, but less by geographical location. According to their findings, there was a higher RRT rate among males and also there was the probability that RRT patients in Wales under the age of 50 years had a greater than 50% chance of having a kidney transplant while patients over the age of 75 years had a high likelihood of being on dialysis. They also indicated that there was the probability that the areas in Wales that showed a higher rate of RRT than the average rate in Wales was not a chance phenomenon.

A national report on RRT in Australia indicated that only 6% of the people on dialysis received a transplant in 2008 and the average waiting time for a transplant was about 4 years but waits of up to 7 years were not uncommon (Kidney Health Australia, 2011). Similar to the studies in Wales, there have also been studies on the geographical disparities in access to renal transplantation. Among these was a study in Australia by Chapman and Russ (2003), who were able to identify a significant variation between states concerning patients' access to the transplant waiting list. Their findings suggested that the variation in accessing the waiting list was attributed to the dominant policy operation in each state i.e. whether the operating policy for each state was focused on the general community or determined from a patient's perspective. They also suggested that the variation across the states of patients that actually received kidney transplants were more as a result

of each states' cadaveric donation[17] rates modified by increasing use of living donors (Chapman and Russ, 2003).

A similar result was also observed in the United States, as the researchers were able to identify a significant variation in the pre-transplantation waiting times across the regions in the United States (Ellison et al., 2003). Their result showed that for four months after listing, the transplant rate for all U.S. kidney transplant candidates was 10.9%. Regionally the 4-month transplant rate ranged from 4.2% to 18.5% for highly sensitized patients[18] and from 5.4% to 19.6% for non-sensitized patients. This result has a significant impact on stage 5 CKD patients especially those that require immediate kidney transplant due to the severity of the disease. Ellison and her colleagues concluded their findings by carrying out a computer-simulated model that suggested that a redrawing of the organ distribution boundaries could reduce but not eliminate geographic variations in the pre-transplantation waiting times across the United States.

At the end of a 4-month follow-up period in France, a study showed that 22% of 2,207 CKD patients received kidney transplants (Roudot-Thoraval et al., 2003). The transplantation percentage for all organs transplant in the country was found to have decreased from 63% in the West to 43% in the Paris region and mortality increased from 2% in

[17] Cadaveric donation comprises organ donation—that is, taking organs (heart, lungs, kidneys, liver, pancreas) from brain dead people.
[18] highly sensitized patients are those whose immune system are very sensitive to foreign cells or organ and therefore produces antibodies that attacks the foreign cells or organ even when it is a life-saving transplanted organ

the West to 7% in the Southeast. This result equally included CKD patients and therefore had a significant impact on CKD patients that needed kidney transplants. All tests of inter-regional differences were statistically significant. They therefore concluded that the factors explaining geographic differences related to the background of transplant teams, activity of organ procurement, and severity of the patients' illness on the transplant list.

In many developing countries, the prevalence of chronic kidney disease and the number of patients requiring RRT are not actually known. Specialized care is not readily available within many of these countries. As such, a number of patients would have to travel to far places sometimes, outside their own countries, to seek medical help. Hence, data from places within the developing countries where specialized care for CKD is offered, may not reflect the incidence and prevalence of stage 5 CKD in the nearby geographical areas (Jha and Chugh, 2005). Attempts have however been made to collect data indirectly, such as the reported causes of death collected by the government in Egypt and through the institute of social security in Mexico (Barsoum, 2002) as well as by other means e.g. questionnaires from nephrologists. The responses were usually found to be incomplete (Jha and Chugh, 2005). A large proportion of patients living in the rural areas in the developing countries do not seek medical advice because of ignorance and poverty. Based on this notion, the precise incidence and prevalence of CKD patients requiring RRT in the developing countries can only be determined by

organizing community-based detection programmes. Unfortunately, the availability of such organized community programmes are very few and may be classified as non-existent in many developing countries.

A significant number of patients in developing countries come to medical attention for the first time only after the development of CKD at stage 5 (Jha and Chugh, 2005). Research studies carried out on such patients indicated that the age group was younger than its western counterparts, particularly UK and the USA. In some countries, 70-80% of the dialysis population was in the age range of 20-50 years (Bamgboye, 2003; Naicker, 2010) compared to the UK which reported a mean age of 60 years (Rayner et al., 2004). It has equally been indicated that children are usually under-represented in the dialysis population because of the lack of pediatric dialysis units (Jha and Chugh, 2003b; Anochie and Eke, 2005; Olowu, 2003). This might indicate a younger dialysis population than originally reported; however, this is only a speculation, as there is not enough evidence to back that assumption due to the absence of a CKD registry in these countries.

By 2005, the average kidney transplant rate in Latin American countries exceeded 10pmp and nearly half were living donors (Rizvi et al., 2005). As in other regions, there were differences among countries. Renal transplantation rate in Brazil reached 22pmp in 2001, which was double the Latin American average. Overall, renal

transplantation had improved in Latin American countries with nine out of eighteen countries surveyed having some type of registry (Rizvi et al., 2005).

In Asian countries, the average annual kidney transplant rate was below 10 per million persons (pmp) (Zhang et al., 2008) in contrast to the developed world at 45 to 50 pmp with living donors' transplantation forming the bulk of transplant activity (Rizvi et al., 2005). Southern Asia had a generally low transplant rate though some of the economies are fairly prosperous with Thailand and Singapore having a kidney transplant rate using cadaveric donors, of 10pmp while Indonesia, the most populous country in the region had a very low kidney transplant rate (Rizvi et al., 2005). In Japan, 257,765 patients with stage 5 CKD who required RRT were reported at the end of 2005 (Yamagata et al., 2008) and the country had an annual incidence rate of approximately 14% (Nakai et al., 2007; USRDS, 2009).

The availability of renal replacement therapy across the African nations is generally inaccessible to the poorer, less educated rural patient as opposed to their urban counterparts (Alebiosu and Ayodele, 2005). The dialysis population within Africa accounts for only 4.5% of the world's dialysis population, with a prevalence of 74 pmp, compared to a global average of 250 pmp (Abu-Aisha and Elamin, 2010).

In a study by Arije and Akinkugbe (2002) on dialysis sessions among CKD patients in Nigeria, 70.8% of the patients were able to remain on dialysis for less than one month, 12.7% for between three and six months, 5.1% for between 7 and 12 months, and only 1.9% remained on dialysis for more than 12 months. Other research studies within Nigeria (Alebiosu and Ayodele, 2005; Bamgboye, 2003; Olowu, 2003) had shown the inability of patients to continue the treatment, because very few could afford the regular cost of treatment (Alebiosu et al., 2006). A recent study in the eastern part of Nigeria made a similar observation stating that approximately 50% of patients at the last stage of CKD underwent dialysis; however, a majority of this group stopped dialysis after only a few sessions (Ulasi and Ijoma, 2010).

In summary, renal transplant activity is correspondingly low compared with other developing countries outside the African continent with an average of 5pmp (Rizvi et al., 2005). Kidney transplantation has been limited to North African countries and South Africa as they currently have the highest record of transplant cases per year in relation to other African countries where there is little or no transplant cases recorded (Katz et al., 2011). To emphasise this, the first successful kidney transplant in Nigeria was successfully carried out in August 2009 (Orakpo, 2009).

It can therefore be deduced that the availability of renal health care particularly RRT is severely limited in developing countries.

The overall outcome of these research studies within the countries discussed in section 2.6, throws some light on the geographical disparity of the prevalence of CKD.

2.7 The utilization of Geographical Information Systems (GIS) in the African health sector

It is important that relevant and current information is available to decision-makers at all levels of the public health system in order to appropriately plan, manage, and monitor any public health problem. It has been argued that geographical location is an important determinant of health outcomes (Carstairs and Morris, 1989; Haan et al., 1987). Geographical information systems (GIS) provides an analytical framework where public health authorities and researchers can understand problems by identifying spatially related risk factors in order to create a response by targeting resources and interventions to areas where they are needed (Beyer et al., 2010). From detecting and responding to infectious disease outbreaks, to delivering healthcare services, to preserving the safety of the water supply, and other amenities, the data integration and analysis capabilities of GIS supply better access to information and equally facilitate better decision making than relying only on statistical figures (UNAIDS, 2008).

However, it has been less clear whether GIS technology is both applicable and sustainable in an African setting as a method to spatially evaluate health outcomes (Tanser and le Sueur, 2002). While developed countries are taking initiatives to establish a well-organised

GIS based health care system, the developing countries are still facing different problems mainly due to rapidly growing populations and severe resource constraints (Paik, 2000). Countries within the African continent are not an exception. Studies from Nigeria (Chukwujekwu et al., 2010), Ghana, South Africa and Tanzania (Borghi et al., 2009) have all highlighted the issue of the absence of reliable or current information in the health sector, which are essential for health care management and decision making.

The focus of this section on GIS and health in Africa is to provide some balance in the discussion of the application GIS for healthcare in Africa. The review outlines the relevance of GIS development to African health sector and highlights some of the difficulties in the sustainable implementation of GIS.

2.7.1 The application of GIS in combating and monitoring health issues in Africa

Despite the increasing use of GIS in many areas of health care research and planning, its adoption in the African health research is still minimal. Other health research outside the continent especially in developed countries has demonstrated that the utilization of GIS within the health sector can help to recognize issues that have otherwise been ignored in the past, helping in projecting future phenomena, and also in managing the situation. Nevertheless, this review would show that most of the research studies across Africa that applied GIS were carried out on mainly infectious diseases especially

malaria, tuberculosis, and HIV. This is not surprising as these diseases have significant public health impact on the continent coupled with the fact that a majority of the research studies carried out on these diseases are adequately sponsored by large organisations like the United Nations Development Programme (UNDP) and the World Health Organisation (WHO). As such, medical researchers and the health geographers and GIS analysts present within the African countries are more likely to focus their studies on the study of these three diseases, as there are financial resources to support their research. This argument can be supported by the research studies on these diseases that are reviewed below, as the majority of these studies were sponsored by health organisations interested in the outcomes of these three diseases within Africa.

2.7.1.1 *Application of GIS in the study of Malaria in Africa*

Due to the high impact of malaria in Africa, a number of studies have been carried out on malaria epidemics, its impact on the economy (Teklehaimanot et al., 2007) as well as the climate conditions associated with the disease (Senay, 2005). Climatic factors play a major role in determining the distribution of malaria. Rainfall, temperature, humidity, and soil moisture are recognized factors that affect the transmission rate of malaria. It is therefore not surprising that compared to other diseases in the continent, GIS has been widely applied to the understanding and management of malaria in Africa. In its simplest application, GIS has been used in mapping out the prevalence of malaria in a number of countries and they include

malaria mapping using transmission models in Mali (Gemperli et al., 2006b), and in countries in West and Central Africa (Gemperli et al., 2006a). It has also been used in generating models of malaria occurrence using climatic and remotely sensed data (Craig et al., 1999; Thomson et al., 2006) and transmission intensity (Gemperli et al., 2006a; Kleinschmidt et al., 2000; Rogers et al., 2002). The outputs of such models were combined with population data to estimate population exposure, mortality, and morbidity (Kleinschmidt et al., 2002; Omumbo et al., 2005; Snow et al., 1999) and to analyse (Hay et al., 2002) and project future prevalence of Malaria (Lindsay and Martens, 1998). Other notable research on GIS and malaria is the use of GIS in studying the anopheles mosquito, which acts as a vector for the disease malaria (Coetzee et al., 2000). It has also been used in the monitoring and control of malaria (Booman et al., 2000; Martin et al., 2002), to measure the effects of access to malaria treatment (Noor et al., 2003) and to evaluate the effects of intervention strategies.

A majority of these reviewed studies on malaria highlighted that the outcome of their studies could contribute to the achievement of the Millennium Development Goal recommended by the UN Millennium Project for reducing the burden of malaria by 75% in Africa (Teklehaimanot et al., 2007).

2.7.1.2 *Application of GIS in the study of tuberculosis in Africa*

There have been fewer publications that utilized GIS in the study of tuberculosis within the African continent. The most recent study was

the spatial distribution of tuberculosis and the identification of significant tuberculosis clusters in Greater Banjul, in Gambia (Touray et al., 2010).

Other studies investigated the association of various risk factors and places of transmissions of tuberculosis (Munch et al., 2003; Murphy et al., 2009). The study had identified significant associations of tuberculosis with unemployment, overcrowding, and the cluster of drinking places per enumerator sub-district of these communities.

In 2008, a research study evaluated the geographical and temporal distribution of tuberculosis across African countries in order to identify possible high-risk areas (Uthman, 2008).

Another study focused on the use of GIS/GPS technology to document improved access to tuberculosis treatment through a community-based programme (Tanser and Wilkinson, 1999). While another research study focused on the burden and risk factor of tuberculosis on children in an urban population in Cape Town (van Rie et al., 1999). In a previous study, GIS was used to map 4011 tuberculosis cases in two suburbs of the same city (Beyers et al., 1996). The findings of the study indicated that significant clustering of tuberculosis was associated with socio-economic factors. A similar result was equally identified in Madagascar, which indicated that spatial clustering of tuberculosis was significantly associated with socio-economic and patient care factors that related to the care of the patient such as patients lost to follow-up (Randremanana et al., 2009).

From the reviewed studies on the utilization of GIS in the study of tuberculosis within Africa, there appear to be more research studies carried out in the southern part of the continent particularly in Cape Town than other parts of the continent. Although the study by Uthman in 2008 attempted to give an overview of the spatial distribution of tuberculosis across the African countries, the implementation of GIS in the study of tuberculosis can still be classified as being at its initial stage. This is because there are fewer studies on tuberculosis compared to the number of studies on malaria that utilised GIS within the African health sector.

2.7.1.3 *Application of GIS in the study of HIV/AIDS in Africa*

There has been a significant literature within health geography that investigated the spatial pattern of HIV. This ranges from the geographical spread of the disease to the investigation into how people with HIV/AIDS use space differently as well as government responses to the epidemic (Turner, 2009). Although previous studies have shown the severity of the impact of HIV/AIDS in Africa (Bock and Johnson, 2008; Bourne et al., 2009; Gouws et al., 2008; Weir et al., 2002) and also the benefits of GIS in the health sector, only four research studies could be located that applied GIS to the analysis of HIV. This is intriguing given the fact that HIV accounts for a significant proportion of the continent's health burden and the reduction of the impact of disease within the continent is currently sponsored by WHO and the UNDP (Schim van der Loeff, 2005; UNDP, 2011). As mentioned earlier in section 2.4.2, HIV is classified as one of the known risk

factors of CKD. Therefore, a review of the studies on HIV/AIDS that utilised GIS can be regarded as relevant to my research as the outcome of these research studies could be beneficial in estimating the trend of CKD and it association with the prevalence of HIV within African countries.

The first study was a project classified by the authors as an intervention study that focused on using participatory methods and GIS to prepare for an HIV community-based trial in Vulindlela, South Africa (Chirowodza et al., 2009). The research study was based on the effectiveness of combining participatory methodologies and GIS technology in order to understand and inform community-based intervention studies. Their research can be regarded as one of the ways in addressing the issue of data avaliablity as the authors were able to fill in the missing gap of previously incomplete data with the information they collected from the community members using the participatory mapping and transect walks.

The second study attempted to justify the use of GIS in creating a model that predicted the prevalence of HIV/AIDS across the various countries in Africa from 2004 till 2010 (Kalipeni and Zulu, 2008). They began the study by evaluating the prevalence of HIV/AIDS in Africa for the period from 1986 to 2003. They concluded their study by defending the application of GIS in the study of health outcomes especially for extrapolating results when there are insufficient data available to cover the whole study area. They argued that their study was able to show how spatial patterns of HIV/AIDS prevalence in

sub-Saharan Africa have progressed over the past 20 years using GIS spatial interpolation.

The third study can be referred to as a simple project that showed the spatial prevalence of HIV/AIDS and tuberculosis and its demographic consequences in selected countries in sub-Saharan Africa (Pillay, 2003). The spatial dynamics and the association of tuberculosis with HIV involved using Cartographic and GIS techniques via choropleth mapping of HIV/AIDS and tuberculosis prevalence data. Although the project was not an in-depth study, the author however, argued on the relevance of his project as it may provide some guidelines to the possible trend that HIV/AIDS would take over the next four year cycle and how the relationship between HIV and tuberculosis would pan out in the future. He also mentioned the importance of its demographic impact on key population indicators for example life expectancy (Pillay, 2003).

The fourth study on the use of GIS in the study of HIV described the difference in HIV prevalence among pregnant women in one of the health district in South Africa and its correlation with proximity of homestead to roads (Tanser et al., 2000). The study provided some indication for an ecological relationship between transport accessibility and HIV prevalence (Tanser and le Sueur, 2002). This involved the measurement of HIV prevalence among pregnant women who were measured through anonymous surveillance and stratified by their local village clinic. They explored the relationship between HIV prevalence and the proximity of homesteads to primary and to

secondary roads, which they found, had a close correlation. Tanser and Sueur have however, criticised their own finding stating, "*the relationship needs to be tested at an individual as well as at an ecological level… much remains to be learnt about the causes and nature of this heterogeneity*" (Tanser & le Sueur 2002, p. 4).

2.7.1.4 *Application of GIS in the study of other diseases in Africa*

Further review on the application of GIS and the study of diseases in Africa revealed that there were other diseases where GIS was applied. However, they could all be categorized as infectious diseases. They included a prediction model on cholera (Fleming et al., 2007), a prediction model on urinary schistosomiasis[19]in Tanzania (Brooker et al., 2001), the Rapid Epidemiological Mapping of Onchocerciasis[20] in Nigeria (Abanobi, 1999) and mapping human Helminth[21] infections in Southern Africa (Brooker et al., 2000).

It is therefore clear from the reviewed papers that in Africa, there is little or no research on the application of GIS on non-infectious diseases. This might be attributed to the fact that infectious disease like malaria and HIV/AIDS currently account for a majority of the disease burden of the continent particularly in sub-Saharan Africa. According to the global malaria report in 2006 by the World Health Organization, Africa accounted for about 86% of the estimated 247

[19] A tropical parasitic disease caused by the larvae of one or more of five types of flatworms or blood flukes known as schistosomes
[20] Also known as river blindness.
[21] A parasitic roundworm or flatworm

million malaria cases worldwide, 91 % of the malaria deaths the same year, and approximately 80% of these cases occurred within countries in sub-Saharan Africa (WHO, 2008). Studies equally indicated that sub-Saharan Africa had the highest prevalence of HIV/AIDS in the world, accounting for approximately two thirds of all incident and prevalent HIV infections and three quarters of all AIDS deaths (Vitoria et al., 2009; UNDP, 2011).

Another contributing factor to the absence of spatial studies of chronic diseases within the African health sector is the unavailability of reliable database(s) or survey data for these chronic diseases at the national, regional, or state level. The only available data are hospital data, which are usually only available to health researchers that work within these hospitals. As a result their studies usually focus on the impact of the disease within the boundaries of the hospital and therefore do not provide information on the prevalence and severity of these chronic diseases across different geographical areas.

Given the limited number of studies that spatially evaluate non-infectious diseases within Africa, my research study which focuses on the utilisation of GIS in the spatial analysis of chronic kidney disease in Nigeria can be regarded as a contributor to spatial epidemiology using GIS to spatially evaluate chronic diseases in Africa. This is because there are currently no studies that have utilised GIS to examine the spatial distribution of CKD or estimate its attributed risk due to the associated risk factors of CKD.

2.7.1.5 *Application of GIS in the study of health care services in Africa*

Given the role of healthcare services in the management of diseases within a society, its importance in the management of the public's healthcare cannot be overemphasised. The need to improve the performance of the health systems is a major global health priority (WHO, 2000). This should have a high priority in Africa especially as emerging, and re-emerging diseases pose a serious public health threat to most countries of tropical Africa and therefore better laboratory services and disease surveillance systems are essential to monitor disease trends and to initiate public health strategies (Shears, 2000). Poorly managed health systems would hinder the effectiveness of health interventions especially for those who are classified as high-risk groups relating to any disease or health outcome. This is particularly applicable to Africa where health systems often perform poorly and are unreliable (Tanser and le Sueur, 2002).

Regardless of its shortcomings, there are few published illustrations of the use of GIS in health systems research in Africa. The majority of the research studies were focused on healthcare accessibility. Past research studies have indicated that healthcare decisions are influenced by the type and quality of services available in the local area and the distance, time, cost, and ease of travelling to reach those services (Haynes et al., 1999).

A notable research study was on the creation of a model that was used to investigate differences in rural, urban, and sub-urban utilization of clinics by homesteads in rural areas of South Africa as well as to

quantify the effect of physical access to the utilization of the clinic (Tanser et al., 2006). They used a cost analysis within a geographical information system to estimate at any given location, the mean travel time to clinic and to derive the clinic catchments. They suggested that their model would constitute a framework for modelling physical access to clinics in many developing country settings, as conventional network analysis/cost models within a GIS are not suitable due to a number of difficulties that tend to be peculiar to many developing countries. Previous research carried out in 2004, addressed the issue of health accessibility. The research, which was conducted in South Africa, demonstrated the application of GIS in measuring the geographical accessibility to primary health care and its potential as a tool with assisting in planning and providing health services. They found that only a third of the population lived within 5 km of a clinic and the utilization of that clinic declined with increasing distance. They were able to argue that geographical accessibility to primary health care was not adequate and the utilization of each clinic depended on distance from primary health care facilities (Tsoka and le Sueur, 2004).

A research study carried out in Malawi investigated the access to reproductive health services using GIS (Heard et al., 2004). The paper discussed its attempt to identify whether access to reproductive health services partially explained the use of modern contraception in Malawi. A geographic information system was employed to integrate health facility data from the Malawi health facilities register with

global positioning data from the 2000 Malawi demographic and health survey. An attempt was made to detect a practical connecting pathway by using distance to health services as a proxy variable for access to services. Based on their findings, they concluded that increased access to reproductive health services did not seem to be the driving force of the change in contraceptive practice in Malawi.

A different research study was carried out in Kenya to create spatially defined databases for equitable health service planning in low-income countries (Noor et al., 2004). The authors focused on creating a comprehensive and spatially defined list of health service providers. Their research study identified a number of weaknesses in the existing national health management information systems, which they suggested could be redressed with better commitment and minimal costs. One such weakness included incomplete demographic data of patients. They recommended that the outcome would enable GIS to exploit more fully facility-based morbidity data, population distribution, and health access models to target resources and examine the ability of health sector development to achieve equity in service provision. A previous study in 2002 used GIS in the fair allocation of fieldworkers' workload in a large health survey. The methodology predicted average inter-homestead walking time and divided the study area into units of equal workload (Tanser and le Sueur, 2002). The outcome of the study suggested that the method presented had numerous applications to health systems provision in developing

countries where limited physical access to primary health care is a major factor contributing to the poor health of populations.

In summary, the reviewed literature on the application of GIS in the African health sector appears to indicate that the potential of GIS remains largely unrealised. GIS analysts within the continent should be encouraged to participate in the spatial analyses of health outcomes because the utilization of GIS within the health sector can help to recognize issues that might have been overlooked in the past and also provide information for decision makers in the health sector. Providing jobs for GIS researchers within the African health sector can serve as a means of encouraging GIS analysts to participate within the African health sector. Although some progress has been made in the study of infectious disease over the years, there has been little or no evidence shown in the application of GIS in the study of non-infectious diseases within the continent of Africa. There is therefore a need to extend the potential of GIS into the research on the growing number of non-infectious diseases that are now becoming a concern within Africa. Using GIS will allow disease control activities to be focused and cost-effective, and would help in establishing a system for community-based intervention. Most importantly, there is an urgent need for the creation of an up-to-date database to aid in the investigation of the utilization of GIS for health surveillance and monitoring, and health forecasting and control. In settings where census data are not available which is usually the case in rural areas of

developing countries, high-resolution satellite imagery can be used in the estimation and location of populations.

The problem of the accessibility of spatial data is not limited to just the health sector but is also an issue in other disciplines that utilize GIS. There are similarities in the field requirements for GIS across a number of disciplines, these include forestry, ecology, archaeology, and epidemiology, and these disciplines could therefore benefit from sharing resources as well as experiences. Collaborations between various sectors should therefore be encouraged as well as funded, as this would result in the development of an up to date database for population and environmental studies, which can contribute to the growth of GIS in developing countries.

2.8 The application of GIS in the study of CKD

The application of GIS in the investigation of health issues is becoming a growing phenomenon as the advantages that are offered by GIS within the health sector has heightened the awareness amongst health-related practitioners and researchers.

By implementing geographical thinking and modelling through GIS, digital maps and visual displays are produced that can be used for research, practice and / or health policy analysis (Soret et al., 2001). A good example is the creation of a Multi-Source Information System (MSIS) by Landais and his colleagues in 2002 (Landais et al., 2002). This was designed for the Renal Epidemiology and Information Network (REIN) dedicated to End-Stage Renal Disease (ESRD),

which is currently referred to as stage 5 CKD, and based in France. MSIS has been operational since 2002 and progressively deployed in nine regions in France. MSIS aims at providing reliable follow-up data for ESRD patients. MSIS facilitates documenting medical events, which occur during the course of ESRD patients' health care, and provides a means to control the quality of each patient's record and reconstruct the patient's line of care. Consolidated data are made available to a data warehouse and to a geographic information system for analysis and data representation in support of public-health decision making. An example of the analysis that can be carried out by the consolidated data provided by MSIS is that a user can choose to study CKD incidence in 2003 for one specific region of interest (Ben Said et al., 2005). Given the available data provided by MSIS, more detailed spatial as well as temporal research studies could be carried out on CKD incidence and prevalence within France. The utilisation of a MSIS for CKD management within the Nigerian health sector could be beneficial especially since it makes use of consolidated data thereby solving the current problem of the absence of a CKD database in the country. However, a number of factors need to be considered. One of these is the establishment of an effective network of the renal institutes, hospitals, and clinics in the country. This network would be needed for the provision of reliable follow-up data for CKD patients within the country. Another factor that needs to be considered is the availability of trained data-entry officials and GIS analysts who are needed to update and process the consolidated data respectively. In

addition, a functioning back-up system should be in place to ensure that in the event of a system failure, data loss could be prevented.

Another example is a Web-based Geographic Information System (Web-GIS), the SIGNe (Système d'Information Géographique pour la Néphrologie) in France, which was designed for the Renal Epidemiology, and Information Network (REIN) dedicated to the last stage of CKD. The Web-based application allows access to the epidemiology of the demand and the supply of care concerning Stage 5 CKD cases. It is dedicated to medical professionals and public healthcare decision-makers who specialises in the management of stage 5 CKD cases (Richard et al., 2005). The system is described as a visualisation and decision-support tool for the management Stage 5 CKD cases in France. Its main aim is to provide maps matching the offer of renal healthcare to the demand of Stage 5 CKD patients in France.

It can however, be observed that the actual application of GIS to research on CKD is limited given the space of time that GIS has been made available in the health sector. In many cases where GIS had been applied, it had been for the simple application of visual display of results (Fan et al., 2007; van Woerden et al., 2007). This argument was equally supported by Toubiana and his colleagues when they reviewed the PubMed journal. They argued that of all the PubMed-reviewed international literature, only 15 articles addressed GIS and medical decision making or health care planning and none of these

dealt with nephrology, CKD (Toubiana et al., 2005). Although their review on the issue is about six years ago, the utilization of GIS in the study of CKD has not greatly improved. As my attempt at carrying out a systematic review of available literature on the application of GIS in the study of CKD using databases such as web of Knowledge (WOK), Medline, and Google scholar, did not identify many studies that has contributed to the advancement of the utilisation of GIS in the study of CKD. It should be noted that out of the available studies that utilised GIS in their research on CKD none has currently been published within an African setting. Therefore, the absence of such study within an African context further highlights the importance of the outcome of my research study. Below is a review of some studies that utilised GIS in their research on CKD and although these studies were done within developed regions, I am of the opinion that their approach can be applied within an African setting.

Christie et al (2005) examined the spatial analysis of renal service provision in south and mid Wales. They carried out a point prevalence analysis of the utilization of renal replacement therapy (RRT) by patients within the area that had CKD and required either dialysis or kidney transplantation. The renal/kidney units that were located in the study area provided the postcodes of CKD patients that required RRT and their postcodes were geocoded at the level of unit postcodes against the 1998 Postcode Directory for Wales. They used the geocoded patient dataset and mid 2002 resident population estimates, to calculate the RRT point prevalence for the 16 unitary authorities in

the area, fifths of small area deprivation defined by the 2001 Townsend index for Welsh electoral divisions, and three bands of travel time. The spatial accessibility of renal services was investigated by constructing geographical polygons that represented the areas within 30 and 60 min road travel time from main renal/kidney units and all (main and satellite) units and the travel speeds were based on the Department for Transport surveys of off-peak driving speeds in England. Their results showed a variation in the point prevalence of RRT across the study area and also that the estimates of RRT prevalence were lower in more deprived areas. They however, stated that their point prevalence was not adjusted for age and as such, prevalence differences between populations may have reflected some variations in the age structure of the population. They also mentioned that their point prevalence estimate of 633 pmp was slightly higher than the figures reported by the UK Renal Registry in the 2001 registry report, which estimated a prevalence of between 558 and 632 pmp in Wales. They however, suggested that the differences were probably due to the different methods used, including differences in the denominator population used for prevalence calculations, differences in prevalence between the study area and the rest of Wales, and changes in the number of prevalent cases between the dates for the estimates. Since their model made no allowance for any travel other than via the quickest route to the nearest unit, it can be deduced that the results for their travel time were just rough estimates. Nevertheless, their research was able to demonstrate the utilization of

GIS as a method that can provide useful information for the planning of future service provision.

A study done in California was classified by the researchers as a GIS-based, multi-method approach to study the pressing issue of health care access to kidney transplantation (Soret et al., 2001). They started their research by comparing the underlying illness in this case-End Stage Renal Disease (ESRD or stage 5 CKD) and the demand it created for new kidneys, with actual kidney transplantation. ESRD and transplantation cases in California were identified, extracted and geocoded to GIS maps of California ZIP Code boundaries. The processed data set was used to show the proportion of kidney transplant procedures and the geographically varied proportion across California. Their result produced smoothed maps from California patient discharge data (1995-1998) to reveal spatial variation of recipient distributions. Smoothed maps were compared with patient clusters obtained through tests for spatial randomness. This resultant map showed a region of concern for public health officials and policy makers, where higher than expected levels of the underlying illness and poor access to treatment overlap. From their result, they stated that GIS could be used to produce related information for the identified areas of concern that could help in generating interventions that are more effective as well as improve health policies. They also examined healthcare access to organ transplantation using geographical correlations of distance and intensity of competition.

They concluded their findings by saying that their analysis implied that the likelihood for the CKD population to receive a kidney transplant did not necessary follow the presence of stage 5 CKD, which was revealed in both smoothing techniques, and statistical tests of spatial randomness. They therefore suggested that geography seemed to play a role in access to kidney transplantation.

The study has been able to show that a GIS-based approach helps to clarify and recognise the geographical variability of health differences. By utilising the visualisation of data, they were able to locate under-served or over-served regions.

2.9 Summary

Previous studies have identified a number of factors that are either directly or indirectly associated with the prevalence of CKD. The majority of the factors that directly influence the development of CKD in a person can be classified as biological risk factors. These include hypertension, chronic glomerulonephritis, diabetes, toxic nephropathy and other previously mentioned causes of CKD (see section 2.4.2 above). The demographic factors discussed in section 2.5 can be regarded as factors that are indirectly associated with the CKD outcome of a patient. The varying influence of these biological risk factors as well as demographic factors on the outcome of CKD can be observed across the various research studies both at a local and global perspective.

It could be observed that there were variances in the prominent risk factors associated with CKD. For example, the presence of toxic nephropathy as one of the prominent risk factors of CKD in Asian and African countries could be attributed to the fact that the herbal medications are not as regulated as in the more developed countries. Therefore, the herbal medications in the Asian and African countries are more likely to contain harmful compounds, which could have been detected before they were allowed into public circulation if there were adequate regulatory bodies that monitor the quality of these herbal medicines.

The review on the utilization of GIS within the African health sector has shown that there are benefits in the use of GIS in the African health sector. However, the majority of the GIS applications in the African health sector are currently located in the southern region of the continent. Despite the fact that the application of GIS has been focused on the monitoring, analysing, and management of infectious diseases, it can be argued that due to its adaptable capabilities, GIS can be applied to the study of non-infectious diseases within the African health sector.

In regards to the spatial distribution of the prevalence of CKD, there were more detailed research studies on CKD that were applied within the developed countries than in developing countries. Furthermore, even where published research studies that focused on the developing countries were available, they mainly gave a simplistic overview of

the spatial distribution of the disease across the developing region. However, the emphasis on how GIS provides a framework for the combination of multidisciplinary approaches and techniques to present a full picture of health outcomes were made apparent in the majority of the studies reviewed. They focused on showing the health variations when analysing geographically defined data.

It should be noted that not all academic research on CKD could be reviewed as a majority of these studies were written from a medical perspective. Therefore, an attempt at reviewing these studies from a geographical perspective turned out to be very restrictive. Efforts at getting enough academic researches on the use of GIS in the study of CKD proved equally to be challenging. However, this only confirms the underlying fact that there is a need to educate health practitioners and researchers affiliated with the study of CKD on the advantages of the application of GIS. This is particularly essential in developing countries where limited data resources are available. GIS could therefore be applied in order to highlight areas of concern that could otherwise be overlooked.

Chapter 3 The evaluation of the data collection process and the research methods

3.1 Introduction

The previous chapter focused on the basic concepts as well as the relevant literature associated with this research study. This chapter will outline the research approaches undertaken to answer the research questions outlined at the beginning of this thesis. The data collection process undertaken during the course of this research study as well as the research methods that were applied in the course of this study are examined in detail later in this chapter.

3.2 Research design: A quantitative approach

This research study can be classified within the field of health geography, which is a sub-discipline of human geography. This is because my study focuses on the spatial analysis of a health issue (i.e. the study of chronic kidney disease). It has been suggested that health geography can be broadly grouped into two main sectors – the spatial spread of diseases and the access to healthcare (Parr, 2003) and this gives a brief summary of what this research study focused on.

Given the nature of my research study, the quantitative approach, which is regarded as quantitative geography within the geographical discipline, was adopted for this research study. Quantitative geography is the collection of methods that can be applied, by geographers and researchers in other disciplines, to study spatial phenomena, issues, and problems (Murray, 2010).

It has been argued that the emphasis of the quantitative approach in human geography is to gather enough evidence that makes the adoption of a particular explanation compelling (Bradley and Schaefer, 1998; Fotheringham et al., 2000). A known strength of the quantitative approach as noted by Fotheringham et al (2000 p. 6) is that…"*it enables the measurement of the determinants that can be measured (and in many cases these provide very useful and very practical information for the real world decision-making) ...*"

The quantitative approach within a geographical research study is usually categorised into two perspectives. These are the research studies that focus on the statistical analysis of spatial data and those that focus on spatial modelling. The statistical approach, which ranges from descriptive statistical methods to statistical models (such as regression and analysis of variance) as well as non-parametric methods, have been an important part of quantitative geography (Murray, 2010). The application of statistical methods within the social sciences can be attributed to the need to account for errors and uncertainty in both data collection and model formulation (Fotheringham et al., 2000). It has been argued that the modelling approach can be classified as an important tool that could help researchers handle complexities in a variety of situations in order to produce a compelling explanation about spatial processes (Macmillan, 1989; Wilson, 1989). Quantitative geography combined with geographical information systems (GIS) in the 1990s by using a descriptive, inductive, and applied view and this trend was supported

by the rapid development of computer technology and the data storage of geographical information (Yano, 2000). This has led to a boost in empirical investigations especially those that are computationally intensive, which could explain the application of GIS in a number of modelling research studies. Examples include location-allocation modelling (Ghosh and Rushton, 1987; Yeh and Chow, 1996), accessibility studies (Sherman et al., 2005), space-time modelling (Dijst et al., 2002; Kwan, 2004), and spatial interaction modelling (Beale et al., 2006; Fotheringham et al., 2000). It has been argued that for certain aspects of the modelling approach, the integration of GIS with a quantitative approach could lead to a reasonably high probability of producing insights that would otherwise be missed (Fotheringham, 1999). According to Poon (2004), the integration of GIS along with the increasing developments in geoprocessing capabilities has potentially allowed researchers to study at individual rather than group level in an attempt to reveal the heterogeneous positions and experiences of their population studies. This has been made possible because the use of GIS allows the incorporation of large amounts of geographic data that are essential for any meaningful analysis of human activity pattern that might have been previously difficult to attain before the integration of GIS (Kwan, 2004). Health geography can be regarded as one of the many fields where the utilisation of GIS has had a reasonable number of applications (Parr, 2004; Verhasselt, 1993). This ranges from the simple mapping of diseases to the application of more in-depth analyses such as cluster

analyses of health outcomes (Mosavi-Jarrahi et al., 2007), spatial interaction models of exposure to pollution (Conley, 2011), as well as models on accessibility to healthcare (Tsoka and le Sueur, 2004). These applications have helped to highlight areas of concern thereby contributing to the implementation of more insightful policy decisions that could both benefit the population and the environment. An example is the identification of areas that might be under-served or over-served by available healthcare services in order to improve the healthcare provided to the population within the study area(s) (Christie et al., 2005, Soret et al., 2001).

In summary, the quantitative approach in a geographical context provides a way for the production of strong evidence that can be used to support or disprove an idea/explanation about spatial processes.

As previously mentioned in chapter one, my research study is a cross sectional study that relied mainly on secondary data, therefore the methods used within this quantitative approach can be regarded as a pragmatic or practical approach.

3.2.1 **What led to the development of my research questions?**

Given the fact that the research problem and the research questions has been outlined but not discussed in details in the first chapter, this section focuses on the factors that led to the development of the research questions outlined at the beginning of this thesis.

The commencement of this research study was born out of curiosity as I had originally intended to study the spatial prevalence of CKD within Sheffield and the rest of south Yorkshire in the United Kingdom. I had hoped to work with data that would be provided by the Sheffield Kidney Institute (SKI) in order to contribute to their on-going study on the prevalence of CKD and the impact of socio-economic factors on its prevalence in the community. However, the turning point of my research happened after a meeting with the lead medical investigator at the institute - Professor Meguid El Nahas, who informed me that there was currently an affiliation between the Sheffield Kidney Institute and the nephrology department of the University of Benin teaching hospital (UBTH) in Edo state. The affiliation between the institute and the hospital involved a routine medical training of renal doctors and nurses from UBTH for a period of three months at the SKI. This information resulted in my interest about what the equivalent research on the prevalence of CKD might show in a developing country, given that the UK is seeing a substantial growth in CKD (see chapter two). The information about the affiliation raised two main questions. The questions were as follows - does what has been learned in the UK translate easily to a developing country and to what extent does the Nigerian context differ from what is experienced in the UK?

However, a comparative study was soon abandoned as the extent of the data limitations in my study area was revealed (discussed in section 3.3). In addition, my early reading of the available literature on

the current CKD status of Nigeria, strongly indicated that most patients are diagnosed with CKD only after they had developed the last stage of CKD, which tended to be expensive to treat or manage as well as unaffordable by majority of the patients. Therefore, the aim of my research study was to identify ways of improving the early detection of CKD among patients by attempting to identify any variation(s) among the factors associated with CKD patients and determine if it can be regarded as an influence on to the severity of CKD at the time of diagnosis in patients (see chapter one).

As mentioned earlier, the research study intends to address the following questions:

1. Is there an association between socio-demographic factors and the severity of CKD at first presentation?
2. Is there a relationship between the severity of CKD at first presentation in Edo state and known biological risk factors of CKD?
3. What factors are likely to lead to the late diagnosis of CKD among patients in Edo State?
4. What is the trend of diagnosed CKD within Edo state?
5. What is the spatial pattern of diagnosed CKD cases within Edo state?
6. Is the prevalence and distribution of CKD in the state appropriately serviced by the available CKD healthcare service?

Having already mentioned in the previous chapters that there are no registers of CKD in Nigeria, it was apparent that I needed reliable data sources for my study. These included reliable data on who had been diagnosed with CKD. This data would be used in addressing the first four research questions outlined in this study. Also needed, was the data on the base population, which includes the population for the LGAs and the wards within the state, and boundary maps for the LGAs and the wards, as they would be relevant in addressing the fifth question of the research study. A road network dataset along with the data on the location of diagnosed CKD patients and available CKD health services within the state were required to address the last research question. The subsequent sections within this chapter examine the data collection process and the methods that were applied in the course of this study so as to answer the research questions. Equally discussed are the methods that were considered but were not applied in the course of this study.

3.3 Data collection: Experience at the University of Benin Teaching Hospital (UBTH) and the Regional Centre for Training in Aerospace Surveys (RECTAS)

As mentioned in chapter one, the University of Benin teaching hospital (UBTH) was selected as the source for the CKD data for my study area. This decision was based on the fact that at the time of the study, the hospital was the only health institute within the state with a functioning nephrology unit and this ensured that anyone in the state diagnosed with the disease would likely have a CKD health record

within that hospital. The nephrology department at the hospital is also responsible for the treatment of all CKD cases within the Niger-delta region; therefore, CKD patients who reside just within the boundary of Edo state do not travel to neighbouring states to receive treatment.

This section also examines the data collection process experienced at the RECTAS agency in the retrieval of spatial datasets including the population data and the boundary data needed for the research study.

3.3.1 Ethical approval for research study

Since this research study required the collection of data on CKD patients from their health files within UBTH, there was the need to obtain ethics approval from the hospital. In order to access the health files of the CKD patients, a letter was written to the ethical committee of the hospital explaining the reason for accessing the files and the nature of the research study for which the CKD patients' data would be used. Once the committee was able to determine that the data were only going to be used for research purposes and the privacy of the patients would be maintained, ethical approval was granted (see Appendix A).

3.3.2 **CKD data collection**

There are currently four Adult Nephrologists[22] and two Paediatric Nephrologists in UBTH and each nephrologist has approximately five doctors working on his/her team.

The data collection process for the retrieval of data on CKD patients required visiting the study area twice in the course of this study. The first visit can be classified as the initial fieldwork, which was from the beginning of July to the 14th of October 2009 while the second visit can be classified as the validation fieldwork and this was carried out for 6 weeks at the beginning of 2010. The need for a second period of fieldwork was because during the initial fieldwork, a number of CKD records were not retrieved which warranted the need for a second visit.

During the initial data collection process, it was discovered that all patients that have ever attended UBTH have health files opened for them, which are kept in the records department. The patients' files are catalogued according to their hospital identification number and not by any other criteria.

One of the first things noticed at the records department was the difficulty in sorting out the required files from the rest of the records in the file room without prior knowledge of the exact hospital numbers that were for CKD patients in Edo state. Due to a staff

[22] A nephrologist is a Consultant that specialises in the treatment of the kidney

shortage problem at the hospital, it was difficult to get the adequate help needed to find the required files, as I was not allowed access to retrieve the files from the records department. A records officer at the department was eventually allocated the job of sorting out the files by extracting those that were relevant for my study. All the files that were under the head consultants in-charge of CKD diseases were located but since these consultants were also in charge of the treatment of patients with other diseases, the files found were further examined in order to extract those that were CKD patients and had been diagnosed between 2006-2009. It was clear that the format on how the files were catalogued was to make it easier for the records officials to locate a patient's file once the patient or a health official had a hospital identification number for the file. However, difficulties did arise when there was no identification number(s) for the records official to use to locate the needed file(s).

Due to the problem stated above, the renal department at the hospital began a new database project at the beginning of 2009 that involved the creation of a digital database for its CKD patients. Access to this database indicated that this database utilised a well-detailed format on which the necessary data for each patient can be recorded. However, in the absence of a data entry officer, the job of logging-in patients' data was the responsibility of the house officers[23] who had other

[23] **House officer:** A resident physician who is receiving further training, usually in a medical or surgical specialty, while caring for patients under the direction of the attending staff

duties that equally required their time. A cross-examination of the digital database with patients' files indicated that most entries were incomplete and in some cases inaccurate. One of such inaccuracies was found among the address section for the patients and another was their mode of referral to the renal department. Since the creation of the digital database at the beginning of the year only 114 records were entered into the database as opposed to the large number of CKD cases diagnosed and managed by the renal unit over the years. The hospital had earlier reported that it catered for over a thousand patients with CKD. However, after the patients that resided outside Edo state were extracted from the rest of the records, along with those that were diagnosed before 2006, it was discovered that the patients qualified to be included in the research study totalled 609.

During the course of the data collection process, different means were used in retrieving the required CKD data. One method was by following the doctors on their clinic days as they attended to patients. When they attended to CKD patients, their files were kept aside after their check-up and later passed on to me in order to extract the necessary information. Although this was part of the data collection process, this approach was time consuming, as there were instances where none of the patients they treated had the disease. Another approach was accessing the records on CKD patients that had undertaken any dialysis session. This information was retrieved from the dialysis unit, which had data on all the patients that has ever received dialysis, including patients that did not have CKD. Once the

relevant CKD data was extracted, the data was used to identify their hospital identification number, their diagnoses (*whether they were medically classified as CKD patients or not*), and the dates and number of dialysis sessions. Therefore, I was able to gather all the data for all the CKD patients that had received dialysis from 2006-2009, which were predominantly those with stage 5 CKD.

The patients that were excluded from this study were those who were diagnosed for acute kidney failure or any other non-chronic kidney disease e.g. kidney stones, as well as CKD patients that were diagnosed with the disease before 2006 and those that were not residing in Edo state. The last group were not easily identifiable as some patients stated a temporary address in Edo state as their permanent address. To resolve this problem, each patient's files had to be searched for any information that indicated that he/she lived outside the state before coming to the hospital for treatment (for example, a reference letter from any health institute outside Edo state that referred the patient to UBTH). Another way that patients were excluded was if there was any mention within the health file that the patient did not originally reside in Edo state at the time of their diagnosis; therefore only Edo state residents were included within this dataset.

The retrieved CKD dataset used for the research study contained variables on the following:

- Hospital identification number of each patient

- Demographic variables (age, date of birth, sex, marital status, education, occupation, ethnicity, and religion)

- Geographical variables (house number, street name, name of residential area, LGA, name of town or village)

- Diagnosis variables (date of diagnosis, the various diagnosed risk factors, the stage of CKD at time of diagnosis, and the name of the health facility that referred the patient for treatment)

- Management variables (the number of dialysis session *(if required)*, the current health status of the patient, *which indicates whether the patient is on follow up, deteriorating, or dead*

Following the criteria discussed above, a total of 609 patients was identified. However, 224 of these patients' files could not be located as at the time of the initial fieldwork therefore, only 385 cases were initially collected. Out of these, 28 cases did not have adequate addresses needed to locate them on a map. Thus, there was concern that the results derived from the 357 cases may not produce valid results that would represent the CKD population. However, the dataset was validated when further cases, were collected during a second visit to the hospital (discussed in section 3.3.2.1). These were analysed and compared with the results obtained from the original 357 cases (discussed further in chapter four).

3.3.2.1 *Validation dataset*

In order to discover if there was any systematic bias in the initial data collection process, there was the need to compare the initial dataset with a similar dataset. An example of the presence of a selection bias within the data was the possibility of having access to data on certain proportion of CKD patients and not having access to the rest of the other CKD patients. This could include having access to CKD patients diagnosed at the last stage of CKD and not having access to patients that were diagnosed at earlier stages of the disease. Since UBTH was currently the only tertiary hospital that managed CKD in Edo state, it was therefore necessary to attempt to locate some, if not all of, the missing case files that were not retrieved in the initial data collection process.

In order to achieve this, the help of the staff at the UBTH records department as well as some doctors carrying out research on CKD was solicited. The same template was used for the data collection (see Appendix B). I should however, mention that due to some security problems that were being experienced in Edo State, I was unable to remain in the state for more than a few days, so I had to completely rely on the data collected by the staff and research doctors at UBTH.

An attempt at retrieving additional CKD cases that were diagnosed between 15th October 2009 and 31st December 2009 failed, as the renal department's new digital database system had crashed and they had lost all the records saved in the system. A total of 92 cases were

located and the necessary data were retrieved. However, after sorting through the data collected, and removing duplicated CKD records as well as those that did not reside within Edo state, they finally came to a total of 85 CKD health files.

3.3.3 **Missing data**

At the end of the CKD data collection process, a total of 139 CKD patients' files could not be found by the record officer at the records department. This was attributed to a number of factors, one of these was that the patients' consultants may have their files but since the records department could not identify the consultants without access to these file they could not be sure, especially since each of the six nephrologists usually had five doctors working within their team. Another reason given was that the files may have been mixed-up and filed in another medical section of the records department when they were being returned from the clinic (for outpatients) or the wards (for patients that were admitted).

This left 442 cases eligible for the data analyses within the study. The study was therefore based on an estimate of 72.6% of the CKD cases treated in UBTH within the study period.

Not all the records were complete. This might be attributed to patients refusing to answer some of the questions due to perceived health stigmas associated within chronic illnesses or they might have been worried about the possibility of been tracked down by the health authorities should they default in payment. Another possible

explanation might be that some of these questions were not asked by the health officers during the creation of these patients' health files.

3.3.3.1 *Determining the appropriate method for calculating a patient's stage of CKD at time of diagnosis*

Although the diagnosis of CKD was indicated in these patients' files, the CKD stage at presentation (or stage of CKD at time of diagnosis) needed to be calculated. However, the needed indicators required in determining the stage of the disease were recorded.

The formula that the doctors recommended was the Cockcroft-Gault formula. This formula is expressed as:

Equation 3.1: A Cockcroft-Gault Formula

$$\frac{(140\text{-Age}) - \text{Weight}}{72 \times \text{Serum creatinine}} \times (.85 \text{ if female})$$

Source 3.1: (Thorp, 2005)

The Cockcroft-Gault formula is regarded as a widely accepted formula for calculating the Glomerular filtration rate of CKD patients (Larsson et al., 2004). The GFR that is derived from this formula is used to indicate the patient's stage of CKD by comparing the value with the range of values that is used to identify the five stages of CKD (See Table 2.1).

3.3.4 How the spatial dataset was collected from RECTAS

Currently, the lowest hierarchical unit of health services delivery in Nigeria is at the ward level. The ward boundaries are geopolitical and

therefore arbitrary. This has been compounded further by the constant boundary disputes experienced within and among the settlements that make up the wards. As a result, there are no officially released administrative boundary maps for the wards. Therefore, the boundary map for the wards within the study areas had to be created and this was generated for this study by the Regional Centre for Training in Aerospace Surveys (RECTAS) agency at Ile Ife, Nigeria. To do this, the RECTAS consultants required two separate lists on the settlements within Edo state from two different government agencies. The first list was from the Independent National Electoral Commission (INEC), which showed the various communities within each ward during an election exercise while the second list was data from the National Population Commission (NPC), which had the names of the communities that made up each ward during a census exercise. A request was therefore sent to INEC and NPC. These requests were approved by both government departments and a copy of these lists was sent to the agency. The information was cross-referenced to determine the similarities among the communities that were classified within a certain ward in order to delineate the boundaries for the ward. It was discovered that the communities within the wards classified by both agencies were the same, the only difference were in the names by which the wards were identified by both agencies. RECTAS also created an administrative state boundary map of Edo state, which also had some large settlement areas (which were represented as polygons) the largest settlement being the state's capital, Benin City. Also

generated for the study was a road network dataset for the study area, which was required for the accessibility analyses for CKD healthcare. The road network comprised of five road types: these included the Benin roads, major roads, main roads, secondary roads, and other roads (discussed in section 7.3.1.1).

3.3.4.1 *Limitations experienced during the data collection process at RECTAS*

There were two main limitations with the dataset for the road network and these were attributed to insufficient data for the study area. The first was the absence of detailed street and road networks for towns and settlements outside the state's capital. These therefore meant that only the access roads to and from these areas were included within the dataset. The second limitation was the absence of any road network data for the southwestern boundary of the state. This therefore meant that network analyses would not be carried out for that area within the state; however, given the small size of that area, a rough estimation was generated for some of the outcomes of the analyses (see chapter seven for details).

Another problem was the issue of population data at the ward level. This was not published after each census. Attempts at retrieving the population data at the ward level was unsuccessful as I was informed that such data were only kept for a short time after each census before they were destroyed. The only data available was a 2008 survey data carried out by the National Population Commission (NPC), which was

based on approximately 5 per cent of the total population within each of the wards in the state. This was used to extrapolate the total population within each ward. A further issue was the absence of the population by sex or age group. As a result of these limitations, the analysis could only use population totals.

3.3.5 Geocoding of the CKD dataset

Once the spatial dataset was retrieved, the spatial locations of the CKD patients were geocoded. However, this was not a straight-forward process as the required information needed within a GIS platform was not readily available for the study area.

3.3.5.1 *Georeferencing techniques attempted within the geocoding process*

The initial geo-referencing technique that I intended to use was to geocode the patients using the road shape files as a reference dataset and to create address locators in order to identify the associated geographic coordinates for each patient. However, the road data did not have the necessary features required in the creation of an address locator. I therefore attempted to use some online mapping software. The best was OpenStreetMap, but the street names for most of the areas within Edo state were not labelled which therefore made it difficult to identify the location of the patients' addresses on the map.

3.3.5.2 *Google Earth*

The next method was to use Google Earth as a platform. Authors have shown that the geo-information provided by Google earth

could be used for geospatial work as the range of error for geo-referencing using satellite images on Google earth was within 15 metres. A close look at the satellite images available on Google Earth showed that Edo state was not adequately labelled and as such, the right spatial location for each patient could not be easily identified. The next hurdle was to find a way to update the satellite images in Google Earth with enough information that would facilitate in identifying the spatial location for each patient. This necessitated uploading the road shape files for Edo state, which also contained a detailed and labelled road map for Benin City as well as a point shape file of various locations within the state. Google Earth can only read Keyhole Markup Language (KML) files and therefore any software that could convert shape files to KML files was needed.

ExpertGPS software was ultimately used to export the road maps, the LGAs, and the ward boundaries within Edo state onto Google Earth. This improved the chances of geo-referencing the patients' records on Google Earth. Another advantage of the ExpertGPS was its ability at converting the locations identified within Google Earth from a KML file back to shape files for further GIS analyses. Although an imbedded tool within ArcGIS version 9.3 did not have a KML conversion tool at the time of the geocoding process for my study, the recently released ArcGIS 10 now includes the tool that can convert between shape files to KML files.

The majority of the patients had enough address details to locate their homes or streets on Google Earth. The remaining cases (approximately 5% of the total number of CKD cases) were assigned to their corresponding wards using the available address detail. For some patients, their geographical location on Google Earth was blurred, i.e. no data capture at the appropriate scale, which was particularly noticed for some rural areas within the state.

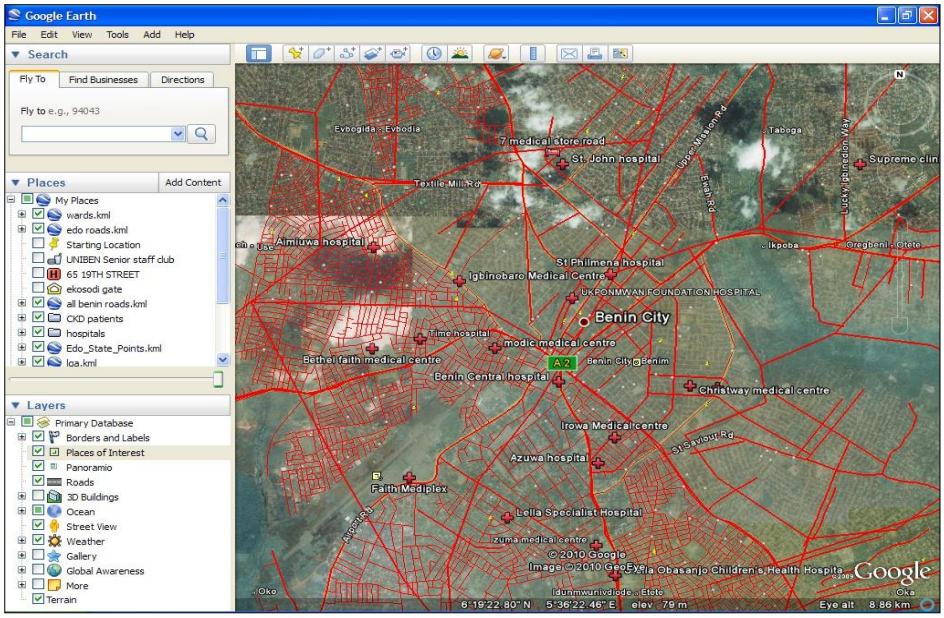

Figure 3.1 : A screen-shot from Google Earth of an area within Benin City, the red crosses are the locations of health services that referred CKD patients to UBTH for treatment, while the broad red lines are major roads and the thin red lines are minor roads. The white dots are the geocoded locations of CKD patients that reside within the area.

To examine the accuracy of using Google Earth to geocode, I compared the outcomes generated using two approaches to locate some health services. This involved comparing the results derived

by using a global positioning system (GPS) with those identified using their addresses. After uploading the administrative boundaries for the LGAs and wards as well as the street and road layers on Google Earth, I inserted the GPS derived coordinates of UBTH and other health services within Benin City that referred patients to UBTH for CKD treatment. The results showed that Google Earth was able to identify, the location of each health service and their locations correctly matched the street and road addresses of these health services.

3.4 Research methods

This research study can be described as a quantitative research study that applies statistical and spatial analyses in the study of diagnosed CKD in Edo state. The discussion of the methods used in this research study were categorised into two broad groups. The first group focused on the methods used for statistical analyses while the second group were the methods used for spatial analyses.

3.4.1 Choice of methods for statistical analyses

In order to answer the first four research questions, the appropriate statistical test or method had to be determined. Three sets of statistical analyses were carried out on the CKD dataset. The first dealt with the statistical tests used for exploratory purposes to determine the level of association between variables. The second statistical analysis was a logistic regression, which was used to create a model in order to address the third research question. In order to answer the fourth

research question, the time series analysis was used to examine the trend of CKD diagnosis within the study period.

In the course of this study, all statistical analyses were carried out using the Microsoft Excel program and SPSS software.

3.4.1.1 *Methods used in variable exploration*

Given the range of variables mentioned in section 3.3.2, the type of data used for the study had to be assessed, as it would help in determining the appropriate statistical test to use on the dataset. There are two main groups of statistical tests and they are the parametric tests and the non-parametric tests. A parametric test requires data on the interval, ratio scales while non-parametric test are used for ordinal (ranked), or nominal (categorised) data (Robinson, 1998). It was discovered that only the variables for the age of the patients and the number of dialysis sessions undertaken by the patients could be classified as an interval data while the remaining variables within the CKD dataset were categorised variables. For ease in the variable exploratory process, the age variable and the variable indicating the number of dialysis sessions were reclassified. Given the fact that parametric tests are based on the assumption that the data is normally distributed and should have similarity of variance (Clegg, 1983), none of the parametric techniques was used to test the data because none of the variables fulfilled the assumptions required for a parametric test. This was because when the variables were tested for normality using the Shapiro-Wilk test in SPSS, none of them were significant. Some

have argued that parametric tests are better than non-parametric tests, which is reflected in the transformations of data i.e. the conversion of non-normally distributed data into a normally distributed data, by some researchers (Rascati et al., 2001; Afifi et al., 2007). However, other researchers have argued against this procedure, stating that it alters the fundamental characteristics of the data and they therefore recommended that the appropriate non-parametric test should be used (Norcliffe, 1982; Robinson, 1998).

According to Siegel (1956), non-parametric tests have five advantages over parametric tests (cited In Robinson, 1998):

- Regardless of the probability distribution, the probability statements obtained from most non-parametric tests are exact probabilities.
- Non-parametric test is not affected by small samples
- There are non-parametric tests that are suitable for analysing samples from various different populations.
- Non-parametric statistics can make use of data on a variety of measurement scales.
- Non-parametric test do not make assumptions about the background population from which the sample is collected, therefore they are usually easier to apply than parametric tests.

In the course of this study, two non-parametric tests (chi-square test and correlation) were used to test the CKD data so as to draw inferences that could be used in answering the research questions outlined in this thesis.

3.4.1.2 ***Logistic Regression***

Logistic regression is part of a group of statistical models called generalized linear models (Robinson, 1998). The mathematical concept that led to the logistic regression is the logit, which is the natural logarithm of an odds ratio (Peng et al., 2002). It is used for predicting the probability of an event occurring from a set of variables that may be either interval or categorical. Usually, the dependent variable is dichotomous (i.e. it has only two values). This means that the dependent variable can take the value 1 with a probability of success/present, or the value 0 with probability of failure/absent. In the cases of my study (see chapter five), the values for the dependent variable (i.e. the stage of CKD at the time of diagnosis) had been regrouped into only two possible outcomes which were *earlier CKD stages* or *late stage of CKD* at time of diagnosis (this was discussed in detail in chapter four).

Logistic regression is usually estimated using maximum likelihood techniques, which is preferred over the weighted least squares approach (Peng et al., 2002). The maximum likelihood technique is created to maximize the likelihood of reproducing the data given the parameter estimates. According to Peng et al (2002), the null

hypothesis for the logistic regression model states that all the coefficients equal zero, which means that the logistic regression equation is unable to predict the probability of the outcome better than the mean of the dependent variable. When at least one coefficient does not equal zero in the population, the null hypothesis is rejected. This implies that the logistic regression equation predicts the probability of the outcome better than the mean of the dependent variable. The interpretation of results is made using the odds ratio for the predictors.

Evaluations of the Logistic Regression Model

In order to determine how effective a logistic regression model is, three major components have to be evaluated namely; the evaluation of the overall model, the statistical tests of individual predictors, and the goodness-of-fit statistics (Peng et al., 2002).

The evaluation of the overall model

A logistic model is said to provide a better fit to the data if it demonstrates an improvement over the null model (Field, 2000; Peng et al., 2002). The null model is a model that contains just the value of the constant and has no predictors included within the model. It is therefore regarded as the baseline in the creation of the overall model. An improvement over the null model is examined by an inferential statistical test called the likelihood ratio.

The likelihood ratio statistic is transformed by multiplying it by its deviance (represented as -2 Log Likelihood or -2LL in the SPSS

software) and this means that the likelihood ratio statistic is multiplied by -2 times its natural logarithm (Luke, 2004).

Goodness-of-fit statistics

The goodness-of-fit statistics assesses the fit of a logistic model against the actual outcome of the model. An inferential test known as the Hosmer and Lemeshow test is used to determine the fit of the model. The Hosmer and Lemeshow test statistic is *a Pearson chi-square statistic, calculated from a 2×g table of observed and estimated expected frequencies, where g is the number of groups formed from the estimated probabilities* (Peng et al., 2002, p.6). The Hosmer and Lemeshow's goodness-of-fit test tests the hypothesis that the observed data is significantly different from the predicted values from the model (Field, 2002). This means that if the model is good then the chi-square should not be significant at p=0.05. Therefore, a non-significant value for this test would indicate that the model does not differ significantly from the observed data.

3.4.1.3 *Time series analysis*

One of the variables of interest within the CKD dataset was the time of diagnosis of each CKD patient. In order to determine the trend of CKD diagnosis within the study period, time series analysis was selected. Time series analysis is used in evaluating the set of values of a variable generated in an ordered sequence over a time period (Brockwell and Davis, 2009).

A time series analysis has two main functions. It can be used to obtain an understanding of the underlying factors as well as the structure (such a trend or seasonal variation) that produced the observed data. It can also be used to fit a model that can be used in forecasting and monitoring subsequent data.

The time series analysis used here only focused at understanding the underlying factors that contributed to any variation(s) found within the variable (discussed in chapter five). The outcome of this analysis was used in providing an answer to the fourth research question.

3.4.2 **Choice of methods for spatial analyses**

Spatial analysis involves the accurate description of data relating to a process operating in space, the study of patterns, and the interactions within such data (Bailey and Gatrell, 1995). Three main spatial techniques were carried out in the course of this study. These were the simple mapping of the CKD data using choropleth maps, the use of kernel density estimator to evaluate the density distribution of CKD within the study area and two models of network analyses.

3.4.2.1 ***Visualising spatial data using choropleth maps***

Choropleth maps were used to map the number of diagnosed CKD cases within area of interest (such as the LGAs and the wards) and to map the proportion of the diagnosed CKD cases in relation to the underlying population. These choropleth maps were used to highlight areas of concern for the disease within the study area. The choropleth maps showing the CKD counts across the study area were able to

indicate areas where there were a relatively high or low number of diagnosed CKD cases, which is important for allocating health resources while the proportion map was able to indicate the spatial distribution of the rate of diagnosed CKD across the state.

As there were no available data on the total number of CKD cases in the country or any other African country or any similar country that could be used as a standard population for CKD rates, a standardized CKD morbidity rate could not be computed for the state. Therefore, only a simple crude rate could be calculated within this study (discussed in chapter six).

Two other analyses that required their outcomes to be displayed using choropleth mapping were initially considered in this study – the standardised morbidity/mortality rate (SMR) and the geographically weighted regression (GWR). An overview of why these geo-statistical methods were initially considered as well as why they could not be applied in the study was discussed below.

The standardised morbidity rate (SMR)

The standardised morbidity/mortality rate (SMR) was one of the first methods that were considered at the onset of this study. The appropriate SMR was the standardised morbidity rate as the focus of the study was on diagnosed CKD patients and not on the death rate within the study area. The standardised morbidity rate is regarded as a measure of the relative risk. This method is used to give a geographical picture of the extent to which the disease rate observed

in an area exceeds an expected disease rate (Leyland and Davies, 2005). The idea is to identify areas where the occurrence of the disease is in excess in order to study those areas in greater detail. The outcome of this method is mapped using choropleth mapping. One of the advantages of the SMR is that the method tends to be less sensitive to numerical instabilities (Breslow and Day, 1987).

The main limitation that hindered the application of SMR in this research study was the absence of a population data at the ward level, which contained the demographic characteristics (such as the sex and age groups) of the population. Another limitation was the absence of a standardised population. This could be attributed to the lack of a CKD registry within the country or any similar country within Africa, which could have been used as the total number of diagnosed CKD cases within a standardised population. However, the total number of diagnosed CKD cases within the study area could theoretically be used as the standardised population that can be divided by sub populations such as the LGAs and ward population, to give estimated rates for these LGAs and wards. The absence of a reliable CKD dataset that contains an estimated number of the diagnosed CKD patients within the state is not currently available.

In summary, what hindered the application of SMR in this research study was the absence of relevant population datasets (i.e. age-specific populations for the wards and a reliable morbidity rate of a

standardised population), which were needed in determining the expected CKD rates across the study area.

Geographically weighted regression (GWR)

Geographically weighted regression (GWR) was developed to allow the relationship between the dependent variable and the independent variables to vary spatially as the authors argued that regression coefficients do not always remain fixed over space (Brunsdon et al., 1998). According to Brunsdon et al (1998), GWR can be described as a technique for producing local 'mappable' regression coefficients in order to see variations in relationships that were previously unobservable.

The GWR technique was primarily of interest for my study as it could be used to investigate whether any relationships that exist between diagnosed CKD cases and associated risk factors were stable over space, or whether they changed to reflect the characteristics of different regions in the study area. Although the method appeared to a useful technique that could be used to explain the spatial distribution of the research problem, a couple of problems were encountered.

The main problem encountered in the attempt of using the GWR method was the non-availability of independent/ explanatory variables at the ward level, which is the scale of the research study. Also an attempt to apply the method at a higher scale (i.e. at the level of the LGA), equally proved unsuccessful as the data available for that level only had two independent variables available (i.e. sex and age

variables). The other relevant variables needed for the analysis such as the socio-demographic variables and associated biological risk factors diagnosed within the study area were not available at the LGA level. Based on these limitations, the GWR method could not be applied in this study.

In conclusion, one problem associated with the use of choropleth maps is that physically large areas tend to dominate the resultant map even when they are not the area of interest (Martin, 1989). Given the fact that choropleth maps use aggregate data, a known problem associated with using aggregated data in spatial analysis is the modifiable areal unit problem (MAUP) (Openshaw, 1984). This tends to occur when a more detailed dataset is aggregated. Openshaw (1984) defined MAUP as a situation in which modifying the boundaries and scale of data by aggregating the initial dataset into a simpler dataset could significantly affects the result of the spatial analysis of the data. This means that the outcome from an aggregated data could result in the loss of information of spatial processes that would have been highlighted if the data were not aggregated.

3.4.2.2 *The kernel density estimation (KDE) technique*

In order to avoid the MAUP mentioned above, the Kernel Density Estimation (KDE) technique was used to analyse the CKD data. This is classified as one of the techniques used in point analysis. This was used to examine the spatial pattern of diagnosed CKD by estimating the spatial density of diagnosed CKD cases within the study area. The

KDE is a non-parametric method of extrapolating or interpolating point data over an area of interest and has the advantage of not invoking MAUP as it does not rely on fixed boundaries (Carlos et al., 2010). This analysis was done using the LandScan™ 2008 Global Population Database. This population database was developed by the OakRidge National Laboratory (ORNL) using multiple techniques to disaggregate census counts within an administrative boundary and allocate the population distributions to a 30-second-by-30-second latitude/longitude grid (Dobson et al., 2000; Carlos et al., 2010). It was decided to use this dataset instead of the ward dataset created by RECTAS because of the grid format of the Landscan population dataset, which standardizes the areal unit for population values, unlike polygon formats representing administrative boundaries that vary in size (Carlos et al., 2010). This makes population at different locations more spatially comparable and facilitates spatial analysis operations.

Although this study attempted to identify areas with high and low rate of diagnosed CKD, the use of cluster techniques as an approach was not explored in this study. The reason is the associated limitation known as the a priori choice of cluster size, which has been found to have significant effects on results and there seems to be no clear guidelines on how to deal with the problem (Besag and Newell, 1991; Cuzick and Edwards, 1990; Pfeiffer et al., 2008). According to Pfeiffer et al, "*The main problem that arises, is that, by exploring a range of maximum cluster sizes, an upper cluster threshold can be chosen that presents a pattern of clustering best suited to support a*

particular argument, rather than that which best reflects reality" (Pfeiffer et al, 2008, p. 66). This could become a problem, as the location of UBTH within Benin City is expected to result in more patients being diagnosed within the city than in other areas within the state. This is because there are indications that show that access to healthcare is likely to influence ones' decision to seek medical treatment (Buor, 2003). Due to the possibility that Benin city could be identified as a clustered region as opposed to the rest of the study area coupled with the fact that gaps were expected in the dataset, the use of a cluster technique might not reveal any new information on the spatial spread of CKD within the state. The reason why gaps were expected in the dataset was because there was the possibility that some areas would not register the presence of CKD patients within their boundaries. This is attributed to the fact that within the state, not all residents that have the disease have been diagnosed particularly in remote areas that are of a considerable distance from the hospital.

3.4.2.3 ***Network analyses***

The network analyses were used to address the last research question. Service area analysis and location-allocation analysis were selected. All the network-based spatial analyses were carried out using ArcGIS 10.

Service Area analysis

Service area analysis was used to examine the CKD patients' accessibility to CKD healthcare facilities within the state. There was

the need to evaluate the impact of distance to the hospital and the spatial distribution of diagnosed CKD cases within the study area. The outcome of this analysis could help to identify deficiencies in the current service area for CKD management as well as recognise populations who were at risk but had limited access to CKD healthcare. According to Haynes (2003), the measurement of geographical accessibility tends to focus on the physical separation that impedes contact. As variations in the use of health services are more strongly associated with road distance and estimated travel time than with Euclidean distance (Martin et al., 1998), travel times were used in creating the service area models for evaluating the accessibility of CKD patients to UBTH (see chapter seven).

Location-allocation analysis

Over the years, there has been progress in the research and development of methods for efficient allocation of healthcare resources, which address the planning issues of hospital locations and service allocations (Mitropoulos et al., 2006). The Location-allocation model provides a structure for evaluating service accessibility problems by comparing the effectiveness of available services and generating alternatives in order to improve the performance of the existing service systems (Rahman and Smith, 2000).

There are three main techniques used in solving location-allocation problems. These are the exact, the heuristic, and the metaheuristic techniques (Densham and Rushton, 1991; Mladenovic et al., 2007). In

the exact technique, the location-allocation problem needs to determine the solution for finding a set of locations without using any approximation to get an optimal result. On the other hand, heuristic techniques use approximations to determine the optimal location for solving a location-allocation problem. However, the solution might not give an optimal result (Scott, 1970). Although the metaheuristic techniques also uses approximations to determine the optimal location, they can be classified as general strategies to design heuristic algorithms in order to produce a more accurate outcome with regard to a given measure of quality (Mladenovic et al., 2007).

One of the most frequently used models within the location-allocation analysis is the "*p*-median problem" (Harper et al., 2005; Revelle et al., 1970). Given the demands within an area, the main objective of the *p*-median problem is to locate a number (p or less) of facilities, by minimising the total weighted travel distance or time between facilities and demand centres. It is based on the assumption that all users of the facility choose to travel to the closest one, however, this model does not take into account the worst-case scenario as the results from the *p*-median model may be forcing a few users to travel far (Harper et al., 2005; Rahman and Smith, 2000). This may mean that the most distant users do not actually travel to their nearest facility or to any facility as it has been observed that the usage of service facilities declines rapidly when the travel time (distance) exceeds some critical value (Rahman and Smith, 2000). This has been classified as a distinctive situation with the use of health facilities

within rural areas in developing nations (Muller et al., 1998; Rahman and Smith, 2000). Given the limitation of the *p*-median problem, another model was formulated known as the location set covering problem (LSCP) and it considers the maximum distance or time constraints in formulating a location problem (Toregas et al., 1971). The main objective of the model is to locate the minimum number of facilities such that each demand centre is covered by at least one facility within a given maximum service distance or travel time. This model has been used in a study on renal replacement therapy for locating kidney dialysis machines, as it is a form of treatment for which the patient must make frequent and repeated journeys to the healthcare centre (Ebenchaime and Pliskin, 1992). A similar model to the LSCP is known as the *pq*-median problem. The main objective of this model is finding a functional set of facility locations, which can be associated with partitioning the catchment areas for two or more levels of facility (Serra and ReVelle, 1994; 1993). Both the LSCP and the *pq*-median models have a limitation, as there is the possibility that the outcome from these models can lead to more centres being required than is financially feasible. This is because there may not be enough resources to supply the number of facilities that would be needed for the optimum solution to the location problem (Mohan, 1983; Rahman and Smith, 2000).

Should the location of a facility be faced with the limitation mentioned above, another model could be used instead, which attempts to locate the facilities so that as few people as possible lie

outside the desired service distance. This model is referred to as the maximal covering location problem (MCLP) and its objective is to maximise coverage within a desired service distance by locating a fixed number of facilities (Church and ReVelle, 1974).

Apart from the *pq*-median problem, the remaining three problems/models discussed are included within the Network analyst in ArcMap 10. Three other models were included within the location-allocation analysis in ArcMap 10. These are the "maximum attendance", "maximise market share" and the "target market share". The objective of the maximum attendance problem is to identify the facility that maximises the total allocated demand (Holmes et al., 1972). The model is based on the assumption that the probability of the utilisation of the facility decreases linearly as the distance from the facility increases. This model was found to be relevant in addressing part of the last question outlined in this study and is therefore discussed in detail in chapter seven. The maximize market share model solves the competitive facility location problem by attempting to find the location for a facility that will maximise the market share in the presence of other competitive facilities. The target market share is another form of the competitive facility location problem. Its objective is to locate facilities that will achieve the required market share in the presence of other competitive facilities. It also uses the gravity-based formula to determine the proportion of demand allocated to each facility and the minimum number of facilities required in achieving the required market share is chosen.

3.5 Summary

This chapter has evaluated the research design as well as the data collection process that was completed in the course of this study. In order to answer the research questions formulated at the beginning of the thesis in chapter one, this chapter also discussed the methods that were used for analyses and those that were considered but not applied to the datasets that was available for this quantitative research study.

The next chapter can be classified as the 'preliminary analysis' chapter as it involved the descriptive analysis of the variables within the dataset. The outcome of the preliminary analysis provides a profile of diagnosed CKD patients represented within the dataset.

Chapter 4 Profile of CKD cases in Edo state

4.1 Introduction

In the past decades, there has been an increase in the overall health, social, and economic development across the world and there has also been a marked decrease in some infectious diseases notably trypanosomiasis sleeping sickness also known as sleeping sickness (WHO, 2006) and cholera (Carrel et al., 2009). In some developing countries, despite the decrease in some of these infectious diseases, there has been an increase in the diagnosis of chronic and degenerative diseases (WHO, 2011). The current priority of many of these countries is how to develop and strengthen their health systems in order to support prevention, diagnosis, and treatment of notable chronic diseases (Dye et al., 2010). As discussed in chapter two, there is a gap in the development of a suitable health monitoring system for CKD in a number of countries particularly nations in Africa. This has resulted in their inability to manage the disease efficiently and monitor its effect on these nations' populations. As previously mentioned in chapters one and two, little has been done about the implementation of a CKD register in Nigeria. In addition, no attempt has been made at creating a model for renal healthcare that can be combined with established national prevention programmes already functioning in the country such as the National Malaria Control Program (NMCP) and the National AIDS Control and Prevention Program (NACPP). There

is therefore the need to develop a programme that would help in recognising the current CKD prevalence in the country as well as develop an effective prevention and management programme to combat the disease.

Before extensive analyses were implemented in order to answer the research questions and make any recommendations that would be relevant to CKD management in Edo state, a descriptive analysis was carried out of the CKD dataset. This is the focus of this chapter. The research evaluated the profile of CKD patients registered at the renal department of the University of Benin Teaching Hospital (UBTH) and their spatial distribution within Edo state. As mentioned in the previous chapters, CKD patients are referred to the nephrology unit at UBTH once they have been assessed by doctors from other clinics or hospitals in order to confirm the patients' diagnosis; therefore it is expected that the patients' stage of CKD within the hospital's records represents the patients' actual stage of CKD at the time of diagnosis. The outcome of this chapter can be regarded as an overview of the characteristics of CKD cases diagnosed within the study period. The first section of the chapter examines the profile of the 357 CKD cases contained in the initial dataset. The second section focuses on the CKD profile of a smaller dataset, which was used to validate and complement the initial dataset. The chapter concludes by examining in more details, descriptive analyses on the combined dataset and comparing the results with previous studies.

4.2 Descriptive statistical profile and spatial distribution of the initial CKD dataset

The variables analysed in this study can be categorized into three groups, namely: the socio-demographic variables, the diagnosis variables, and the disease management variables. The socio-demographic variables comprised of the sex, age, ethnicity, educational level, occupational status, and religion of the patients. The diagnosis variables were the date of diagnosis, four diagnosed biological risk factors/diseases that were mentioned in the CKD patients' health files, the stage of CKD at time of diagnosis, and the type of referral centre (i.e. the type of healthcare service that referred the patient to the renal unit in UBTH for diagnosis and treatment). The management variables entailed the number of dialysis session taken by the patients that required it, and the health outcome of the patient, i.e. the current health status of the patient at the time when the data was collected for the research study. This included whether the patient was on follow up, deteriorated, or dead. Analysis was performed using the Statistical Package for Social Science (SPSS) version 15.0. Results are presented as frequencies and percentages.

4.2.1 The socio-demographic variables for the initial dataset of 357 CKD cases

The initial dataset of 357 CKD cases indicated that more males were diagnosed with CKD than females (see Table 4.1). The result

indicated that a higher proportion of males than females were diagnosed with CKD with a ratio of 1.8:1. However, given the number of missing cases that were not included within this initial dataset a complete assessment on the proportion of male and females could not be justified at this point.

Table 4.1: The number of males and females with CKD within the 357 dataset

Sex	Numbers	Percentage
Male	229	64.1
Female	128	35.9
Total	357	100

According to the statistics results on the ages of the CKD patients, the mean age of the patients that were included in the study was 45years (See Table 4.2). The youngest and oldest ages were 11 years and 88 years respectively. The mean age for the male patients was 46.5years while the mean age for female patients was 42.5years. A total of 297 patients were between the ages of 18 and 65 years therefore, it can be argued that 83.2% falls within the working age population and this may have a negative impact on the future of the state's economy.

Table 4.2: The mean age of the 357 CKD patients in the initial dataset

AGE			
sex	**Mean Age**	**N**	**Std. Deviation**
male	46.5	229	17.7
female	42.5	128	16.7
Total	**45**	**357**	**17.5**

Within this initial dataset, two patients did not indicate their marital status. The majority of the patients were married with only one

divorced and the rest being single; none of the 357 cases was registered as widowed (see Table 4.3). The results show that 80.4% of the patients diagnosed with CKD were married.

Table 4.3: Marital status of the 357 CKD patients in the initial dataset

Marital status	Numbers	Percentage
married	287	80.4
single	67	18.8
divorced	1	0.3
Unknown	2	0.6
Total	**357**	**100**

There were 20 ethnic groups represented within the dataset with 5 belonging to areas outside Edo state (see Table 4.4), Warake, Agbor, Isoko, Ika, and the Igbo ethnic groups. The patients that belong to these ethnic groups outside Edo state were included in the study because they had indicated an address within Edo State as their permanent address. A total of 172 patients (48.2%) out of the 357 patients indicated their ethnicity.

Table 4.4: Ethnic groups of CKD patients in the initial dataset

Ethnic group	Numbers	Percentage
Bini	86	24.1
Esan	33	9.2
Igbo (Anioma)	13	3.6
Urhobo	8	2.2
Etsako	6	1.7
Yoruba	6	1.7
Akoko-edo	3	0.8
Afuze	2	0.6
Agbor	2	0.6
Ika	2	0.6
Ora	2	0.6
Afemai	1	0.3
Auchi	1	0.3
Ibillo	1	0.3
Ibie	1	0.3
Igarra	1	0.3
Irrua	1	0.3
Isoko	1	0.3
Unmima-fuga	1	0.3
Warake	1	0.3
Unknown	185	51.8
Total	357	100

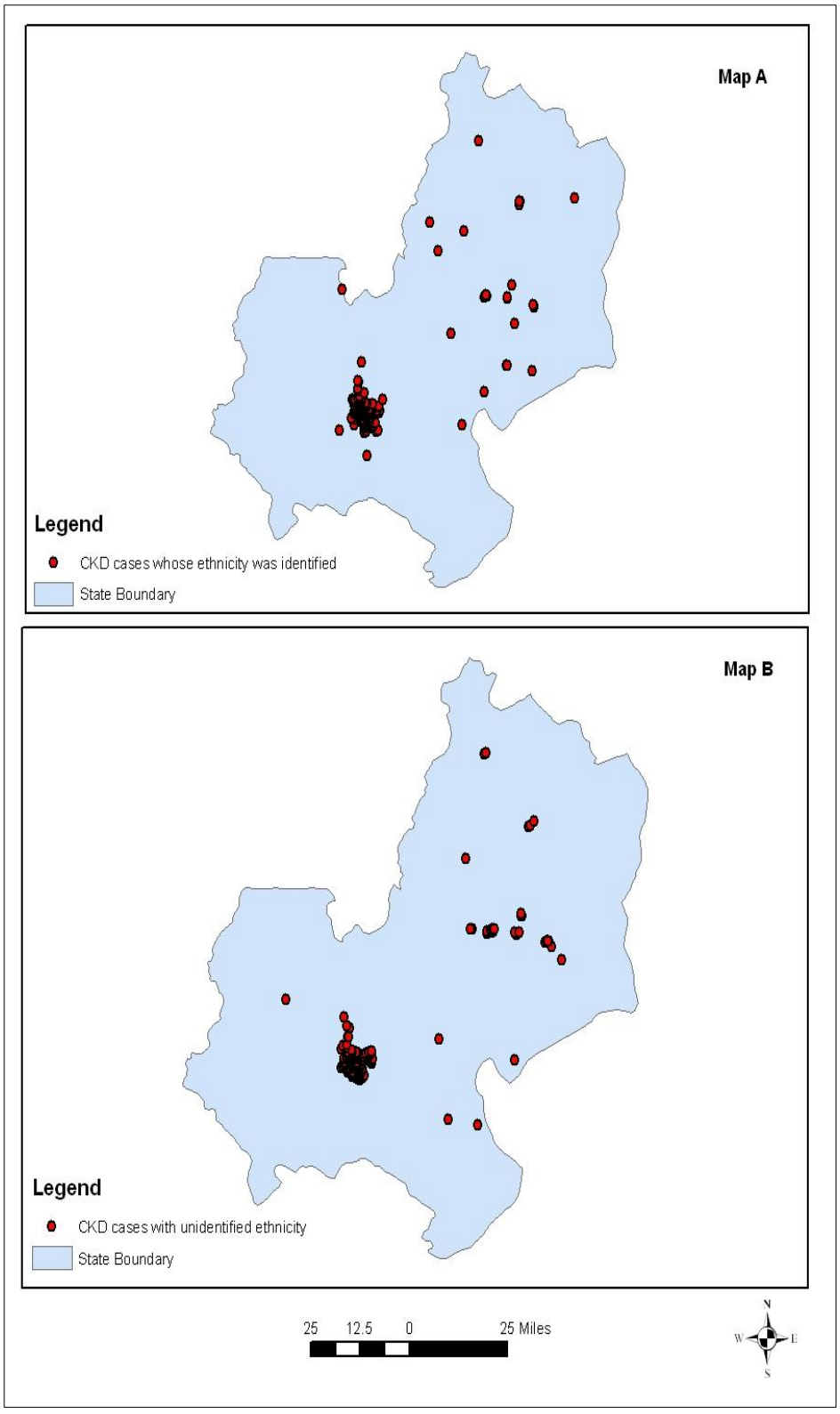

Figure 4.1:Map A shows the spatial distribution of CKD cases whose ethnic group were recorded within their health files, while map B shows the spatial distribution of CKD cases whose ethnic group were not included in their health files.

The spatial distribution of the CKD cases that had their ethnic groups identified in their health files (map A) was found to have a similar spatial distribution with those that did not have their ethnicity indicated (map B) in their health files (see Figure 4.1).

As previously discussed in chapter two, studies have indicated an association between religion and health, which has been found to be generally positive (see section 2.4.6). Although there are still debates on the quality of these research inferences (Sloan and Bagiella, 2001), the inclusion of religion as a variable in this study was to check for any association with CKD. The religious beliefs of the patients were not fully indicated in most of the patients' records, as only 170 patients out of the 357 patients had their religious beliefs documented (see Table 4.5) and a total of 177 CKD cases had no indication of their ethnicity or their religious affiliation within their health records. According to the records, Christians represented 45.4% of the dataset. This is not surprising as Edo state has a high proportion of Christians in relation to the other two religions - the Muslims and traditionalist. This assumption has not been disputed within the state, even though there are no official records to indicate the proportion of religious groups within the state. Attempts at getting an estimate of the proportion of religious groups from past censuses proved unsuccessful, as there was no census data on religion that are made available to the public.

Table 4.5: Religious status of CKD patients in the initial dataset

Religion	Numbers	Percentage
Christian	162	45.4
Muslim	5	1.4
African traditionalist	3	0.8
Unknown	187	52.4
Total	357	100

In regards to the occupational structure of the CKD patients, 10 out of the 357 patients (2.8%) did not indicate their occupational status. The remaining 347 patients indicated that students, which consists mainly of those in the secondary and tertiary institutions, represented the highest number of CKD cases with a total of 61 (17.1%) followed closely by traders with 51 (14.3%). The patients that are retired made up 13.2% with a total of 47. The number of cases registered among the students appeared to be high, because students usually are within the lower age groups as opposed to those that are employed. This is based on the fact that studies have indicated that CKD is more prominent among the older population than the younger age groups (El Nahas, 2005). The results from the CKD dataset indicated that only four students were over 29 years and none was older than 36 years, this raises the question: '*why is the frequency of diagnosed CKD high in this category of people?'* An assumption which applies mainly to those in boarding schools and those in tertiary institutions, is that they had access to free medical check-up at their institutions and they are likely to seek medical help once they felt unwell, which enabled the doctors to identify the disease and refer them to the

hospital for treatment. However, this can regarded as speculations that can only be verified with further studies on the issue.

Table 4.6: Occupational status of CKD patients in the initial dataset

Occupation	Numbers	Percentage
student	61	17.1
trader	51	14.3
retired	47	13.2
business	38	10.6
Civil servant	24	6.7
farmer	23	6.4
housewife	18	5
driver	12	3.4
teacher	10	2.8
pastor	5	1.4
police officer	5	1.4
unemployed	5	1.4
accountant	4	1.1
tailor	4	1.1
brick layer	3	0.8
hair dresser	3	0.8
mechanic	3	0.8
carpenter	2	0.6
musician	2	0.6
nurse	2	0.6
photographer	2	0.6
technician	2	0.6
welder	2	0.6
apprentice	1	0.3
barrister	1	0.3
bike driver	1	0.3
Caterer	1	0.3
clerk	1	0.3
doctor	1	0.3
electrician	1	0.3
engineer	1	0.3
estate agent	1	0.3
journalist	1	0.3
lawyer	1	0.3
lecturer	1	0.3
painter	1	0.3
palace chief	1	0.3
plumber	1	0.3
politician	1	0.3
saw miller	1	0.3
soldier	1	0.3
typist	1	0.3
Unknown	*10*	*2.8*
Total	**357**	**100**

The data on the educational status of the patients were incomplete as only 72 patients had their educational status indicated in their health files (see Table 4.7). This meant that 79.8% of the data was missing.

Therefore, the available educational status of CKD cases within the initial dataset is unlikely to give a true representation of the educational status of CKD patients in Edo State. However, a look at the table showed that there were more patients with a tertiary education while the lowest number of CKD patients was recorded among those without any educational background. This result could be attributed to a number of factors, one of this would be that the level of awareness of CKD is very low among those with no education and as such, they do not come to the hospital until it is too late. This is based on the assumption that the awareness programmes carried out among the general public may not be catering for those with little or no education. This is because the mass media, which is the general form in which information is generally disseminated to the public, is not the best means of disseminating information especially among those who are not educated. A survey by the Nigerian Population Commission (NPC) indicated that a large proportion of the population in the country do not have access to either a radio or television and they rely on other forms of message dissemination like a town crier (NPC, 2005). However, these deductions can only be confirmed with further research studies focusing on the patients' awareness of the disease especially before diagnosis.

Table 4.7: Educational status of CKD patients in the initial dataset

Education	Numbers	Percentage
Unknown	285	79.8
Tertiary education	42	11.8
Secondary education	18	5
Primary education	10	2.8
No education	2	0.6
Total	357	100

4.2.2 The diagnosis variables for the initial dataset of 357 cases

As mentioned in the beginning of the thesis, the study period for this research study was from January 2006 until 14th October 2009. Therefore, in order to analyse the trend of the diagnosis of CKD cases (discussed in section 5.4), the patients' year of diagnosis was included as a variable within the dataset. The frequency of the diagnosed cases within the time period indicate that there was an annual increase in the number of diagnosed cases as indicated in Table 4.8. Even though, data collected for 2009 was not for the whole year, it still registered the highest number of cases (27.7%) in respect to the previous years.

Table 4.8: year of diagnosis for the 357 CKD cases in the initial dataset

Year of diagnosis	CKD cases	percentage
2006	76	21.3
2007	84	23.5
2008	98	27.5
2009	99	27.7
Total	357	100

The referral centres that referred patients to the University of Benin Teaching Hospital (UBTH) were identified using the details on the

CKD patients' health file. These referral centres were classed into their respective categories and this was included as a variable within the dataset (see Table 4.9). A total of 24 referral centres were identified. The addresses of these referral units indicated that most of them are concentrated in Benin City with only three referral units outside the state's capital. Further explanation on the proportion of identified CKD referral centres in relation to the healthcare services available within the state is discussed in more details in chapter seven.

Apart from the 24-referral units identified within the CKD patients' records, there were a number of other medical departments within UBTH that also referred patients to the renal department. According to the results, the highest number of referrals came from the medical departments within UBTH (27.2%) as opposed to the other types of health centres within the state. The renal department within UBTH was however still responsible for diagnosing over half of the cases (53.5%) as these cases had no indication within their records of being diagnosed or referred from another department or health centre. The clinics were found to have the lowest referral rate of 0.8% for the public clinics and 4.2% for the private clinics (see Table 4.9).

Table 4.9: Referral rates of the 357 CKD patients by health centres in Edo State

Type of referral unit	Numbers	Percentage
Not referred / no referral information indicated	191	53.5
Referred from within other departments in UBTH	97	27.2
Referred by a Private Hospital	27	7.6
Referred by a Public Hospital	24	6.7
Referred by Private Clinic	15	4.2
Referred by a Public Clinic	3	0.8
Total	**357**	**100**

In determining the stage of CKD at time of diagnosis for the CKD patients, the information required to calculate their estimated Glomerular filtration rate (GFR) was retrieved from their case files (discussed in chapter three). However, 10 (2.8%) patients did not have all the necessary indicators within their files that were needed to determine their stage of CKD. Their CKD status was only established later on as their treatment progressed. As such, the stage of CKD at time of diagnosis for these 10 patients (2.8%) was classified as "*not indicated*". It was observed that there were no patients with CKD at the first stage. This was expected because of the difficulty in clearly identifying those at that stage. It was also observed that a high proportion of the patients were diagnosed with stage 5 of the disease as opposed to the rest of the CKD stages (see Table 4.10). Patients with stage 5 CKD accounted for 85.2% while the remaining stages only came to a total of 54 patients out of 357 patients. The low number of stage four CKD cases within the dataset appears to indicate an underlying problem that can only be verified with further studies as one would expect that more cases should be diagnosed at this stage

than at the third stage. The high number of stage five cases confirmed that most patients are not diagnosed at the earlier stages, when it is cheaper and easier to treat, and allows more time for interventions that can slow its progress.

Table 4.10: The 357 patients' stages of CKD at time of diagnosis

Stage of CKD	Frequency	Percent
stage 2	10	2.8
stage 3	20	5.6
stage 4	13	3.6
stage 5	304	85.2
Not indicated	*10*	*2.8*
Total	357	100

As mentioned in the previous chapters, studies have shown that the commonest causes of CKD in Nigeria are chronic glomerulonephritis, hypertension, Type 2 diabetes, and toxic nephropathy. Therefore, these four risk factors were included as variables within the dataset.

Table 4.11: risk factors amongst CKD patients in the initial dataset

Diagnosed risk factors	**Chronic glomerulonephritis**	**Diabetes**	**Hypertension**	**Toxic nephropathy**
no	211 (59.1%)	288 (80.7%)	215 (60.2%)	323 (90.5%)
yes	137 (38.4%)	60 (16.8%)	132 (37%)	24 (6.7%)
missing data	9 (2.5%)	9 (2.5%)	10 (2.8%)	10 (2.8%)
total	357 (100%)	357 (100%)	357 (100%)	357 (100%)

The results from the data showed that 38.4% of the CKD patients within the initial dataset had chronic glomerulonephritis while 6.7% had toxic nephropathy (see Table 4.11). While retrieving data from the patients' health files, it was observed that the exact type of Diabetes was not indicated. According to a recent study, about 90% of diabetic CKD patients have Type 2 diabetes (Williams, 2010). The renal

doctors at the renal unit at UBTH confirmed that most of the patients with Diabetes are likely to have Type 2 diabetes, this observation actually tallies with past studies, which showed that the main diabetes found among CKD patients in Nigeria is Type 2 diabetes (Alebiosu and Ayodele, 2005; 2006). However, this is an assumption.

4.2.3 The management variables for the initial dataset of 357 cases

The frequency of dialysis taken by the patients requiring dialysis as stated in their health files indicated that out of the 303 patients needing dialysis (diagnosed with CKD at stage 5 and recommended for dialysis by the nephrologist), 177 did not undergo dialysis while the remaining 126 patients that actually underwent dialysis only had few dialysis sessions.

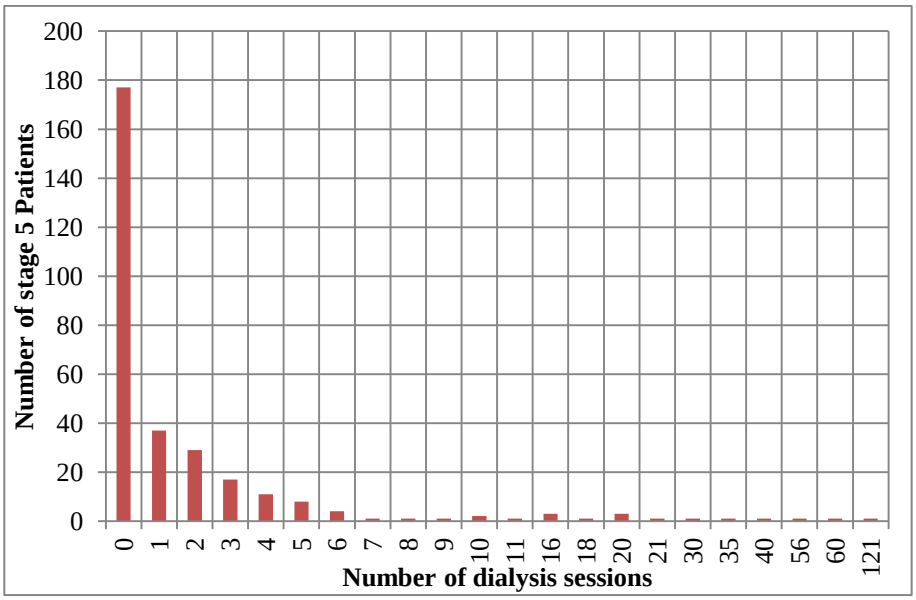

Figure 4.2: the number of dialysis sessions done by stage 5 CKD patients that required dialysis

The highest number of dialysis sessions was 121 and only one patient attempted this before discontinuing the treatment (see Figure 4.2).

Within the initial dataset, three patients with stage 4 CKD had dialysis sessions and according to the renal consultants at UBTH, this was attributed to a lapse in the health of these patients, which resulted in a temporary failure of their kidneys and therefore they required dialysis for a short period. Those patients whose CKD stage was not indicated within their file appeared not to have undergone any dialysis sessions, which may indicate that they are not stage 5 CKD patients or they could not afford to begin the dialysis treatment. However, the former is more likely as some information on the latter would have been indicated in their files. Such information would include the recommendation of dialysis by the nephrologist and also the patient's inability to afford the treatment would be stated as a reason why the dialysis session was not carried out.

Information retrieved from the patients' case files also included their current health status. This indicated whether they were improving, deteriorating, on follow up or deceased. However, 11 patients did not have any current health status on their case files while five patients were confirmed as dead at the time of the retrieval of the data and they had all been stage-5 CKD patients. Only one patient during the time of the research study discontinued treatment, citing both financial and personal reasons for the decision. A summary of the management

outcomes of the CKD patients collected for this study is indicated in Table 4.12.

Table 4.12: Health status of CKD patients in the initial dataset

Health status	Numbers	Percentage
on follow up	313	87.7
improved and on follow up	18	5
unknown	*11*	*3.1*
died	5	1.4
in hospital	5	1.4
discharged and on follow up	2	0.6
Deteriorated and discharged	1	0.3
discharged self from treatment	1	0.3
In poor health but stable and on follow up	1	0.3
Total	***357***	***100***

4.2.4 The spatial distribution of the initial dataset of 357 cases

Most health and human related issues can be viewed within a geographical context. Therefore understanding these issues requires a reasonable understanding of their geography. In order to evaluate the spatial prevalence of CKD within Edo state, there was the need to identify the spatial distribution of the disease.

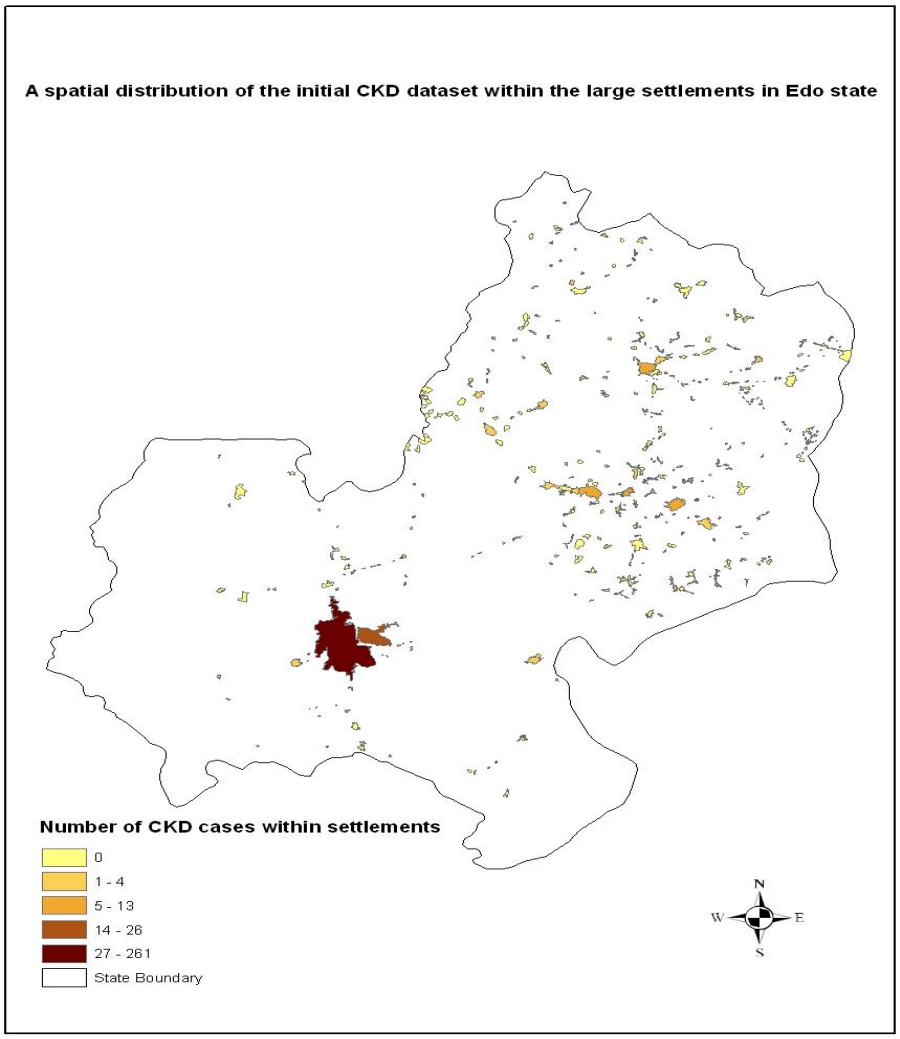

Figure 4.3: Spatial distribution of the 357 CKD patients within the large settlements in Edo State

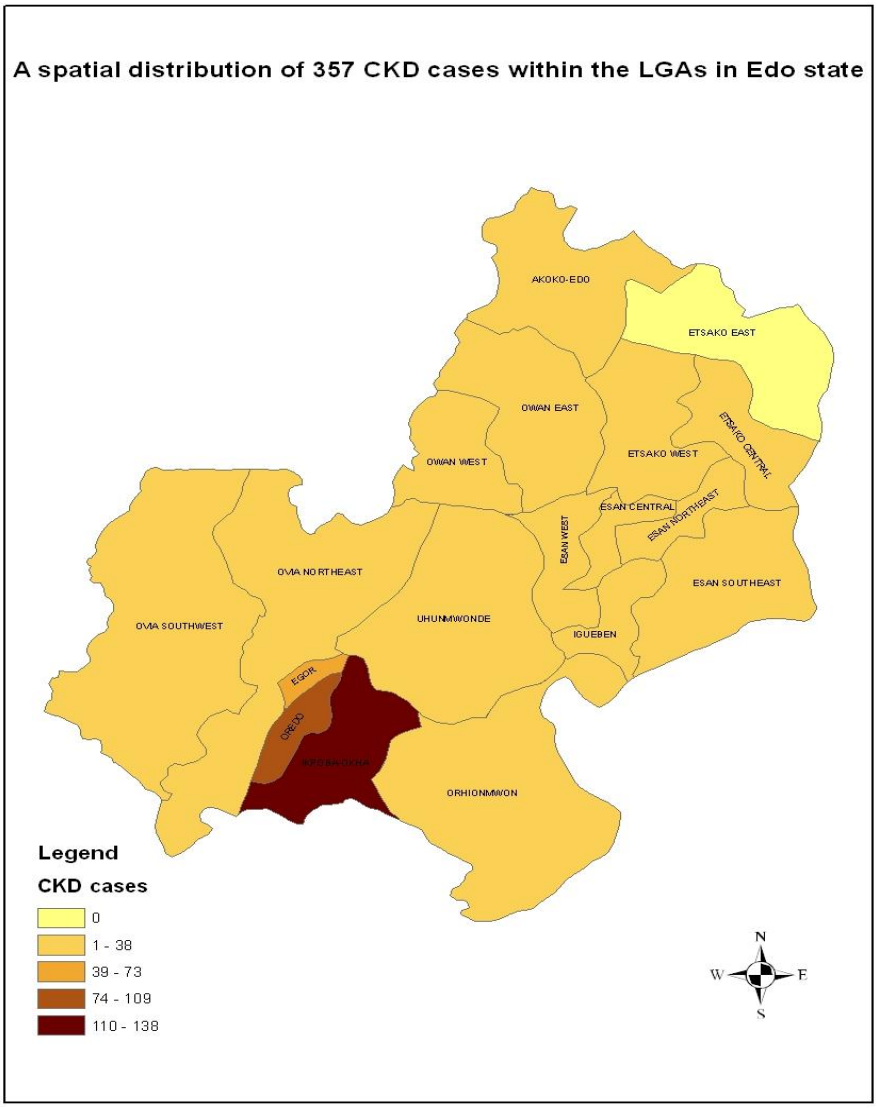

Figure 4.4: The distribution of the CKD patients from the initial dataset across the LGAs in Edo State

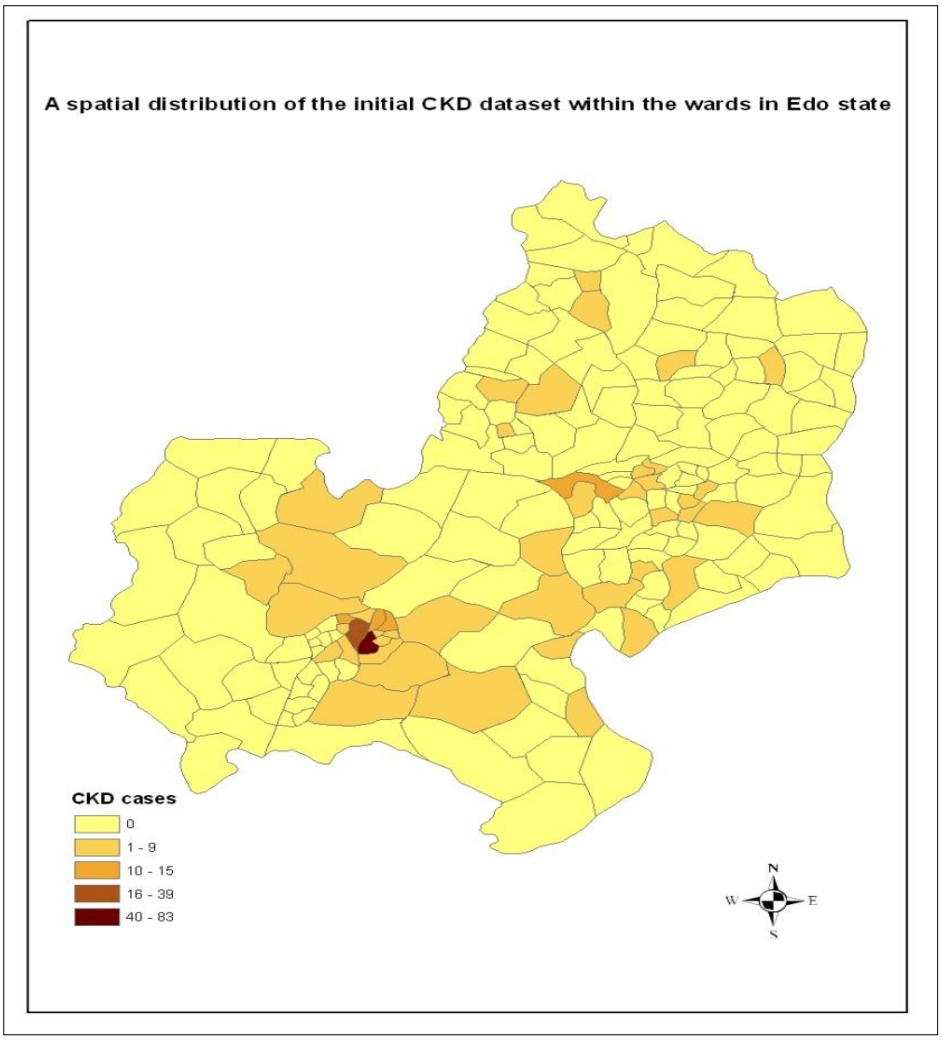

Figure 4.5: The spatial distribution of the 357 CKD cases across the wards in Edo State

To display the spatial distribution of the CKD cases within the state, the location of the CKD cases using their addresses were identified. This enabled their distribution to be aggregated and displayed within the large settlements, their LGAs, and their wards respectively. The natural breaks (Jenks) classification was used to determine a five-class interval. However, the first class interval was manually set to zero in order to identify the areas without diagnosed CKD cases. The first map of the spatial distribution of CKD within the large settlements in the state (Figure 4.3) indicated that most of the CKD patients were

concentrated in the state's capital with a few cases located in smaller towns or settlements around the north eastern part of the state. The settlements displayed on the map (see Figure 4.3), are classified as large settlements, which were projected within the scale of the map, this does not represent the complete distribution of the inhabited areas within Edo State. The spatial distribution of the CKD patients within the LGAs showed that Ikpoba-okha LGA had the highest number of patients (see Figure 4.4). The distribution of CKD cases within the wards showed that Geretti ward had the highest number of patients (see Figure 4.5). It should be noted that these were all urban areas with very few CKD cases registered in the rural areas. However, this pattern might be an indication of the first order-effect due to the underlying population as urban areas are more populated than the rural areas. It can also be argued that the higher number of diagnosed CKD cases within the urban areas might be attributed to the poorer screening practices noted among nephrologists and physicians, which may be more emphasized in the rural areas, which has no registered nephrologists. According to a nationwide research study on self-reported screening [24] amongst nephrologists in Nigeria, it was discovered that self-reported screenings among the nephrologists were very poor as only 12.7% had ever estimated their glomerular filtration rate (GFR) (Agaba et al., 2009). This poor practice of self-screening among nephrologists might also be transferred to the services the

[24] The self-reported screening study was a cross-sectional study of Nigerian nephrologists in order to determine the nephrologists that had ever got themselves screened for CKD and its known risk factors

nephrologists and physicians give their patients. Particularly those physicians located in rural areas, as they might not routinely screen their patients for CKD until it is too late.

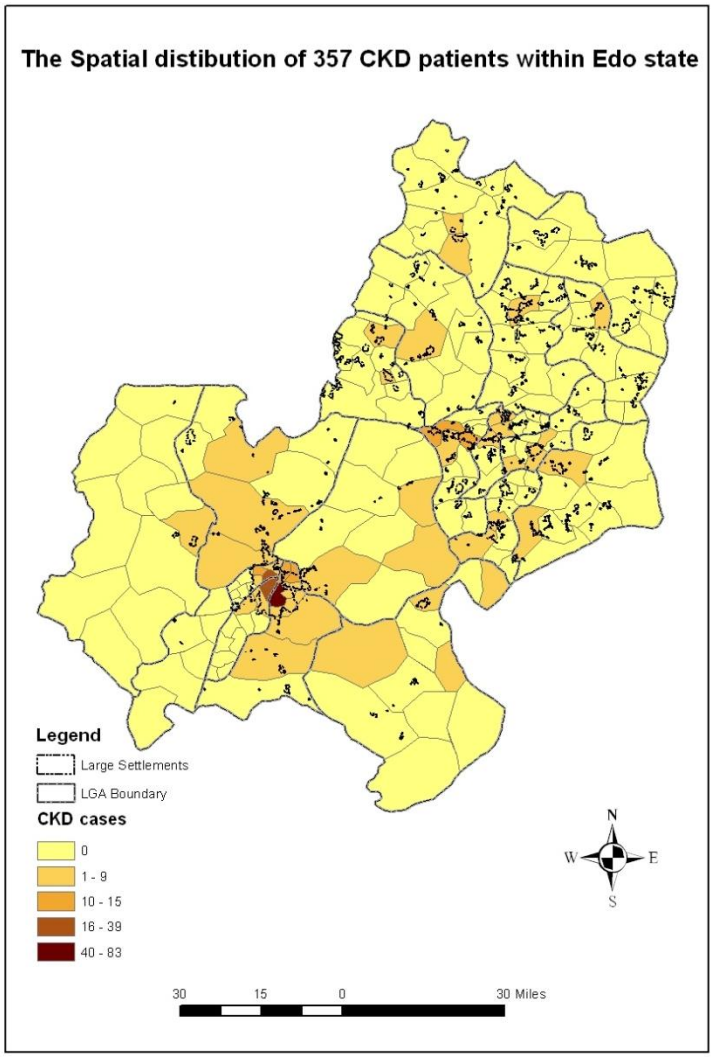

Figure 4.6: The distribution of the 357 CKD cases within each ward and their associated LGAs along with the location of the large settlements in Edo state

The spatial pattern of the distribution of CKD visually displayed across the map of Edo State appears to indicate that the highest concentration of the disease is within the state's capital (see Figure 4.6). However, other factors need to be taken into account about the current spatial distribution of CKD within the state before any

meaningful conclusions can be made. A factor that should be taken into consideration is the issue of distance to the hospital as this might have an impact on the actual number of patients that actually go to the hospital to undergo treatment from other areas within the state. This assumption was examined further in chapter seven. There is also the possibility that some residents that already have CKD may not have been referred by their local health centre to UBTH for treatment. Another assumption might be that residents located in rural areas are not coming forward for treatment as they might be using alternative treatments from their local vicinities. In order to verify these assumptions, further investigations have to be carried out on CKD patients within the state, as this cross sectional study is unable to verify most of these assumptions due to the limited information that can be derived from patients' health files.

4.3 Descriptive statistical profile and spatial distribution of the subsequent dataset

As mentioned earlier, not all the CKD cases from Edo state that were diagnosed between 2006 and 2009 in UBTH could be included in the dataset that was used for this research study and this was because the case files for some of the patients could not be located. To discover if there was any systemic bias on why some files were missing during the collection of the initial dataset, there was the need to compare the results with a similar dataset. Since UBTH was currently the only tertiary hospital that managed CKD cases in Edo state, it was therefore necessary to attempt to locate as many as possible of the missing case

files that were not included in the initial dataset. The health files for a total of 92 cases were located and the required data were retrieved. However, after sorting through the data collected, and removing any duplicated CKD records as well as those that did not reside within Edo state, they finally came to a total of 85. The edited database containing the 85 CKD patients is examined in order to check for similarities in the sex, age, proportion of the stages of CKD at the time of diagnosis, and the geographical distribution of the CKD cases generated for the 357 CKD patients. The other socio-demographic variables included within both the initial and subsequent datasets were not discussed in this section due to the missing data originally registered within the initial dataset.

4.3.1 The socio-demographic variables for the dataset of 85 CKD cases

The result on the proportion of males and females with CKD within this dataset indicated that a total of 51 patients were males while 34 were females. This meant that 60% of the data consisted of males while the remaining 40% were females. As a result, the ratio of male and female CKD patients was 1.5:1. The CKD distribution between the sexes within this data appeared to validate the CKD distribution of the previous dataset of 357 patients (see Table 4.1). This is because both datasets indicated that nearly twice the numbers of males than females were diagnosed with CKD. In order to verify the similarities within both datasets, a *t*-test was used to compare the sex variable in both datasets. This test failed to reveal a statistically reliable

difference between the mean number of males and females from the initial CKD dataset (mean = 1.6, SD = 0.5) and the subsequent dataset (mean = 1.6, SD = 0.5; t (440) = 0.9, p = 0.4). This therefore meant that the variability of the sex variable within both datasets were approximately equal or similar.

The mean age of the patients that were included in the subsequent dataset was 47 years (see Table 4.13). The age and sex of the subsequent dataset showed that their distribution is not so different from the result for the distribution of the sex and age of the 357 CKD patients (see table 4.2). There was a difference of 2.1 years between the mean age of the subsequent dataset and the initial dataset of 357 CKD patients, while the difference between their standard deviation was 0.2. Furthermore, a *t*-test failed to reveal a statistically reliable difference between the mean age from the initial CKD dataset (mean = 45.3, SD = 17.2) and the subsequent dataset (mean = 47.1, SD = 17.7; t (438) = 0.9, p = 0.4). This therefore meant that there was no significant difference between the mean age in each dataset.

Table 4.13: the mean age of both male and female CKD patients in the subsequent data

Sex	Number of cases	Mean Age	Std. Deviation
male	51	47.4	17.9
female	34	46.7	17.6
Total	***85***	***47.1***	***17.7***

4.3.2 **The diagnosis variables for the dataset of 85 cases**

The stage of CKD for the patients within this dataset showed that most of the patients had stage 5 CKD at the time of their diagnosis accounting for 60% of the patients, followed by stage 3 CKD with 21.2%, while stage 4 CKD accounted for 16.5% and stage 2 CKD had the lowest with 2.4% (see Table 4.14). The distribution of the stages of CKD at the time of diagnosis among the patients shows a similar pattern with the results generated among the 357 patients. These similarities appear to indicate that the distribution of the stages of CKD at time of diagnosis among the CKD patients within Edo state may actually follow the same pattern because CKD cases with stage 5 accounted for the highest number followed by stage 3, then stage 4 and finally stage 2 CKD. Similar to the results from the initial dataset, the number of cases that were diagnosed at stage 4 of the disease was equally lower than expected. This seems to raise more questions than answers, which further highlights the need for an extensive study on CKD diagnosis practices within Edo state focusing particularly on the reason(s) behind the frequency of CKD cases diagnosed at stage 4.

Table 4.14: A comparison of the diagnosed stages of CKD for the 85 CKD cases and the 357 CKD cases in the initial dataset

85 CKD cases			**357 CKD cases**		
STAGE OF CKD	**Numbers**	**Percentage**	**STAGE OF CKD**	**Numbers**	**Percentage**
Not indicated	0	0	**Not indicated**	10	2.8
stage 2	2	2.4	**stage 2**	10	2.8
stage 3	18	21.2	**stage 3**	20	5.6
stage 4	14	16.5	**stage 4**	13	3.6
stage 5	51	60	**stage 5**	304	85.2
Total	**85**	**100**	**Total**	**357**	**100**

4.3.3 The spatial distribution of the dataset of 85 cases

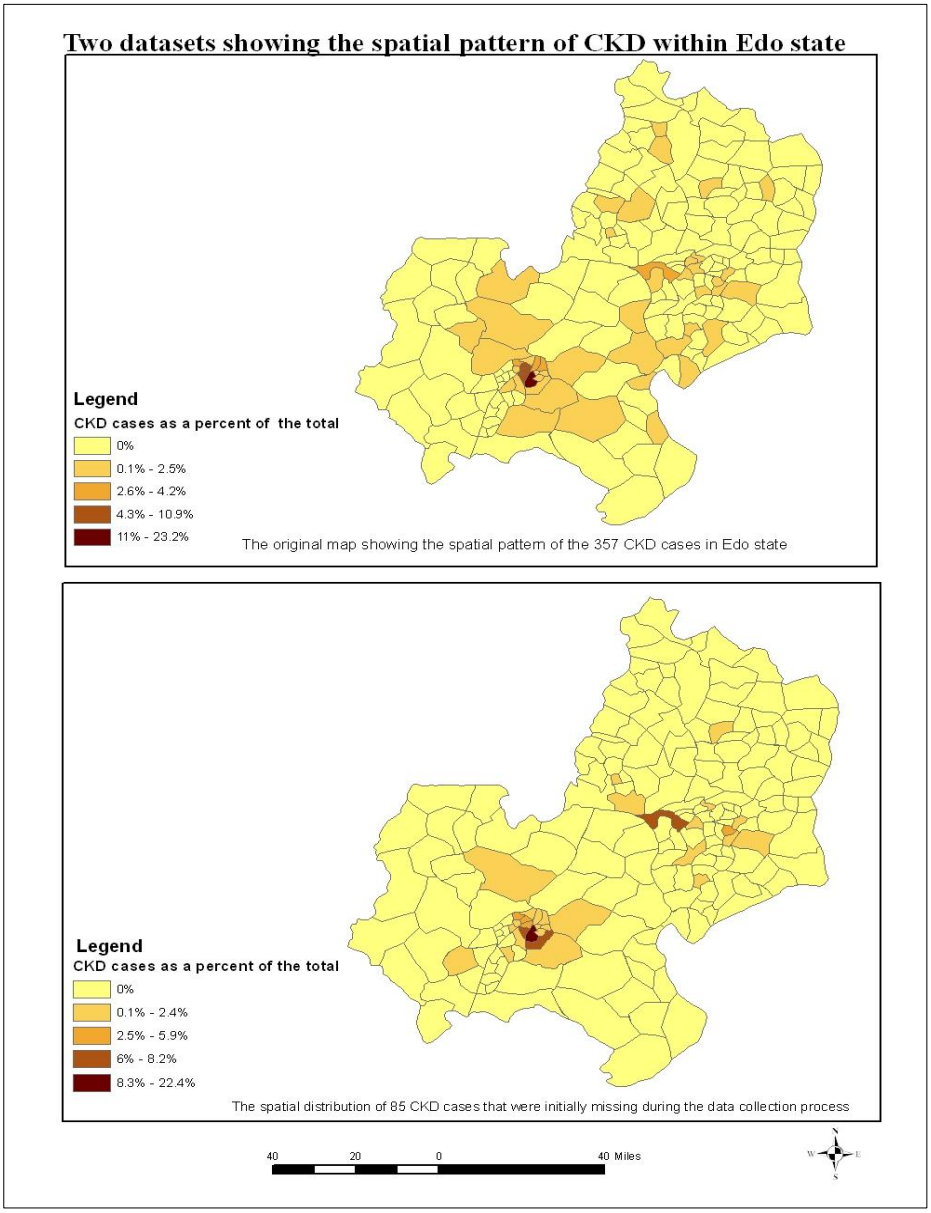

Figure 4.7: Spatial pattern of CKD within Edo state using both the original dataset of 357 cases and the subsequent dataset of 85 cases

Although the map containing the distribution of the 85 CKD patients had a smaller proportion than the original map that had 357 patients, there were still similarities in the spatial distribution of CKD within the state (see Figure 4.7). The Geretti ward located within Ikpoba Okha LGA had the highest number of cases in both maps, with majority of the cases located around the south western part of the

state, which is within and around Benin City, the state's capital. It was observed that the wards away from the state's capital that had relatively high numbers of cases compared to their surrounding wards in the initial dataset were equally represented in the map created using the subsequent dataset namely Ekpoma, and Auchi wards respectively.

In summary, it can be argued that the variables collected from the 85 cases, which were used as a subsequent dataset validates the original dataset of 357 cases. This is because there were no significant differences that existed between the initial dataset and the subsequent dataset when comparing the variables of the CKD patients within both datasets.

Therefore, there is the likelihood that the variables within the initial dataset represented a good profile of the CKD patients in Edo state.

4.4 Descriptive statistical profile of the combined dataset

The initial dataset of 357 cases and the subsequent dataset of 85 cases were combined to create one dataset of 442 cases used in later analyses. The analyses of the spatial pattern of the combined dataset are discussed in details in subsequent chapters (see chapter six and chapter seven).

4.4.1 The Descriptive analysis of the socio-demographic variables for the combined dataset of 442 cases

As previously mentioned in chapter two, studies have shown that socio-demographic factors, such as sex, age, marital status, education,

income, ethnicity, occupational class, and religion are closely associated to the health outcome of an individual (see section 2.4).

It is therefore no surprise that the study of CKD across the globe has some of its focus on the socio-demographical profile of the patients (see Lewis, 2008; Neild, 2010).

4.4.1.1 *Sex and CKD in Edo state*

Results from the combined dataset of the 442 CKD cases used in this research study showed that 63.1% of the cases were males while the remaining 36.9% were females (see Table 4.15). This result appear to be consistent with literature that indicates the possibility of sex bias in healthcare where males are more likely to be diagnosed and ultimately receive treatment for CKD than females (see Ulasi, 2008).

Table 4.15: Frequency of CKD between male and female patients within the combined dataset

Sex	Numbers	Percentage
Male	279	63.1
Female	163	36.9
Total	442	100

4.4.1.2 *Age group and CKD in Edo state*

In respect to the association between age and CKD in Nigeria, one must take into account the life expectancy in the country, which is currently lower than most developed countries and even some developing countries. The nation's life expectancy is currently estimated at 46.9 years and ranked at 216 in comparison to other nations in the world (CIA, 2010). Therefore, it is expected that after a certain age, there should be a decline in the frequency of CKD

amongst the age group as there are a lower number of people that reach that age group.

The results from the data indicated that the mean age of the patients that were included in the study was 45.7 years. The mean age for the male patients was approximately 46.6 years while the female patients' mean age was 43.9 years. The result appears to be similar to previous studies in Nigeria, which indicated that the prevalence of CKD was higher among the ages between thirty years and fifty years (Akinsola et al., 1989; Alebiosu, 2001; Salako et al., 2002).

For the purpose of future comparison of the profile of CKD cases within the state with other studies that might be associated with the Nigerian census or any other similar population study, the ages of the patients were grouped using a 5-year band. It should be noted that the use of the 5-year band was only used for the evaluation of the profile of CKD cases within this chapter. Since, there were no registered cases of patients below 10 years within the dataset; the age group began from 10 years to above 85 years. This resulted in a total of eight age groups. A total of 440 patients (99.6%) had their age registered within their health records. Only two cases had no indication of their age or date of birth within their health files.

Table 4.16: Number of CKD cases across the age group of the 442 patients

National classified age group	Numbers	Percentage
10-14	3	0.7
15-19	22	5
20-24	30	6.8
25-29	41	9.3
30-34	38	8.6
35-39	41	9.3
40-44	34	7.7
45-49	43	9.7
50-54	39	8.8
55-59	37	8.4
60-64	42	9.5
65-69	32	7.2
70-74	14	3.2
75-79	14	3.2
80-84	6	1.4
85+	4	0.9
Total number of patients with a known age group	440	99.6
Missing cases	2	0.5
Total CKD cases	442	100

The frequency of CKD cases among the age groups showed that there was not much variability from 25-69 years until it got to those patients who were above 70 years then there was a steady decline in the frequency of CKD within the remaining age groups. The age group of 45 years to 49 years had the highest number of CKD cases accounting for 9.7%, while the age groups with the lowest were the age group 10-14years with 0.7% and the patients above 85 years with 0.9% (see Table 4.16). This result indicates that a considerable number fell within the working age population. Apart from the age groups below 20 years and patients above 69 years, the frequency of CKD cases did not appear to vary too much across the age categories as the highest frequencies ranged between 6.8% and 9.7%.

4.4.1.3 *Marital status and CKD in Edo state*

Married patients accounted for the highest number of cases (79.9%). This result appears to support previous studies mentioned in section 2.4.3, which indicated that more married patients are more likely to seek out treatment than the unmarried CKD patients because they have the support of their spouses (Bapat et al., 2008). As a result of the support of their spouses, they are more likely to seek out and accept treatment in order to increase their chances of survival.

The marital status variable is further tested and discussed in the next chapter to determine whether there was any significance between the marital status of a patient and its association with the severity of CKD at time of diagnosis.

Table 4.17: Frequency of marital status for the 442 CKD cases

marital status	Numbers	Percentage
Married	353	79.9
Single	86	19.5
Widowed	2	0.5
Divorced	1	0.2
Total	**442**	**100**

4.4.1.4 *Ethnicity and CKD in Edo state*

There are approximately 250 ethnic groups within Nigeria (CIA, 2011). As discussed in section 2.4.5, there have been several studies on the association between racial groups and CKD (See Atkinson et al., 2010; Filler et al., 2010; Kramer et al., 2008). Yet, there has not been any known study on the prevalence of CKD among ethnic groups or tribal groups (as they are commonly called in Nigeria) of the

same racial descent within Africa and particularly within Nigeria. This has been compounded further by the absence of ethnicity data from the Nigerian census. According to the results, the Bini ethnic group had the highest proportion of CKD cases with 28.5% of the 442 cases, followed by the Esan ethnic group with 12.4%. The Igbo and Etsako ethnic groups both had a proportion of 4.1% and 2% respectively (see table 4.18). The origin of both the Bini and the Esan ethnic groups are predominantly located in urban areas. One could argue that the ethnic groups located within urban areas are more likely to be aware of the prevalence of CKD because of the CKD awareness programmes that are made available via the mass media in these areas. This observation is based on the assumption that the ethnic groups are residing in their area of origin however, this might not ring true in all cases, as there are some ethnic groups whose area of origin are not located within Edo state even though they reside in Edo state such as the Igbo, and Akwa-Ibom ethnic groups. To analyse the distribution of CKD across all the ethnic groups that were identified within the dataset, the ethnic groups were classified into five groups based on their area of origin. These were the ethnic groups located in the north eastern region of the state, those located in the north western region, the ethnic groups from the south western region, and the ethnic groups from the south eastern region of Edo state. The fifth group were the ethnic groups whose areas of origin are outside Edo state. The table below shows what region the ethnic groups were classified into and the frequency of CKD within these regions (see Table 4.19). The south eastern region,

which is predominately occupied by the Bini ethnic group, had the highest CKD frequency with 28.5% followed by north western region with 12.7%. As there are no previous studies to compare the distribution or prevalence of CKD among local ethnic groups especially within Nigeria as well as the absence of population data for the ethnic groups, this result can only be regarded as a baseline for further study on ethnicity and the prevalence of CKD within a Nigerian state.

Table 4.18: Frequency of the 442 CKD cases across the ethnic groups

Ethnic groups	Numbers	Percentage
Missing data	185	41.9
Bini	126	28.5
Esan	55	12.4
Igbo	18	4.1
Etsako	9	2
Urhobo	8	1.8
Yoruba	8	1.8
Ika	5	1.1
Ora	4	0.9
Akoko-edo	3	0.7
Isoko	3	0.7
Afuze	2	0.5
Agbor	2	0.5
Auchi	2	0.5
Owan	2	0.5
Afemai	1	0.2
Akwa-Ibom	1	0.2
Ibillo	1	0.2
Ibie	1	0.2
Igarra	1	0.2
Ijaw	1	0.2
Irrua	1	0.2
Itsekiri	1	0.2
Unmima-fuga	1	0.2
Warake	1	0.2
Total	442	100

Table 4.19: The distribution of the 442 CKD cases within the reclassified ethnic groups

Region	Ethnic groups	Number	Percentage
South-eastern	Bini	126	28.5
North-western	Esan, Irrua	56	12.7
outside Edo state	Warake, Akwa-Ibom, Ijaw, Agbor, Isoko, Ika, Igbo	31	7
Northeastern	Afemai, Owan, Akoko-edo, Etsako, Afuze, Unmima-fuga, Igarra, Ibillo, Ibie, Ora, Auchi	27	6.1
Southwestern	Urhobo, Itsekiri, Yoruba	17	3.8
missing data		*185*	*41.9*
total		***442***	***100***

4.4.1.5 *Religion and CKD in Edo state*

The religious beliefs of the CKD patients were not fully indicated in many of the patients' records, as only 57.7% out of the 442 patients had their religious beliefs indicated in their health files (See Table 4.20). According to the records, Christians represented 55.7% of the data set while only 0.7% of the CKD cases were regarded as African traditionalists.

Table 4.20: Frequency of the 442 CKD cases among the three main religions in Edo state

Religion	Numbers	Percentage
Christian	246	55.7
Muslim	6	1.4
African traditionalist	3	0.7
Missing Data	187	42.3
Total	**442**	**100**

4.4.1.6 *Occupation and CKD in Edo state*

In analysing the occupational status of the 442 CKD patients, the various occupations were classified into seven classes. The specialized jobs that usually required a tertiary degree or a higher qualification were classified as the professional occupation and these included

doctors, lawyers, and engineers. The next class were the semi-professionals including nurses, technicians, and also businessmen/businesswomen. The reason why business was included within this category is due to the general assumption that entrepreneurs are generally classified as businessmen/businesswomen and not entrepreneurs at least within the Nigerian context (Schatz, 1977). The next category were the non-manual workers and these were the people that require little or no level of specialization but were not manual labour intensive in their occupational skills. These included clerks, hairdressers, musicians, and petty traders. A petty trader, in this context, ranges from a person that sells small items using just a table and a chair while under a small shade to a small shopkeeper that sells a variety of little items, which are mainly needed for everyday use in a home. This occupational category does not require the person to have a tertiary education or a similar degree to qualify to work within this group. The next category was the manual workers. Jobs within this category included farmers, cleaners, drivers, and bricklayers.

The next three categories are separated from the previously mentioned occupational categories, as they do not fall within any of those categories. The first of this unique category were the students. The student category, which ranges from primary school pupils to tertiary students are full-time students and they do not work part-time. This assumption was based on the fact that such jobs were not mentioned within their health files and although it might not be the case as some

might have had part-time jobs, there was nothing to support that prospect. The second unique category was the retired patients, the majority of which had attributed their retirement to old age. All of these within the retired category were above the age of 50 years. The last category within this group was the unemployed, these were the patients that were looking for employment before they became ill and could not work. This category also included full-time housewives because both the employed and unemployed patients that had families (spouses and or children) also have the similar responsibilities of the full-time housewives (Whooley et al., 2002). These last three categories (i.e. the students, retired and unemployed) are often excluded in occupational classification resulting in an underestimation of socio-economic differences within a population (Galobardes et al., 2007; Martikainen and Valkonen, 1999). The distribution of CKD patients within the various occupational categories indicated that the highest proportion of cases were among the semi-professionals with 25.1%, followed by the non-manual workers with 20.6% of all the CKD cases, the students constituted 16.1%, while the professionals had the lowest with 2.5% of the cases (see Table 4.21). It should be noted that 2.3% (10 patients) of the cases did not have their occupational status registered in their health files.

In order to determine whether the diagnosed patients are either a genuine cross-section of the population in Edo State or are disproportionately drawn from the more affluent parts of that society, the socio-economic profile of diagnosed CKD patients was compared

to that of the wider population. The outcome for this is potentially very useful as it allows insight into how widespread access to CKD diagnosis and treatment is within the state, which has major implications on how the later results can be interpreted, as well as any potential policy implications arising from them. However, it was not possible to compare the socio-economic profile of diagnosed cases to that of the state population as there were no state level socio-economic data. Instead, the socio-economic profile for Nigeria was compared with the diagnosed CKD dataset.

A comparison of the socio-economic group for diagnosed CKD patients with the national socio-economic group indicated that the diagnosed CKD patients might be disproportionately drawn from the affluent group in the society. According to the Federal Office of Statistics (2002), 59% of the Nigerian working population were employed in agricultural and other manual jobs however, approximately 15% of diagnosed CKD patients were manual workers and while 16% of the Nigerian working population were employed in white collar occupations, 27.6% of the CKD patients were in 'professional/semi-professional' jobs. The question that rises from this is '*whether CKD is unusually prevalent among affluent groups or whether differential access to healthcare is a factor underlying the disproportional over-representation of the most affluent socio-economic groups within the diagnosed CKD dataset?*' I would argue the latter because there is currently no substantial evidence that

indicates that the prevalence of CKD is higher among those with a higher socio-economic status (see section 2.5.4).

It can also be deduced from the results of the occupational groups for the CKD dataset that a significant number fell within the potential working population as well as the present working population and this may have an impact on the future of Nigeria's economy. This tallies with a similar argument presented in a report on the likely impact of CKD on the economy of the country by the nation's Kidney Consultants (Kidney Consultants International, 2007). They argued that if the prevalence of CKD were left unchecked, there would be a significant impact on the nation's future as a considerable number of CKD cases were diagnosed among the working population in Nigeria.

Table 4.21: Frequency of 442 CKD cases across the occupational groups

Occupational Status	Numbers	Percentage
Semi-Professionals	111	25.1
Non-manual workers	91	20.6
Students	71	16.1
Manual workers	64	14.5
Retired	57	12.9
Unemployed	27	6.1
Professionals	11	2.5
Missing cases	10	2.3
Total number of CKD cases	***442***	***100***

4.4.1.7 *Educational level and CKD in Edo state*

As discussed in section 2.4.4, the educational level of an individual is one of the commonly used measures for accessing his/her socio-economic status. A number of studies have indicated that the socio-economic status of an individual is a significant determinant of health in an individual.

The frequency of CKD among the various educational levels indicated that the highest number of CKD cases was found among patients with a tertiary education (16.1%) while the lowest number of CKD cases was registered among those without any education (1.4%). However, the result of the CKD distribution among the various educational levels is based on only 35.5% of the patients as 64.5% of the patients did not have their educational status registered in their health files.

Table 4.22: Frequency of CKD across the educational levels of the 442 patients

Educational status	Numbers	Percentage
Tertiary education	71	16.1
Secondary education	54	12.2
Primary education	26	5.9
Uneducated	6	1.4
Total number of patients with a known educational status	***157***	***35.5***
missing data	285	64.5
Total CKD cases	**442**	**100**

4.4.2 Descriptive analysis of the diagnosis variables for the combined dataset of 442 cases

In the midst of increasing emphasis on the early detection of diseases especially for chronic diseases, studies have shown that early detection of chronic diseases such as cancer (Wulfkuhle et al., 2003) as well as CKD (Locatelli et al., 2005) can help improve the survival rate of the patients. The search is currently on for reliable ways that will be helpful in the early diagnosis of diseases. As mentioned earlier, the diagnosis variables in this study were the variables that were related to the diagnosis of CKD at the time the patient was first diagnosed with the disease at UBTH.

4.4.2.1 *Frequency of diagnosed CKD cases from 2006 to 2009*

The prevalence of CKD within Nigeria is not a new development as there have been noted studies of the disease that date back to over two decades such as the study by Akinsola et al (1989) in which they carried out a prospective study on the risk factors associated with CKD in Nigeria. However, as previously mentioned in chapter one, it is only recently that there has been an attempt at a nation-wide awareness campaign to tackle the issue of CKD in Nigeria. In order to examine the annual count of CKD within the state, the total number of cases for each year between 2006 and 14th October 2009 were collected and assessed. The results showed that there was a steady increase in the total number of cases each year with the highest registered number of cases in the year 2008 (see Table 4.23). However, it should be stated that the total number of cases in 2009 is not for the whole year; therefore, there is a probability that the total number of cases for the beginning of 2009 to the end of 2009 might be more than the total number of cases registered in 2008. The variable was further analysed for any association with the severity of CKD at time of diagnosis and a time series analysis was carried out in order to examine the trend of diagnosed CKD cases within the study period (discussed in chapter five).

Table 4.23: The annual frequency of the 442 diagnosed CKD cases from 2006 - 2009

Year of Diagnosis	Numbers	Percentage
2006	92	20.8
2007	108	24.4
2008	126	28.5
2009	116	26.2
Total	**442**	**100**

4.4.2.2 *Stage of CKD at time of diagnosis*

The results indicated that the number of cases diagnosed at the last stage of the disease greatly exceeded all the cases that were diagnosed at the earlier stages of the disease. The high number of diagnosed cases at the last stage of CKD supports previous studies that have indicated that a high number of CKD cases were diagnosed at the late stage within Nigeria (discussed earlier in chapter one). This highlights the burden of CKD in Nigeria given the fact that late diagnosis of CKD is more expensive to treat and unaffordable by majority of the population.

Table 4.24: The stage of CKD at time of diagnosis for the 442 patients

Stage of CKD	Numbers	Percentage
stage 2	12	2.7
stage 3	38	8.6
stage 4	27	6.1
stage 5	354	80.1
missing data	11	2.5
Total number of cases with registered stage of CKD	**431**	**97.5**
Total number of CKD cases	442	100

4.4.2.3 *Biological Risk factors and CKD in Edo state*

For the purpose of this study, four main biological risk factors were included in the analyses of the variables that were collected from the health files of the CKD patients: hypertension, chronic glomerulonephritis, diabetes, and toxic nephropathy. According to the

nephrologists at UBTH, these risk factors were determined either before the patients developed CKD or after an extensive examination. None of the patients that were diagnosed with toxic nephropathy as a risk factor had a predated record of the risk factor before their diagnosis of CKD. This could be attributed to the possibility that the risk factor was identified only after the exclusion of the other three risk factors in an attempt to determine the cause of the disease. According to their health files, toxic nephropathy was recorded as a risk factor after it had been confirmed that the patient had a history of self-medication (such as drugs to relieve pains or reduce fever) and/or used traditional medications. Further tests were sometimes carried out to confirm the presence of the disease but the full details were not disclosed within their health files. The diagnosis of chronic glomerulonephritis as a risk factor among the CKD patients was similar to how those with toxic nephropathy were diagnosed with CKD. This was because most of the CKD patients diagnosed with chronic glomerulonephritis as the cause of the disease were diagnosed about the same time that they were diagnosed with CKD. Chronic glomerulonephritis was identified as a probable cause after the symptoms were examined and then confirmed as the cause of CKD within a patient after urine test had indicated the presence of protein and blood. In some cases, an imaging test of the kidney using X-rays or ultrasound scanning was done before chronic glomerulonephritis was confirmed as the cause of CKD within the patient. Although kidney biopsy is one of the ways of confirming the presence of the

disease as discussed in chapter two, this procedure was not carried out because the hospital did not have access to the necessary facilities needed for the procedure.

There were approximately fifteen other biological risk factors recorded within the CKD health files however, most of them were diagnosed along with the four main biological risk factors and were classified as secondary causes of CKD within the health files of such patients. Some of these other biological risk factors were diagnosed as primary causes of CKD in some patients but the frequency of these risk factors within the dataset was small. Fourteen of these risk factors were included as primary causes of CKD among some of the patients and these were a total of 11.1% of all the risk factors documented within the dataset. A total of 20 CKD cases had no documentation within their health files that identified any biological risk factor as the cause of CKD (see Appendix C). It was observed that most CKD cases had more than one risk factor attributed to their development of CKD. A total of 15 CKD cases had three biological risk factors documented within their health files as possible causes for their development of CKD. In situations where a patient had more than one of the risk factors diagnosed and identified as the probable cause of CKD and none of these risk factors was identified as the primary cause, each of these risk factors was counted and included in the database. This resulted in the frequency of the documented risk factors exceeding 442 cases. Appendix C shows the actual distribution of all

the risk factors documented within the health files of the CKD patients.

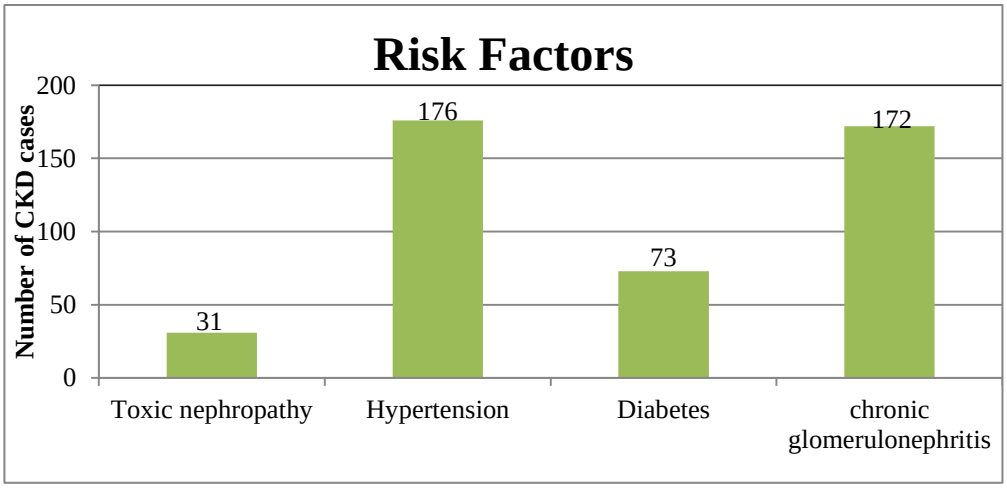

Figure 4.8: Bar chart showing the distribution of risk factors among the 442 CKD patients

The distribution of the biological risk factors among the 442 diagnosed CKD cases showed that hypertension had the highest frequency amongst the CKD cases with 39.8% while toxic nephropathy was present in just 7.01% of the cases (see Table 4.25 and Figure 4.8). This result, which shows hypertension as the main risk factor present in CKD patients, also corresponds with past studies that have been carried out on the association between biological risk factors and CKD and they have all identified hypertension as a major risk factor of CKD (Laliberte et al., 2009; Muntner et al., 2010; Sabanayagam et al., 2010).

Table 4.25: The distribution of biological risk factors present in CKD patients

Diagnosis	Toxic nephropathy	Hypertension	Diabetes	chronic glomerulonephritis
Missing Data	10 (2.3%)	10 (2.3%)	9 (2.0%)	9 (2.0%)
No	401 (90.7%)	256 (57.9%)	360 (81. 5%)	261 (59.1%)
Yes	**31 (7.0%)**	**176 (39.8%)**	**73 (16.5%)**	**172 (38.9%)**
Total	442 (100%)	442 (100%)	442 (100%)	442 (100%)

In relation to the presence of toxic nephropathy as a risk factor, all of the CKD cases diagnosed with toxic nephropathy gave reasons related to the accessibility and affordability of health care services as the reason for their use of traditional treatments (Kadiri et al., 1999; Ojogwu and Anah, 1983).

4.4.2.4 *Referral centres and CKD in Edo state*

There is a general agreement about the importance of early referral to the nephrologist and predialysis educational programmes because this strategy prevents the progression and complications of renal disease (Triolo and Savoldi, 2008). However, studies have shown that the awareness of the disease amongst the general public (Vassalotti et al., 2010) as well as some medical professionals (Agaba et al., 2009) is rather low and as such there are incidences where the disease is not diagnosed until it gets to the late stage when it becomes both difficult and expensive to manage. The inclusion of the referral centres that indicate the proportion of cases referred from the various health care services in the state can be crucial in identifying the referral process of CKD patients in the state.

To analyse the number of referrals, it was necessary to identify the number of healthcare services that actually referred the patients within the study period to UBTH to confirm their diagnosis as well as receive treatment for the disease. Out of the 442 cases, 251 patients (i.e. 56.8%) were referred to the renal department in UBTH for treatment. However, 33% came from other departments within UBTH (see Table

4.26). Both the private and public clinics had the lowest CKD referrals to the renal department accounting for 4.5% and 0.7% respectively. The result indicated a low number of referrals of CKD cases among the healthcare centres within the state. One hundred and ninety-one cases had no indication of being referred from another health centre within their health files as they were likely diagnosed by the renal unit after they arrived in the hospital for an underlying symptom or illness. The result is similar to a previous study done in another state within Nigeria that identified the problem of poor referrals of CKD patients to nephrologists for treatment (Alebiosu, 2001). A plausible reason for the low number of referrals from the health centres could be due to a poor awareness of CKD among the health practitioners within these healthcare centres. Although there is not enough evidence to support this argument, this result might support the comments made by the nephrologists at the renal department during informal discussions with them while collecting my data and following them during their clinical rounds. They suggested that medical practitioners should be made more aware of the effect of CKD on the general public. They stated that although there has been an increase in the referral rates of CKD patients with early stages of CKD from other hospitals, they still believed that most health centres within the state especially those in the rural areas still need to be informed about how to effectively identify CKD at its early stages.

Table 4.26: Proportion of health centres that referred cases to the renal department in UBTH

Referral centre	Number	Percentage
Not referred / diagnosed by the renal unit	191	43.2
Within UBTH	146	33
public Hospital	43	9.7
private hospital	39	8.8
private clinic	20	4.5
public clinic	3	0.7
Total number of referred cases	***251***	***56.8***
Total number of cases	**442**	**100**

4.4.3 The descriptive analysis of the management variables for the combined dataset of 442 cases

The management variables refer to the various factors that contributed to the management of the CKD cases. These included the number of dialysis sessions taken by the patient (when it was applicable) and the health status of the patient at the time the data was collected for the study.

4.4.3.1 *Number of dialysis session among the 442 CKD patients*

The number of dialysis sessions done by the patients were grouped into three categories, beginning with the group of patients that never had any dialysis session, those that had undertaken 1-30 dialysis sessions while the last group of patients were those that had more than 30 sessions. In order to identify the CKD patients that required dialysis, their health files were checked for any indication that dialysis was suggested by the doctor as the choice for their renal replacement therapy. The number of dialysis sessions among the patients diagnosed at the 5^{th} stage of CKD was identified, as this stage of CKD is more likely to require some form of renal replacement therapy than

any of the other CKD stages. Within the 442 cases that were included in this study, 354 patients were diagnosed with stage 5 CKD however, 187 (42.3%) of these patients did not take part in any dialysis session even though it was noted in their health files that they required dialysis to manage the disease.

Table 4.27: The number of the dialysis sessions among the CKD patients

Number of dialysis taken	Stage of CKD					Total
	Unknown	stage 2	stage 3	stage 4	stage 5	
less than 1	11	11	27	15	187	251
1-30	0	1	11	12	162	186
greater than 30	0	0	0	0	5	5
Total	***11***	***12***	***38***	***27***	***354***	***442***

Only five patients had taken more than 30 dialysis sessions since their first diagnosis as stage 5 CKD patients. Health records indicated that all the patients were not undertaking the optimal number of dialysis sessions required to maintain their kidney functions (discussed in section 2.4.3). An insufficient number of dialysis sessions usually lead to a build-up of toxins in the systems. This results in further complications that generally require additional medical attention in order to resolve the problems that arise and these could include swelling of face, swelling of arms/legs, nausea, and kidney failure (Murtagh et al., 2010). All the patients cited in their health files that lack of funds was their primary reason for either refusing to take any dialysis session or why they discontinued their dialysis sessions. This situation tallies with previous studies (discussed in section 2.6.1). The importance of detecting CKD at its early stage cannot be over emphasized as this could enable early interventions, reducing the high

risks of heart disease, progression to stage 5 CKD and premature mortality, which are usually associated with CKD (Stenvinkel, 2010).

4.4.3.2 *Health status of CKD patients*

The high cost of treatment of CKD especially among stage 5 CKD patients within the state and Nigeria as a whole, draws attention to the issue of how these patients are managed once they have been diagnosed with the disease. Many patients with CKD require life-long follow-up in order to manage the disease (Tomson and Udayaraj, 2007). At the onset of the analysis, eleven cases (2.5%) did not have their current health status recorded in their health file and as such, their management outcomes could not be determined and therefore were recorded as missing. The cases that were registered as 'follow-up' were those patients whose CKD status was stable and their health had not deteriorated at the time the data were collected. They made up 74.7% of the cases. Sixty-one patients (13.8%) were dead by the end of the study period and 53 out of the 61 patients were diagnosed at stage 5, seven were diagnosed with stage 4 CKD, and one patient was diagnosed at stage 3 CKD. All 61 patients died within one year of their diagnosis.

In addition, 6.6% of the patients who were originally admitted when they were first diagnosed had now been discharged and they were on 'follow up'. Only one patient was 'lost' during the time period of the study, as the patient's record gave no account of the present location of the patient and no reason was specified for the patient's absence

from the hospital or why the patient had stopped treatment. One patient was found to have deteriorated, was discharged from the hospital, and was no longer taking medical treatment, because the patient did not think there was anything else that the hospital could do to improve his/her health. As at the time of the collection of data, only five patients (1.1%) were still admitted in the hospital while undergoing treatment for complications related to CKD. During the time period of the study, only one patient refused treatment once he was diagnosed with CKD citing lack of finance for not taking any treatment and as such, he discharged himself from the hospital. Although over 70% of the patients were still on follow up as at the time the data was collected, there was still the underlying fact that most of the patients are not receiving adequate treatment due to financial constraints. Notably, those that were diagnosed at the late stage of the disease were not undertaking the recommended dialysis treatment, as they could not afford it.

4.5 Summary

442 cases with CKD diagnosed from 1st January 2006 to 14th October 2009 were retrieved from the renal department at UBTH. Of these 63.1% were males, and approximately 85% were in the economically active age range, most commonly were semi-professionals, although with a surprisingly large number of students. The majority of the patients (80%) were diagnosed at stage 5, which results in very poor health outcomes. Sustained treatment is beyond the financial capability of almost all the patients, this emphasises the need to raise

awareness among both the public and the health professionals to achieve earlier diagnosis of CKD.

Following the evaluation of the profile of CKD cases diagnosed within the study period, the next three chapters will proceed with the analyses of diagnosed CKD within the state using the combined dataset. The outcome from the subsequent chapters will attempt to answer the research questions outlined at the beginning of this research study (see chapter one and three).

Chapter 5 Exploring the factors influencing the severity of CKD at the time of diagnosis and evaluating the trend of diagnosed CKD

5.1 Introduction

This chapter aims at answering four of the research questions raised in chapter one. These are:

1. Is there an association between socio-demographic factors and the stage of CKD at first presentation?
2. Is there a relationship between the severity of CKD at first presentation in Edo state and known biological risk factors of CKD?
3. What factors are likely to lead to the late diagnosis of CKD among patients in Edo State?
4. What is the trend of diagnosed CKD within Edo state?

The first two research questions are addressed in the first section of the chapter by exploring the dataset to examine the variables for any relationships.

The second section of the chapter addresses the third research question by creating a logistic regression model to help predict the probability of diagnosing the stage of CKD of a patient given the variables present within the CKD dataset. This model aims to identify any factor that might have influenced the patient's stage of CKD at the

time of his/her diagnosis. The model was based on the selection of the significant variables identified in the analyses from the previous section.

The chapter concludes by attempting to answer the fourth research question by using a time series analysis to identify trends in diagnosed CKD within Edo state during the study period.

5.2 Determining the variables associated with the severity of CKD at the time of diagnosis.

As mentioned in chapter one, one of the problems faced by many countries including Nigeria concerning the diagnosis of CKD, is the relatively large number of CKD cases that are diagnosed at the last stage of the disease. As previously discussed in chapter two, early detection of CKD is one of the best ways of treating and managing the disease and it would be useful to recognize any variable(s) or factors that may be significantly associated with the detection of CKD at either the earlier stages or late stage. Therefore, for the purpose of this study, cases defined as earlier stages of CKD were those diagnosed with stage 2 to stage 4 between January 2006 and 14th October 2009. This is because stage 5 CKD patients require the use of some form of renal replacement therapy (RRT) such as dialysis or kidney transplant to manage the disease effectively. Although stage 4 CKD is characterised by a low kidney function, it can still be adequately managed using other forms of treatments, which are more affordable in comparison to the treatment required for stage 5 CKD. Given the

low number of cases diagnosed at stage 4, one could argue that any improvement in the diagnosis of cases at this stage could reduce the number of cases that would eventually have been diagnosed at stage 5. Research has shown that a sizable percentage of patients with stage 4 CKD had maintained a stable renal function (El Nahas, 2005). Thirteen variables were examined with the stages of CKD. These were sex, age, marital status, education, ethnicity, religion, occupation, the year of diagnosis, the biological risk factors (i.e. chronic glomerulonephritis, hypertension, diabetes, and toxic nephropathy), and the type of referral centre. These thirteen variables were classified into two main groups: the socio-demographic variables and the diagnosis variables (i.e. the year of diagnosis variables, the biological risk factors, and the type of referral centres). The socio-demographic variables could highlight any significant characteristic among CKD patients that might have been influential in their stage of CKD at the time of diagnosis while the diagnosis variables could give an indication of the choices relating to CKD that the patients had made that might have resulted in the early or late diagnosis of CKD. To measure the significance of the association between the variables and the stage of CKD at time of diagnosis, the Chi-square test, and the correlation analysis were used to test the relationship between the variables and the stages of CKD at time of diagnosis. The analyses were done using a two-tailed test in order to measure the relationship between the variables, as the directions of the relationships were not the point of interest at this point. The choice of using the correlation

analysis and not just the chi-square test was because the assumption for the expected counts was not met in order to validate the chi-square test for the categories of some of the variables. This assumption states that '*as a rule of thumb no more than 20% of expected counts should be less than 5'* (Field, 2000, p.69).

The Phi and Cramer's V correlation coefficient was used to test the association between the variables (excluding the sex of the patients, their age groups, marital status, and the variables for the four biological risk factors) and the stages of CKD. The choice of using the Phi and Cramer's V instead of the Spearman's coefficient is because the variables were nominal (categorical) variables and the Phi and Cramer's V statistics are used in determining the degree of association that exists between nominal variables.

The sex of the patients, their age groups, marital status, and the variables for the four biological risk factors were tested against the stage of CKD using the chi-square test.

5.2.1 Socio-demographic factors and stage of CKD at time of diagnosis

Due to 11 cases not having their stage of CKD at time of diagnosis indicated in their health files, a total of 431 cases were used in the analysis. A total of 77 cases (17.9%) had 'earlier' stages of CKD at time of diagnosis; 29 of these were females while 48 were male cases. The late stage of CKD had a total of 354 diagnosed cases (82.1%) with 224 males (63.3%) and 130 females (36.7%). The stage of

diagnosis between the males and the female, indicated that there were more male diagnosed at both the earlier stages of CKD and the late stage of CKD with the males accounting for almost twice the proportion of females in both stages of diagnosis (see Table 5.1). This supports the finding of Jungers et al., 1996, discussed in section 2.4.1. However, a chi-square test for the significance of the association between both variables indicated that the association was not statistically significant (χ^2 =0.02, 1df, p=0.88), which indicated that the sex of a patient did not have a significant effect on the stage of diagnosis for the patient.

Table 5.1: The association between the sex variable and the stage of CKD at time of diagnosis

Stage of CKD at time of diagnosis		Sex of CKD patients		Total
		Female	Male	
Earlier stages of CKD	Count	29	48	77
	% of CKD patients	37.7	62.3	100
late stage of CKD	Count	130	224	354
	% of CKD patients	36.7	63.3	100
Total	Count	159	272	431
	% of CKD patients	36.9	63.1	100

Chi-square test: χ^2 =0.02, 1df, p=0.88

As mentioned earlier in section 2.5.2, studies indicated that CKD is increasingly prevalent with older age groups. Although the age groups for the CKD patients were initially explored in the previous chapter using a 5-year band, for the purpose of this analysis, the age groups were reclassified into three categories. The three categories within the age group variable included those whose age were below 45 years old, those whose ages were between 45 years to 65 years old and finally

those who were above 65 years old. This is because the profile for the CKD patients indicated that the average age was approximately 45 years and past studies in both developed and developing countries had argued that people above 65 years should be classified as a high-risk population group (see section 2.5.2).

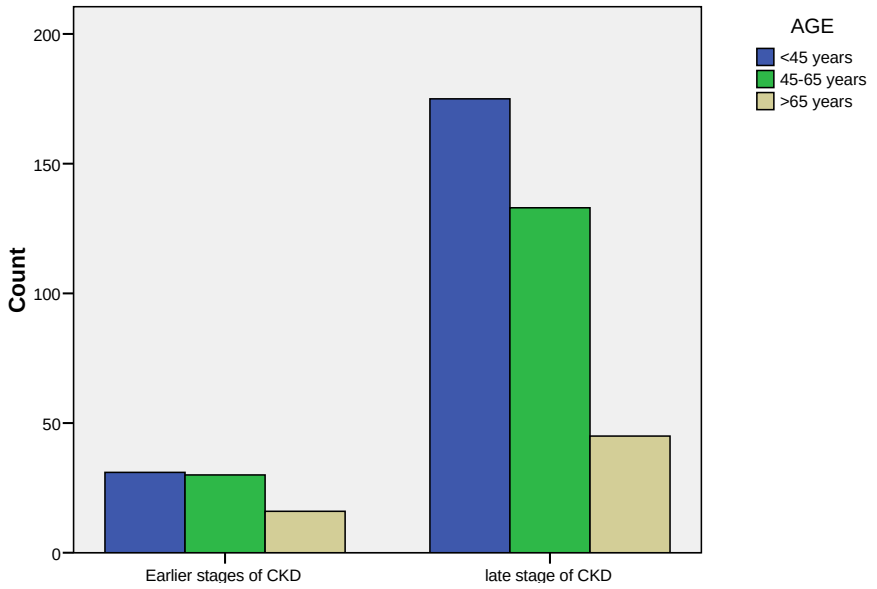

Figure 5.1: The distribution of CKD cases according to their age groups and their stage of CKD at the time of diagnosis

The difference in the number of CKD cases across each age group for those that were diagnosed at the earlier stages of the disease was relatively small compared to those that were diagnosed at the late stage of the disease. However, the pattern appeared to be similar across both stages of the disease as the number of CKD cases decreased across the age groups (see Figure 5.1). There was no statistically significant association at the 95% level between the age groups and the stage of CKD at the time of diagnosis (χ^2 =4, 2df, p=0.1). This indicated that the age group of the patients was not a

significant risk factor for determining the stage of CKD at the time of diagnosis for a patient[25].

As discussed in section 2.4.3, there have been indications that the marital status of an individual could have an impact on the health outcome of an individual and significant findings had also been found among CKD patients.

In order to evaluate the association between the marital status of CKD cases and their stage of CKD at the time of diagnosis, the categories within the marital status variable had to be reclassified because two categories (divorced and widowed) had very small number of cases registered (see Table 5.2).

Table 5.2: The distribution of CKD cases according to theit marital status and their stages of CKD at the time of diagnosis

	marital status				
Stage of CKD	divorced	married	single	widowed	Total
Earlier stages of CKD	0	60	15	2	77
late stage of CKD	1	283	70	0	354
Total	1	343	85	2	431

The reclassified marital status variable had two categories. The married category, which consisted of patients who were married and were still living with their spouses while the second category, was termed “others”; this consisted of patients who were single, divorced, or widowed. The basis for using these two categories was to identify if

[25] A t-test of the average age of late and early diagnosis of CKD was also carried out using the actual ages of the CKD patients and the result was equally not significant

having a spouse might have an influence in the stage at which a patient would seek medical treatment for CKD.

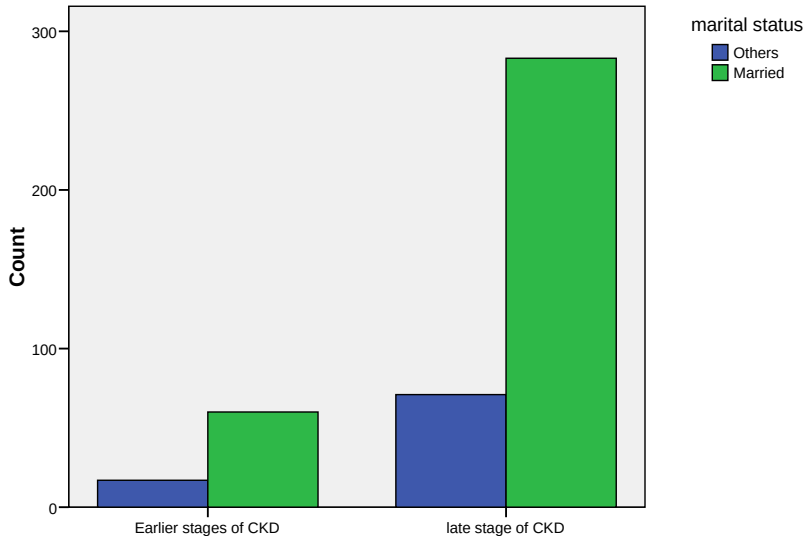

Figure 5.2: The distribution of CKD cases according to their marital status and their stage of CKD at the time of diagnosis

At both stages of CKD diagnosis, the married patients were more than the other cases that did not have spouses. However, a chi-square test on the association between the marital status of CKD cases and their stage of CKD at the time of diagnosis indicated that the association was not significant (χ^2 =0.2, 1df, p=0.7). The result of this analysis indicated that the marital status of a patient might not have a significant influence in determining a patient's stage of CKD at the time of diagnosis. This therefore means that the distribution of CKD cases among the marital groups might be likely due to chance.

In regards to the educational level of the CKD patients, only 155 cases registered their educational status (discussed in section 4.4.1.7). A total of 59 cases were diagnosed at the earlier stages of CKD while 96 cases were diagnosed at the late stage of CKD.

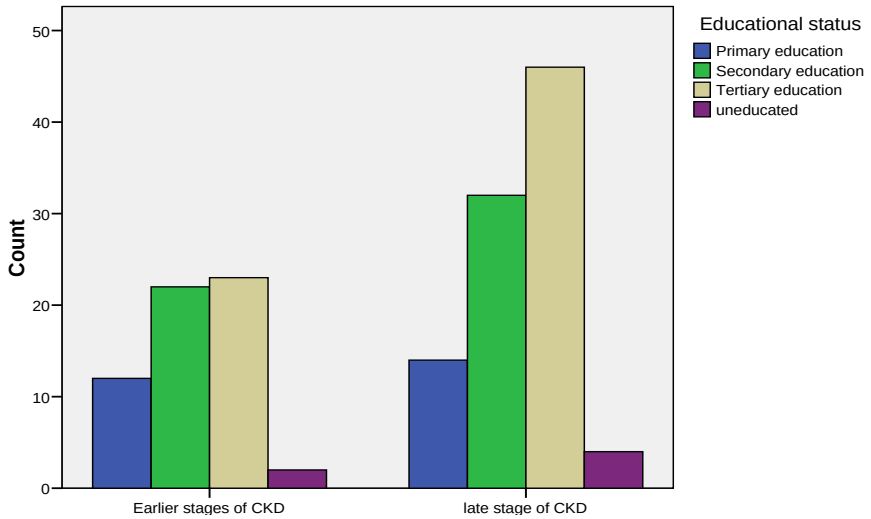

Figure 5.3: The distribution of CKD cases according to their educational status and their stage of CKD at the time of diagnosis

The highest number of diagnosed cases for those at the earlier stages of CKD and those at the late stage of CKD were those with a tertiary education while those that were uneducated had the lowest number of diagnosed cases (see Figure 5.3). However, the Phi and Cramer's V statistics to test the significance of the association between both variables indicated that the association was not significant (R = 0.1, p=0.7). This indicated that the educational level of a patient is not likely to have had a significant influence on the patients' stage of CKD at the time of diagnosis.

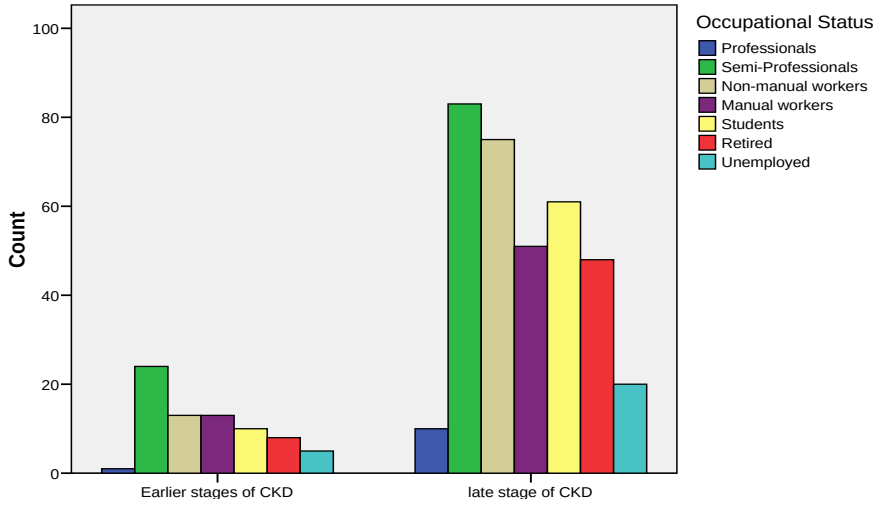

Figure 5.4: The distribution of CKD cases according to their occupational status and their stage of CKD at the time of diagnosis

The association between the occupational groups and their stage of CKD diagnosis show that of the 74 cases diagnosed at the earlier stages, the semi-professionals had the highest number of diagnosed cases with 24 accounting for 32.4% of the total number of diagnosed cases with the earlier stages of CKD (see Figure 5.4). The professionals had the lowest number of diagnosed cases registered with the earlier stages of CKD with just one case from this group accounting for 1.4%. A similar pattern was identified within the occupational groups diagnosed with late stage CKD as the highest number was registered among the semi-professionals with 83 cases representing the 23.9% of the total number of late stage CKD cases within the dataset while the professionals still had the lowest with ten cases (2.9%). The Phi and Cramer's V statistics to test the significance of the association between both variables indicated that the association was not significant (R = 0.1, p=0.6). This indicated that the

occupational status of a patient did not have a significant influence on the patients' stage of CKD at the time of diagnosis.

To analyse the association between the stages of CKD at time of diagnosis and the ethnic groups, the ethnic groups were classified into five groups based on their area of origin (discussed in section 4.4.1.4). However, 184 cases did not indicate their ethnic group and so could not be classified within the five ethnic groups as such, a total of 247 cases were analysed.

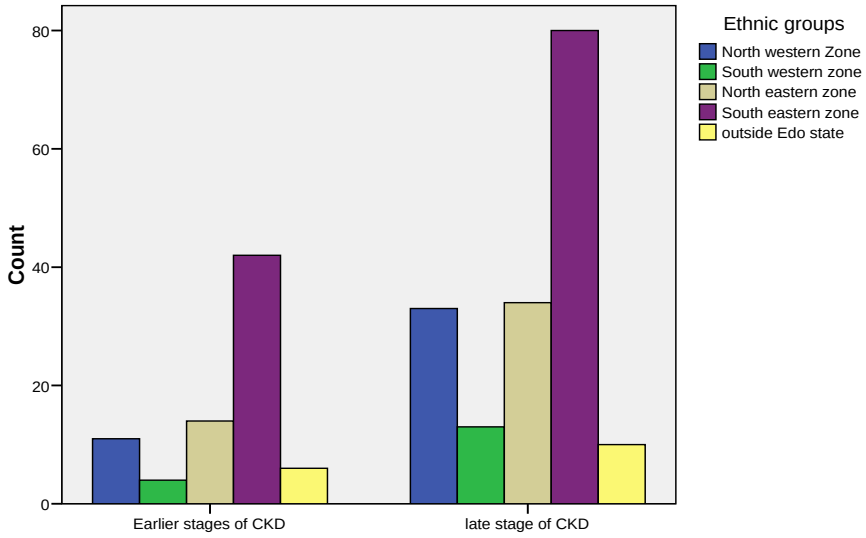

Figure 5.5: The distribution of CKD cases according to their ethnic groups and their stage of CKD at the time of diagnosis

The ethnic groups within the south eastern zone had the largest number of cases that were diagnosed with both the earlier stages of CKD (accounting for 54.5% of all the earlier stages of CKD diagnoses) and the late stage of CKD with 47.1% of all the late stage of CKD diagnoses. The ethnic groups from the south western zone had the lowest number of cases that were diagnosed with the earlier stages of CKD (accounting for 5.2% of all the earlier stages of CKD diagnoses). The ethnic groups whose origins were outside Edo state

had the lowest number of cases that were diagnosed with the late stage of CKD accounting for only 5.9% of all the late stage of CKD diagnoses (see Figure 5.5). There was no statistical significance (R = 0.1, p=0.7) in the relationship between the ethnic groups and the patients' stage of CKD at the time of diagnosis. This therefore indicated that the patients' ethnic group was not likely to have influenced their decision to seek treatment either earlier or at a late stage of the disease. Although there is not much information that can be derived from the result of this variable, it can be argued that the ethnicity of an individual in relation to their ethnic or cultural practices might not be a significant determinant for determining the stage of CKD that the patients would seek treatment.

As discussed in section 4.4.1.5, a total of 247 cases were analysed for a relationship between religion and the stage of CKD diagnosis because these were the total number of CKD cases that indicated their religious affiliation. According to the results, the African traditionalists and the Muslims had the lowest number of diagnosed earlier stages of CKD with just two cases each (accounting for 2.6% for each of the religion) while the remaining 94.8% of diagnosed earlier stages of CKD were registered among the Christians. Among those that were diagnosed with late stage CKD, there were no African traditionalists that were diagnosed and only three were Muslims (1.8%) while the remaining cases were Christians (98.2%). Although Edo state is generally perceived to have more Christians than Muslims within its borders, the exact proportion of the three major religions are

not known due to the absence of religion as an indicator within the censuses (BBC News, 2006). There are only speculations on the actual proportions of the three religious groups within the state. Previous surveys and censuses from previous years have been dominated by controversies. Their results have been disputed by both members of the general public and religious groups particularly the Muslim and Christian organisations (Abdulrasheed, 2008; Aguwa, 1997). However, the results for the association between religion and CKD diagnosis appear to indicate that the African traditionalists have the lowest number of cases that are diagnosed for CKD. One might assume that this group of people are not seeking treatment within the hospital environment or they might be living a healthier life than those from the other religions. I would however, lean towards the first assumption. This is because a recent study that attempted to map the use of conventional and traditional medicines / traditional healers among the general population indicated that a large proportion of the residents within the state used traditional healers and this was above the nation's average use of traditional healers (Ojo et al., 2010).

However, this result can only be verified after further studies have been carried out on the religious practices of CKD patients in the state, which was not covered within the scope of this study. The correlation test to determine the significance of the association between both variables indicated that the association was not significant ($R = 0.1$, $p=0.1$). This indicated that the religion of a patient did not have a significant influence on the patients' stage of

CKD at the time of diagnosis. This may be an indication that the distribution of CKD cases among the various religious groups might be due to chance.

Table 5.3: The proportion of CKD cases across the religious groups in relation to their stage of CKD at the time of diagnosis

Stage of CKD		Religion			Total
		African traditionalist	Christian	Muslim	
Earlier stages of CKD	Count	2	73	2	77
	% of CKD cases within the earlier stages of CKD	2.6	94.8	2.6	100
late stage of CKD	Count	0	167	3	170
	% of CKD cases within the late stage of CKD	0.0	98.2	1.8	100
Total	Count	2	240	5	247
	% of CKD cases within both stages of CKD	0.8	97.2	2.0	100

5.2.2 Diagnosis variables and Stage of CKD at time of diagnosis

As previously mentioned, the study focused on the prevalence of CKD from 2006 until 2009, in order to observe whether there are significant variations in the number of CKD cases that have been diagnosed annually within the state. Although further analysis was carried out to analyse the trend of CKD diagnosis, which is discussed in section 5.4, the time of diagnosis was included as a variable to identify any significant relationship with the stage of CKD at the time of diagnosis. This is because the result could indicate whether the influence of the variable for the year of diagnosis is significantly associated with the patients' stage of CKD at the time of diagnosis. As discussed in section 2.1, the world kidney day, which started in 2006, is one of the global CKD awareness programmes, which aims to increase the awareness of CKD among the general public and within the health

sector. Therefore, there is the possibility that the impact of this awareness campaign might have influenced the number of CKD cases diagnosed at each stage of the disease. The number of the yearly diagnosis of cases that were diagnosed with earlier stages of CKD appeared to have a steady annual increase with the highest number recorded in 2009 accounting for 49.4% of all the cases diagnosed at the earlier stages of CKD (see Table 5.4). The number of cases that were diagnosed at the late stage of CKD also had a steady annual increase even though there was a drop in the number of cases in 2009 but this could be because the dataset did not include the whole year of 2009 as data collection stopped in October. The chi-square test to determine the relationship between both variables indicated that the association was highly significant (χ^2 =31.5, 3df, $p<0.001$). This indicated that the year of diagnosis had a significant influence on the patients' stage of CKD at the time of diagnosis. This means that the proportion of early stage diagnoses goes up over time relative to the proportion of late stage diagnoses. One could therefore argue that the increased number of diagnosed cases might be attributed to a likely improvement in the awareness of CKD among the general population and members in the health sector. As mentioned earlier, this result was further analysed in section 5.4 in order to identify the trend of diagnosis throughout the study time period and determine the level of influence the variable had on diagnosed CKD within the state.

Table 5.4: The proportion of CKD cases diagnosed between 2006 and 2009 according to their stage of CKD at the time of diagnosis

Stage of CKD		Year of Diagnosis				Total
		2006	2007	2008	2009	
earlier stages of CKD	Count	7	10	22	38	77
	% of CKD cases within the earlier stages of CKD	9.1	13.0	28.6	49.4	100
late stage of CKD	Count	82	96	103	73	354
	% of CKD cases within the late stage of CKD	23.2	27.1	29.1	20.6	100
Total	Count	89	106	125	111	431
	% of CKD cases within both stages of CKD	20.6	24.6	29.0	25.8	100

As discussed in section 4.4.2.3, four main biological risk factors were included in the analyses as variables. These were chronic glomerulonephritis, hypertension, Diabetes, and Toxic nephropathy.

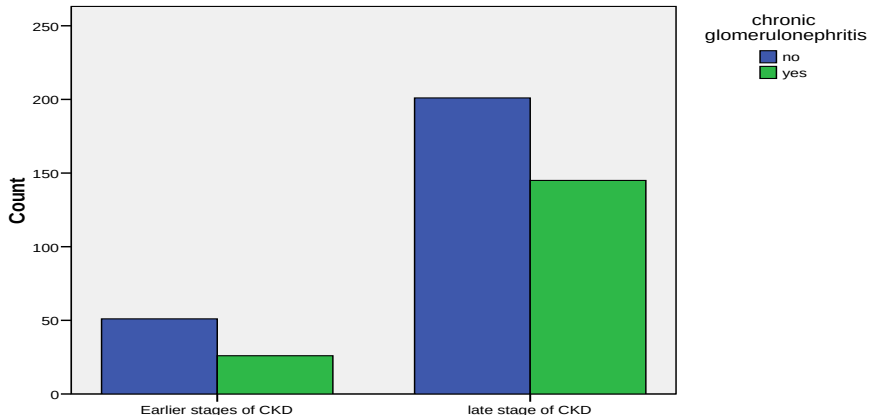

Figure 5.6: The presence or absence of chronic glomerulonephritis among CKD cases diagnosed at the earlier stages and the late stage of CKD

In regards to the presence of chronic glomerulonephritis, 26 cases already had it when they were diagnosed with the earlier stages of CKD (33.8% of all the earlier stage of CKD) while 145 cases of those that were diagnosed with the late stage of CKD were found to have chronic glomerulonephritis (41.9% of all the late stage of CKD). However, the chi-square test indicated that the relationship between

the chronic glomerulonephritis and the stage of CKD at the time of diagnosis was not statistically significant (χ^2 =1.7, 1df, p=0.2). Although chronic glomerulonephritis accounted for 38.9% of the diagnosed cases of CKD (see section 4.4.2.3), it did not appear to contribute significantly to a patient's stage of CKD at the time of diagnosis. This means that the presence of chronic glomerulonephritis in a patient may not significantly determine whether they are likely to be diagnosed at the earlier stages or late stage of CKD.

Hypertension was found among 49 cases with the earlier stages of CKD thereby accounting for 63.3% of all the cases diagnosed with the earlier stages of CKD while 120 cases among those diagnosed with the late stage CKD had hypertension (34.6% of all the late stage of CKD). Although there were less cases diagnosed with earlier stages of CKD, there appeared to be a higher proportion of cases with hypertension that were diagnosed at the earlier stages of the disease than with those diagnosed at the late stage of CKD (see Table 5.5). The chi-square test used in examining the significance of the association between both variables indicated that the association was highly significant (χ^2 =22.2, 1df, p<0.001). This indicated that the presence of hypertension in patients had a significant influence on the patients' stage of CKD at the time of diagnosis. This means that the presence or absence of hypertension in a patient may significantly determine whether they are likely to be diagnosed at the earlier stages or late stage of the CKD.

Table 5.5: The proportion of CKD cases with or without hypertension at the time of CKD diagnosis in relation to their stage of CKD.

Stage of CKD		hypertension		Total
		no	yes	
Earlier stages of CKD	Count	28	49	77
	% of CKD cases within the earlier stages of CKD	36.4	63.6	100
late stage of CKD	Count	227	120	347
	% of CKD cases within the late stage of CKD	65.4	34.6	100
Total	Count	255	169	424
	% of CKD cases within both stages of CKD	60.1	39.9	100

The total number of CKD patients that had diabetes was relatively small when compared to the patients that had either chronic glomerulonephritis or hypertension, because they only account for a total of 70 cases within the dataset (accounting for 16.5% of all diagnosed cases). A total of 21 cases that were diagnosed with earlier stages of CKD had diabetes (27.3% of all cases diagnosed with the earlier stages of CKD) while 49 cases with diabetes were diagnosed at the late stage of CKD (14.1% of the total cases diagnosed at the late stage of CKD) (see Table 5.6). However, the chi-square test used in examining the significance of the association between the diabetes variable and the variable for the stage of CKD indicated that the association was highly significant (χ^2=22.2, 1df, p<0.001). This indicated that the presence or absence of diabetes in patients had a significant influence on the patients' stage of CKD at the time of diagnosis.

Table 5.6: The proportion of CKD cases with or without diabetes at the time of CKD diagnosis in relation to their stage of CKD.

Stage of CKD		Diabetes		Total
		no	yes	
Earlier stages of CKD	Count	56	21	77
	% of CKD cases within the earlier stages of CKD	72.7	27.3	100
late stage of CKD	Count	298	49	347
	% of CKD cases within the late stage of CKD	85.9	14.1	100
Total	Count	354	70	424
	% of CKD cases within both stages of CKD	83.5	16.5	100

Patients with toxic nephropathy accounted for a smaller proportion of diagnosed CKD cases within the dataset with a total of just 31 cases (7.3% of all diagnosed CKD cases). As discussed in section 4.4.2.3, this risk factor is more likely diagnosed as an underlying cause of CKD. This means most patients that have toxic nephropathy only are diagnosed with the disease after they have developed CKD and are seeking treatment for CKD. Therefore, there is the possibility that the diagnosis of toxic nephropathy might be ignored, as the primary focus would be the treatment and management of CKD in such patients. This means that there is the likelihood that there might be more CKD patients that had toxic nephropathy but the disease was not indicated in their health files. As this assumption cannot be readily verified, the outcome of this analysis would be based on those that were identified as having toxic nephropathy.

Among those that were diagnosed at the earlier stages of CKD, 12 cases had toxic nephropathy, which accounted for a total of 15.6% of all cases diagnosed at the earlier stages of CKD. Among those that were diagnosed at the late stages of CKD, just 19 cases out of the 348

cases had toxic nephropathy, which accounted for a total of 5.5% of all cases diagnosed at the late stages of CKD (see Table 5.7). However, the chi-square test used in examining the significance of the association between the toxic nephropathy variable and the variable for the stage of CKD, indicated that the association was highly significant (χ^2 =9.6, 1df, p<0.001). This indicated that the presence or absence of toxic nephropathy in patients had a significant influence on the patients' stage of CKD at the time of diagnosis.

Table 5.7: The proportion of CKD cases with or without toxic nephropathy at the time of CKD diagnosis in relation to their stage of CKD

Stage of CKD		Toxic nephropathy		Total
		no	yes	
Earlier stages of CKD	Count	65	12	77
	% of CKD cases within the earlier stages of CKD	84.4	15.6	100
late stage of CKD	Count	329	19	348
	% of CKD cases within the late stage of CKD	94.5	5.5	100
Total	Count	394	31	425
	% of CKD cases within both stages of CKD	92.7	7.3	100

In relation to the four biological risk factors, hypertension, diabetes, and toxic nephropathy appeared to have a highly significant influence on the patients' stages of CKD at the time of diagnosis. However, the presence or absence of chronic glomerulonephritis did not appear to have a statistically significant influence on the patients' stages of CKD at the time of diagnosis.

The type of referral centres that referred cases to UBTH for treatment was examined. The reason for including this variable is so that it can be used to understand the patients' choice of health service in regards to receiving conventional medical treatment. It should be

stated that medical treatment in this case, refers to treatments received at a conventional health facility and not treatments received at alternative[26] clinics or traditional centre. Therefore, it should not be confused with the choice of seeking alternative medicine or treatment before seeking conventional treatment. However, only 247 cases indicated the health centres that referred them for treatment and so the result is based on 55.9% of the 442 cases that were used in this study.

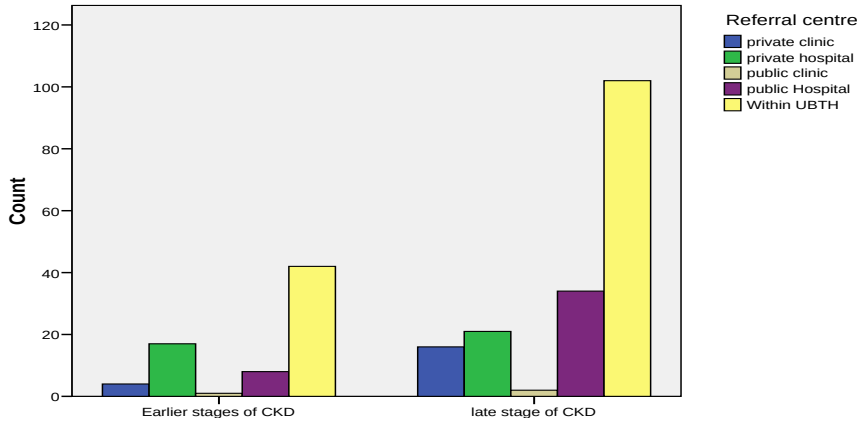

Figure 5.7: The distribution of CKD cases according to their mode of referral to the renal department and their stage of CKD at the time of diagnosis

The result indicated that for cases that were diagnosed at the earlier stages of CKD and those that were diagnosed at the late stage of CKD, the various departments within UBTH had the highest referral rate accounting for 58.3% for both earlier stages of diagnosis and late stage of CKD (see Figure 5.7). The lowest referral rate was found to be those from the public clinics for both earlier stages of diagnosis (1.4%) and those diagnosed at the late stage of CKD (1.1%). Due to the proportion of cases whose mode of referral to UBTH's renal

[26] An alternative treatment is any healing practice that is not within the scope of conventional medicine or has not been shown to be effective or free of contradiction.

department could not be identified, the variable for the referral centres was not statistically tested for an association with the stages of CKD at time of diagnosis. However, according to discussions with some of the nephrologists at the renal unit in UBTH, they identified that the general physicians and even nephrologists have an equally important role to play in the early identification and treatment of CKD. They noted that there has been an increase in the referral rates of CKD patients with early stages of CKD from other hospitals although they still believe that most health centres within the state especially those in the rural areas still need to be informed about how to effectively identify CKD at its early stages.

In summary, the statistical tests for the association between the various variables and the stage of CKD at the time of diagnosis showed that only four variables out of the thirteen variables were statistically significant. All the socio-demographic variables namely sex, age groups, marital status, education, religion, ethnic group, and occupation were not statistically significant when tested for an associated with the patients' stage of CKD at the time of diagnosis. This shows that the socio-demographic variables may not have had an influence on the patients' stage of CKD at point of diagnosis. Therefore, their distributions among the various stages of CKD diagnosis were probably due to chance. Among the four biological risk factors associated with CKD, three risk factors namely: hypertension, diabetes, and toxic nephropathy were found to be statistically significant at the 99% level. A likely reason why these

risk factors were significant and seemed to be more common among early stage diagnoses than late stage diagnoses could be attributed to the fact that patients who already had any of these risk factors were being monitored by their doctors, which made it easier for them to identify CKD at its earlier stages. Chronic glomerulonephritis was however, not significant when tested for an association with the stage of CKD at the time of diagnosis.

The year of diagnosis was found to be highly significant at $p<0.001$ level when tested against the patients' stages of CKD at the time of diagnosis. The high significance noted between the stage of CKD at the time of diagnosis and the year when they were diagnosed, showed that theproportion of early stage diagnoses goes up over time relative to the proportion of late stage diagnoses . It could be suggested that the distribution of the cases across the various stages of CKD could be due to the recent attempt at increasing the awareness of the disease within the state particularly during the World kidney Day programme. This might have enabled healthcare officials as well as members of the public to be more aware of the problem of CKD, which might have resulted in health officials taking necessary actions to identify and treat the disease once a patient showed any symptom(s), which might have been overlooked in the past. However, this assumption can only be confirmed by carrying out further analysis as the actual procedure on how the diagnosis was determined for patients was not documented in detail within their health files. To identify any trend of diagnosed CKD within the study period that might give any indication

to these assumptions, a time series analysis was carried out (discussed in section 5.4).

In the next section, a feasible model was created in order to predict the severity of the stage of CKD at time of diagnosis using the statistically significant variables that were discussed in this section.

5.3 A logistic regression model for predicting the severity of CKD at time of diagnosis for CKD patients in Edo state

This section looks at creating a suitable model for the dataset to predict the possibility of a CKD patient to be diagnosed at either the earlier stage of CKD or the late stage of CKD (discussed earlier in Section 5.2). The result from this model should provide an answer to the fourth research question stated at the beginning of this chapter. The logistic regression was chosen for this analysis because the outcome variable of interest (stage of CKD) is classified into two categories (earlier stage or late stage of CKD at time of diagnosis).

The logistic regression equation is stated as follows:

Equation 5.1: the equation for a logistic regression model

$$P\,(\text{event}) = \frac{1}{1 + \exp(-(b_0 + b_1X_1 + b_2X_2 + \ldots + b_pX_p))}$$

Source 5:1: http://www.eje-online.org/content/162/5/869.full (Barbosa et al., 2010)

where b_0 is a constant; $b_1, b_2 \ldots b_p$ are the regression coefficients for each predictor; $X_1, X_2 \ldots X_p$ are the explanatory variables. The value P represents the probability of a particular outcome, given that set of explanatory variables.

5.3.1 Choice of predictor variables and method for Logistic regression analysis

The stage of CKD at the time of diagnosis was set as the outcome variable with the earlier stage of CKD coded as zero (0) and the late stage category coded as 1; this was because the late stage category had a larger number of diagnosed CKD cases than the category for the earlier stages (see section 4.4.2.2). The three significant variables were included within the first block using the forced entry method, which simultaneously adds the selected predictor variables into the model. The chronic glomerulonephritis was added along with the three variables from the first block to the second block using the forward stepwise selection (likelihood ratio) method. This method was chosen for the second block because some studies indicate that chronic glomerulonephritis (CGM) is a known predictor/risk factor of CKD (Frontera et al., 2008; Ijoma et al., 2010).

The forward stepwise method selects the predictor variable that best predicts the outcome variable and if this predictor variable significantly improves the ability of the model to predict the outcome then it is retained in the model, another predictor is considered, and a removal test is made of the least useful predictor (Field, 2000, p. 120). This procedure ensures that the regression equation of the model is constantly being reassessed to identify any redundant predictor variable that can be removed from the model. It has been argued that because the stepwise methods relies on the computer basing its selection of the predictor variables on a mathematical criterion, the

methodological decisions is taken out of the hands of the researcher and should be used only in exploratory model building (Field, 2000; Menard, 1995). It was for this reason that the forward stepwise method was chosen as the method for the second block as the aim of the model was to explore the data for other variables that would significantly predict the stage of CKD at time of diagnosis.

5.3.2 Saving Residuals for evaluation of regression Model and the Option settings for analysis

To examine how well the model fitted the observed data, residuals were identified using the save dialog box. The boxes for the predicted values, the values for the residual statistics and the influence statistics were ticked.

The casewise listing of residuals was selected and the standard deviation for any outliner was set to 2.5. This value was chosen because 5% of the database is allowed to lie above +/- 2 and 1% to lie above +/- 2.5 but any value outside the +/- 2.5 should be examined further (Field, 2000, p. 188). The criteria of the probability for stepwise, the classification cut-off value was set to 0.5, the maximum iteration value was set to 20 iterations, and the constant in the model was included.

5.3.3 Discussion of results for the first block of the model

A summary table of the analysis indicated that 422 cases (95.5%) were analysed out of the 442 cases within the dataset while 20 cases were classified as missing cases as these cases had missing categories

within the variables that were analysed in the model (Table 5.8). The parameter coding table for the predictor variables, which are important for calculating the probability of the outcome variable (stage of CKD at time of diagnosis), was included and this confirmed the categorical settings that were chosen in the categorical dialog box (Table 5.9).

Table 5.8: A summary table of CKD cases used in the Logistic regression model

Case Processing Summary			
Cases		N	Percent
Selected Cases	Included in Analysis	422	95.5
	Missing Cases	20	4.5
	Total	442	100.0
Unselected Cases		0	.0
Total		442	100.0

Table 5.9: Categorical Variables coding for the predictor variables

Categorical Variables Coding			
		Frequency	Parameter coding (1)
chronic glomerulonephritis (CGM)	no	251	1
	yes	171	0
Hypertension (HTN)	no	254	1
	yes	168	0
Toxic nephropathy	no	393	1
	yes	29	0
Diabetes (Dtm)	no	353	1
	yes	69	0

The first model which was done using a forced entry method began with including just the constant in the regression equation and by default, SPSS attempts to predict that every case belongs to the category in which the most observed cases fell, in this case, it attempted to predict cases diagnosed at the late stage of CKD. This is because SPSS attempts to maximise how well the model predicts the observed data (Field, 2000, p. 176). The -2 log likelihood statistics (-

2LL) for a model was also calculated, used in indicating the extent to which the model fails to perfectly predict the values of the outcome variable, i.e. it tells how much improvement is needed before the predictors provide the best possible prediction of the dependent variable. The value of the -2LL for the constant was 400.993, which indicated the total amount of information that needed to be explained by the model while the value of the constant (β_0) in the model was 1.5 (see Table 5.10).

According to the model prediction with only the constant, the model was unable to predict any of the cases diagnosed with earlier stages of CKD (0%) but it correctly predicted all the cases diagnosed with late stage CKD (100%). The overall prediction percentage of the model with only the constant was 81.8%, which is a weighted average of the prediction values for correctly predicting both stages of CKD (see Table 5.11).

Table 5.10: The value of the -2LL for the constant and the value of the constant

Iteration History[a,b,c]			
Iteration		-2 Log likelihood	Coefficients Constant
Step 0	1	404.474	1.270
	2	401.007	1.485
	3	400.993	1.500
	4	**400.993**	**1.500**
a. Constant is included in the model.			
b. Initial -2 Log Likelihood: 400.993			
c. Estimation terminated at iteration number 4 because parameter estimates changed by less than .001.			

Table 5.11: The classification table for the model with only the constant

Classification Table[a,b]					
Observed			Predicted		
			new CKD stage		Percentage Correct
			Earlier stages of CKD	Late stage of CKD	
Step 0	CKD stage	Earlier stages of CKD	0	77	.0
		Late stage of CKD	0	345	100.0
	Overall Percentage				81.8
a. Constant is included in the model.					
b. The cut value is .500					

The model evaluated the variables that were yet to be included in the model at this first stage (step 0) and identified that the Roa's efficient score of all the three predictors from the first block were highly significant and as such, the model proceeded to include them in the regression equation (Table 5.12).

Table 5.12: Predictor variables for the first block that was not yet included in the model

Variables not in the Equation					
			Score	df	Sig.
Step 0	Variables	Dtm(1)	8.215	1	.004
		HTN(1)	22.313	1	.000
		Toxic nephropathy (1)	11.171	1	.001
	Overall Statistics		40.131	3	.000

The iteration history table for the model indicated that the -2LL had dropped from 400.993 to 363.219 (see Table 5.13), which indicated a change of 37.774 (the value of the model chi-square). The Model Chi-Square with a significant value indicates that one or more coefficients differ from zero, but it does not identify which ones. However, the Block chi-square indicates whether one or all of the variables included

in this block have effects that differ from zero. While the step chi-square indicates the improvement of the predictive power of model since the last stage i.e. whether the effect of the variable that was entered in the final step is significantly different from zero. The significance level for the model chi-square indicated that the model chi-square values as well as the chi-square values for the block and step were all highly significant (χ^2 = 37.77, 3df, p<0.0001). It should be noted that the chi-square values for the step, block, and model are all the same because the predictor variables were simultaneously added into the model (see Table 5.14).

Table 5.13: The values for the -2 log likelihood and the values for the constant and coefficients of the predictor variables

Iteration History[a,b,c,d]						
Iteration		-2 Log likelihood	Coefficients			
			Constant	Dtm(1)	HTN(1)	Toxic nephropathy (1)
Step 1	1	374.091	-.510	.535	.703	.977
	2	363.563	-.915	.774	1.103	1.292
	3	363.219	-1.011	.823	1.207	1.359
	4	363.219	-1.015	.825	1.212	1.362
	5	**363.219**	**-1.015**	**.825**	**1.212**	**1.362**
a. Method: Enter						
b. Constant is included in the model.						
c. Initial -2 Log Likelihood: 400.993						
d. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.						

Table 5.14: Chi-square test for the step, block and model of the logistic regression

Omnibus Tests of Model Coefficients				
		Chi-square	df	Sig.
Step 1	Step	37.774	3	.000
	Block	37.774	3	.000
	Model	37.774	3	.000

The Hosmer and Lemeshow's goodness-of-fit test (see Table 5.15), which tests the hypothesis that the observed data is significantly different from the predicted values from the model (Field, 2002). Therefore, a non-significant value for this test would indicate that the model does not differ significantly from the observed data. The result was found not to be significant (χ^2 = 3.22, 3df, p< 0.360) and as such, the hypothesis for the Hosmer and Lemeshow's goodness-of-fit test is rejected and it therefore indicates that the model is predicting the data for the stage of CKD at time of diagnosis fairly well.

Table 5.15: Hosmer and Lemeshow's goodness-of-fit test

Hosmer and Lemeshow Test			
Step	Chi-square	df	Sig.
1	3.215	3	.360

The SPSS Output included a classification table that documented the validity of predicted probabilities (Table 5.16). The cut-off point was set at 0.5 and the prediction for the stages of CKD at time of diagnosis after the three-predictor variables were added to the model correctly classifies six earlier stages of CKD cases but misclassifies 71 cases as late stage CKD instead of earlier stages of CKD cases. This meant that for the earlier stage of CKD, the model correctly predicted only 7.8%. Although there was an increase in the prediction for this category compared to when the model only had the constant, the prediction was still low. For the late stage of CKD category, the model correctly classified 339 cases as late stage CKD but wrongly classified six cases thereby having a prediction percentage of 98.3% although this was a

very high prediction percentage, there was however, a drop of 1.7% in the prediction level for this category. The overall accuracy of the classification was a total of 81.8%, which was the same as the weighted overall percentage of the model with only the constant included. However, the classification can still be regarded as an improvement because even though the prediction dropped by 1.7% in classifying the late stage cases, it improved by 7.8% in the classification of the earlier stages of CKD.

Table 5.16: The Observed and the Predicted Frequencies for stages of CKD at time of diagnosis by Logistic Regression with the Cut-off of 0.50

Classification Table[a]					
Observed			Predicted		
			stage of CKD		Percentage Correct
			Earlier stage of CKD	Late stage of CKD	
Step 1	CKD stage	Earlier stage of CKD	6	71	7.8
		Late stage of CKD	6	339	98.3
	Overall Percentage				81.8
a. The cut value is .500					

The regression coefficients for all the three variables in the model were highly significant, indicating that hypertension, diabetes and toxic nephropathy significantly predicted the stage of CKD at time of diagnosis.

If exp β, which is an indicator of the change in the odds resulting from a one unit change in the predictor, is greater than 1 then the odds of a predicted outcome happening are larger than the odds of it not happening. This means that the odds of being diagnosed at the late stage of CKD are larger than the odds of being diagnosed at the earlier stage of CKD and this is because the late stage of CKD at time of

diagnosis is the reference category (i.e. late stage of CKD=1). However, if exp β is less than 1, this indicates that the odds of being diagnosed at the late stage of CKD are less than the odds of being diagnosed at the earlier stage of CKD. As the predictor variables were coded as "0" for cases where the risk factor was present at time of diagnosis and "1" for cases where it was not (see Table 5.9), exp β shows how much larger or smaller the odds of being diagnosed with CKD late rather than early are for those who were not diagnosed with the risk factor than for those who were known to have an 'at risk' condition. The odds of a case without diabetes being diagnosed at the late rather than the early stage of CKD were 2.3 times greater than the odds for a case with diabetes. The odds of a case without hypertension being diagnosed at the late rather than the early stage of CKD were 3.4 times greater than the odds for a case with hypertension and the equivalent odds of a case without toxic nephropathy were 3.9 times greater than the odds for a case with toxic nephropathy. This can be regarded as plausible as the presence of these risk factors in a patient enables them to seek medical help early or if they are already undergoing treatment for these risk factors, their physicians may be able to identify the development of CKD thereby diagnosing it at an earlier stage.

Table 5.17: The values for the Coefficients in the model

Variables in the Equation									
								95% C.I. for exp β	
		β	S.E.	Wald	df	Sig.	exp β	Lower	Upper
Step 1[a]	Dtm(1)	.825	.317	6.767	1	.009	2.282	1.226	4.250
	HTN(1)	1.212	.270	20.205	1	.000	3.359	1.981	5.698
	toxic nephropathy (1)	1.362	.430	10.033	1	.002	3.904	1.681	9.068
	Constant	-1.015	.506	4.029	1	.045	.362		
a. Variable(s) entered on step 1: Dtm, HTN, toxic nephropathy.									

Using the equation for the Logistic Regression Model (see Equation 5.1), the Logistic Regression Model for the probability of a patient to be diagnosed at the late stage of CKD could therefore be determined. Given the fact that within the equation, the exp β values for the constant was represented as $\boldsymbol{b_0}$, diabetes was $\boldsymbol{b_1}$, hypertension was $\boldsymbol{b_2}$, and toxic nephropathy was $\boldsymbol{b_3}$, the model for the possibility of predicting that a patient is diagnosed at the late stage of CKD is expressed as:

Equation 5.2: A model expressing the probability of the severity of CKD at the time of diagnosis

$$\frac{1}{1 + (0.362 + 2.3(diabetes) + 3.4(hypertension) + 3.9(toxic\ nephropathy))}$$

5.3.3.1 *The Hosmer and Lemeshow's measure (RL2)*

The Hosmer and Lemeshow's measure (R_L^2), which indicates the proportional reduction in the absolute value of the likelihood measure (-2LL) can therefore be used to indicates how much the **goodness-of-fit** of the model improves because of the inclusion of the predictor variables. The R_L^2 was calculated by dividing the model chi-square

value (for the model when the predictors are included in the model) by the initial value of the -2LL (which is the -2LL value when only the constant is included in the model).

Model chi-square = 37.774; -2LL= 400.993

Therefore: $R_L^2 = 37.774 \div 400.993 = 0.094$

$R_L^2 = 9.4\%$

This meant that the model could account for 9.4% of the variance in the stage of CKD at time of diagnosis, which meant that 90.6% of what helps in the prediction of the stage of CKD at the time of diagnosis is yet to be accounted for. This outcome further places an emphasis on the need for an extensive investigation into the severity of diagnosed CKD within both the state and the country as a whole.

5.3.3.2 *Testing for multicollinearity*

Multicollinearity exists when there is a strong association between two or more predictors in a regression model and in order to ensure that there are no correlations between the predictor variables, a collinearity diagnostics in the form of a correlation matrix was generated in SPSS to test for any correlation among the predictor variables. The results from the collinearity Statistics indicated that none of the variables had any strong correlation with any of the other variables. According to Menard (1995), a tolerance value of less than 0.1 likely indicates collinearity while Myers (1990) suggests that a VIF value greater than 10 indicates a collinearity problem (Menard, 1995; Myers, 1990; cited by Field, 2000). As none of the variables

have any tolerance value less than 0.1 or a VIF value greater than 10, there were no indications of multicollinearity within the model.

Table 5.18: A Collinearity Statistics to test for multicollinearity among the predictor variables

Coefficients[a]			
Model		Collinearity Statistics	
		Tolerance	VIF
1	Diabetes	.997	1.003
	hypertension	.996	1.004
	Toxic nephropathy	1.000	1.000
a. Dependent Variable: stages of CKD at time of diagnosis			

5.3.4 **The forward stepwise method for the second block**

The results from the second block of the model which consisted of the diabetes, hypertension, toxic nephropathy, and chronic glomerulonephritis variables as predictor variable was unable to produce a better model than the first block as the chronic glomerulonephritis variables could not make a significant contribution to the predictive power of the model. As a result of this, the regression model terminated at this point but the output also produced an analysis of the model to show if any of the significant variables from the first block were removed. The result in table below indicated that all the values for the log-likelihood ratio for the variables were highly significant. This showed that the removal of any of these variables would have a significant effect on the predictive ability of the model.

Table 5.19: Test to show the significance of the predictor variables to remain in the model

Model if Term Removed					
Variable		Model Log Likelihood	Change in -2 Log Likelihood	df	Sig. of the Change
Step 0	Dtm	-184.813	6.407	1	.011
	HTN	-192.197	21.175	1	.000
	toxic nephropathy	-186.262	9.305	1	.002

The SPSS output for the logistic regression also produced a table to indicate the variables that were not included in the model, this showed that the score statistics significance values for the chronic glomerulonephritis variable was not significantly different from zero, therefore it was not included to the model. This indicated that the chronic glomerulonephritis variable was not a significant predictor for the diagnosis of CKD at the late stage.

Table 5.20: A statistical test on the variables that could not be included in the model

Variables not in the Equation					
			Score	df	Sig.
Step 1	Variables	CGN(1)	2.958	1	0.085
	Overall Statistics		2.958	*1*	0.085

5.3.5 **Interpreting the residuals**

In order to identify any case that the model fitted poorly, the studentized residual, standard residual and deviance statistics were examined for values that were above ±2.5 and for cases that may exert an undue influence on the model the cook's distance, the leverage, and the DFBata for the three predictors variables were examined. An examination of the standard residual and deviance statistics for values above ±2.5 showed that none of the values was above ±2.5 (see

Appendix D) as residual values above ±2.5 indicate that the model is a poor fit of the dataset (Field, 2000, p. 123). In order to also confirm that less than 5% of the dataset had studentized residual values less than ±2, the outlier's standard deviation value set at 2 so that a casewise list of the studentized residuals with values above ±2 were listed. The SPSS output produced a table of 19 cases with studentized (the *ZResid* variable) residual values above ±2 representing 4.3% of the dataset and since this was less than 5% of the total dataset, there was no evidence that the model is a poor representation of the actual dataset (Table 5.21).

Table 5.21: Predicted Probability for stages of CKD at time of diagnosis with outliners cases

Casewise List[b]						
serial number	Case number	Selected Status[a]	Observed	Predicted	Temporary Variable	
			new CKD stage		Resid	ZResid
1	5	S	1**	.916	-.916	-3.293
2	11	S	1**	.916	-.916	-3.293
3	14	S	1**	.916	-.916	-3.293
4	15	S	1**	.916	-.916	-3.293
5	113	S	1**	.916	-.916	-3.293
6	125	S	1**	.916	-.916	-3.293
7	136	S	1**	.916	-.916	-3.293
8	252	S	1**	.916	-.916	-3.293
9	253	S	1**	.916	-.916	-3.293
10	256	S	1**	.916	-.916	-3.293
11	257	S	1**	.916	-.916	-3.293
12	258	S	1**	.916	-.916	-3.293
13	259	S	1**	.916	-.916	-3.293
14	316	S	1**	.916	-.916	-3.293
15	319	S	1**	.916	-.916	-3.293
16	322	S	1**	.916	-.916	-3.293
17	324	S	1**	.916	-.916	-3.293
18	326	S	1**	.916	-.916	-3.293
19	327	S	1**	.916	-.916	-3.293
a. S = Selected, U = Unselected cases, and ** = Misclassified cases.						
b. Cases with studentized residuals greater than 2.000 are listed.						

To determine if any of the cases were exacting undue influence over the parameters of the model in order to determine whether the regression model was stable across the dataset or was biased by a few

influential cases, the cook's distance, the leverage, and the DFBeta for the three predictors were examined. The cook's distance is a measure of the overall influence of a case on the model (Field, 2000) and it has been suggested that values greater than 1 may be a reason for concern (Cook and Weisberg, 1982). Another measure for influential cases is the leverage statistics, which gauges the influence of the observed value of the outcome variable over the predicted values. The leverage values can lie between zero indicating a case with no influence, to one indicating that the case has complete influence over prediction however, cases with large leverage values will not necessarily have a large influence on the regression coefficients because they are measured on the outcome variables instead of the predictors. The third method for measuring the influential cases is known as the DFBeta statistics in SPSS, it measures the difference between a parameter estimated using all cases and estimated when one cases is excluded from the dataset. In SPSS, the DFBeta, which is a standardized version of the Cook's distance statistics, is calculated for the constant and the predictor variables in the model and a value above one (1) indicates cases that influence the model parameters.

As mentioned earlier when the parameters for the model was set, the SPSS programme was instructed to save the values for the residuals for each case as variables in the dataset in order to carry out a residual diagnostics on the model. A case summary for the leverage and the DFBeta residuals for each predictor variable using the report option were created. The values for the leverage statistics were assessed for

values high (close to the value of one) however, none of the values were above 0.61. The values for the DFBeta residuals were assessed for values that were above one. However, none of the values in any of the DFBeta statistics for the predictor variables was greater than 1 therefore there were no cases that appeared to be exacting undue influence on the model (see Appendix E).

Although the model had a low classification percentage for predicting earlier stages of CKD at time of diagnosis, it had a 98.3% classification for cases at the late stage of CKD and the model was found to have an overall classification of 81.8% for predicting the stage of CKD at time of diagnosis. The logistic regression model can be regarded as a good representation of the dataset as the diagnostics of the residuals indicated that there were no outliners or influential cases within the dataset that could lead to a biased model. Since the values of the exp β for each predictor variables in the model were significant, it can be argued that the relationship found between these three predictor variable and the stage of diagnosis in this dataset is true for the whole population within Edo state.

In conclusion, if any of the three biological risk factors are absent in a patient, the odds of being diagnosed at the late stage of CKD are larger than the odds of being diagnosed at the earlier stages. This can be regarded as plausible as the presence of these risk factors in a person enables them to seek medical help early or if they are already undergoing treatment for these risk factors, their physicians may be

able to identify the development of CKD thereby diagnosing it at an earlier stage. Therefore, in the development of strategies that might help in the early diagnosis of patients, those without any previously known risk factors should equally be taken into account.

5.4 A time series analysis of CKD diagnosis in Edo state

There are awareness programmes that are sponsored by private and public organizations using the media, as well as grass-root initiatives, created to combat CKD within the country. There have been issues raised that the disease may have a current and future impact on the nation's health and economy. One such initiative within Edo state is the location of a free CKD screening centre in Ogbona ward of Etsako central LGA, which is at the northern part of the state, which began in 2008 and runs for 6 weeks each year. This initiative is led by the nephrology department of UBTH to reach out to the population that is too far from the hospital. The World Kidney Day is still the main CKD awareness programme currently running within the country to promote the awareness of CKD. As previously mentioned in chapter one, although there is no renal registry, the Nigerian Association of Nephrology (NAN) has stated that hospital records show that CKD accounts for 10% of medical admissions within the country (NAN, 2008). Apart from this report by NAN, there has been no other report or statistics to support or dispute this figure.

Before the World Kidney Day, which began in 2006, there have been previous attempts at making both the health officials and the general

public aware of the prevalence of CKD within the country (Akinsola et al, 1989) and in other nations around the world (Alebiosu & Ayodele, 2005; Jones et al., 1998; Jungers et al., 1996). However, the World Kidney Day in 2006 marked the first attempt at combating the disease from a global viewpoint and as such marked the choice for the start of the study period for this research study.

5.4.1 The trend of CKD within Edo state

To identify the impact of CKD in Edo State, there is the need to identify high CKD prevalence areas along with areas with low CKD prevalence and observe as well as analyse the changes within these areas over the years. However, before such spatial analysis can be done, there is the need to evaluate the trend of diagnosed CKD cases during the study period. One of the ways that the trend of CKD diagnosis can be assessed is by identifying the diagnosed CKD cases for each month from the time of the first globally recognised awareness programme for CKD in 2006, in which Nigeria took part. The result from the time series analysis was used to identify the trend of CKD diagnosed within the study period in the state. These results were cross-referenced with the geographical locations of the diagnosed patients thereby identifying areas where the disease likely had an impact as well as areas where there were little or no indications of diagnosed cases within certain times during the study period. These analyses will help the organizers of the healthcare delivery services to manage the impact of CKD across the state more effectively. The outcome could also enable them to create ways to reach out to the

general public so as to make them aware of the benefits of the prevention of CKD and the early detection of the disease if they already have it.

The date CKD diagnosis for each of the 442 CKD cases was recorded within their case file, which was included in the dataset as a time variable. These were totalled for each month. A time series analysis was carried out on the aggregated dataset. To reduce or remove any random fluctuations present within the time series, a moving average was used to smooth the dataset. A 3-month or quarterly moving average was used in order to identify the underlying trend of CKD diagnosis for each quarter within the study period.

The result of the time series analysis showed that there was an upward trend in the number of cases diagnosed each year, which is indicated by the red line on the chart below (see Figure 5.8).

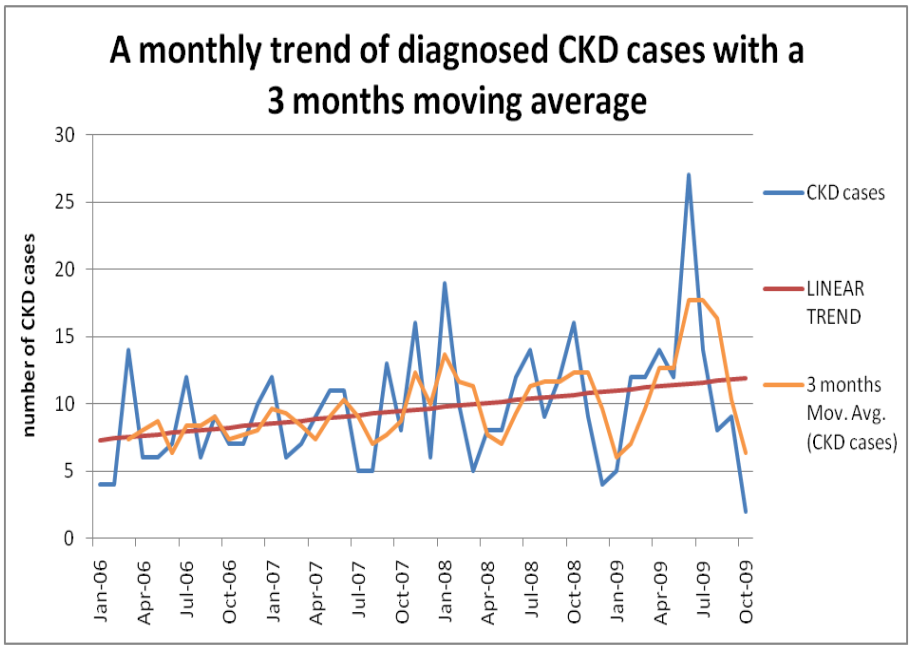

Figure 5.8: The trend of diagnosed CKD within the study period of 2006 to October 2009

The time series for the original dataset is represented by the blue line and as mention earlier, it appears to have a number of fluctuation within its pattern, which might be attributed to noise or variations within the dataset.

Using the 3-month moving average, the trend showed that there appeared to be an increase in the number of diagnosed cases followed by a drop in the number of diagnosed cases as one moves from one quarter to the next quarter with January within the thirteenth quarter (January 2009) registering the lowest number of cases within the series. However, the highest number of diagnosed cases was also registered in the same year within the fourteenth quarter in the month of July 2009.

To identify the geographical locations of the lowest and the highest number of diagnosed cases within the dataset, the date of diagnosis for

the patients represented within these two time periods were cross-referenced in the original dataset with the patients' corresponding Local Government Areas (LGA).

It showed that the month of January 2009 had a total of five cases (see Table 5.22) while the month of July 2009 had a total of 17 cases (See Table 5.23). Ikpoba-okha LGA had the highest number of cases within the month of January 2009 with just two diagnosed cases while the remaining three LGAs each had one diagnosed case. In July 2009, Ikpoba-okha LGA also had the highest number of diagnosed cases with a total of eight cases distributed among three wards within its boundaries.

Table 5.22: Frequency distribution of diagnosed CKD cases within the LGAs and corresponding wards in January 2009

LGA	Ward	number of diagnosed CKD cases
Ikpoba Okha	St. Saviour	2
Oredo	New Benin II	1
Esan West	Ekpoma	1
Egor	Uselu II	1
Total number of diagnosed cases		**5**

Table 5.23: Frequency distribution of diagnosed cases within the LGAs and their corresponding wards in July 2009

LGA	Ward	number of diagnosed CKD cases in the wards	Total number of diagnosed cases in the LGA
Ikpoba Okha	Geretti	5	8
	Iwogban	2	
	Ogbeson	1	
Oredo	New Benin II	1	2
	GRA	1	
Esan West	Ekpoma	1	2
	Uke	1	
Egor	Uselu I	1	2
	Uselu II	1	
Etsako West	Auchi I	2	2
Esan North East	Efandion	1	1
Total number of diagnosed cases		**17**	**17**

5.4.2 The impact of the World Kidney Day on the number of diagnosed CKD in Edo state

Studies carried out on the prevention and management of CKD suggest that the way forward is to focus on improving on the early detection of CKD in patients, such as carrying out routine screening (Bosa, 2006) and intensifying the awareness of CKD among the general public and the medical professionals. As mentioned earlier, the main route taken by the country to combat the disease was by raising awareness of CKD among the general public. One of the forerunners in this campaign was the initiation of the World Kidney Day (WKD) in 2006, in which Nigeria was among the first countries in Africa to participate (ISN, 2006). To mark the World Kidney Day, the Nephrology Association of Nigeria (NAN) along with charities affiliated with kidney diseases would organise a series of activities across the country. These include free kidney disease screening exercise, charity walks with kidney patients and health promoters, seminars and workshops, and audience participatory programmes on local radio and televisions stations (Nigerian Association of Nephrology, 2007).

During the period of this study, four World Kidney Days have been marked in Nigeria, on 9th March 2006, 8th March 2007, 13th March 2008, and 12th March 2009. Although free screenings were carried out during these periods, there were no diagnosed cases on these dates within the dataset used for this study. This might be attributed to the fact that during this event in Edo state, screened cases are referred

back to UBTH for more test before a diagnosis is made as such, there is the possibility that referred cases do not go to the hospital on the same day that they are screened. The preparations for the WKD usually includes a series of awareness campaigns especially with the use of the media – TV, radio and billboard advertisement, which usually begins several weeks before the actual date for the World Kidney Day. It is expected that these activities along with the actual WKD event should help increase the awareness of kidney disease even though some may argue that it would only hold the public's attention for a short time. However, it is expected that around this period, more people should be screened for CKD, which could potentially lead to more CKD diagnosis at this period each year. To determine the trend of CKD diagnosed around these periods, a time series analysis was carried out on CKD cases that were diagnosed between February and April each year from 2006 to 2009. In addition, a weekly aggregate of the diagnosed cases for the three months in each of the four years was created resulting in a 48-week dataset with a total of 106 diagnosed cases.

In order to smooth the result of the trend for the diagnosed cases within the time series, a 2-week moving average was calculated and plotted with the frequency of the diagnosed cases. The result of the 2-week moving average gave an overview of the trend of diagnosed CKD around the weeks that preceded the WKD events as well as the weeks that were after the events within the months that were analysed in the time series.

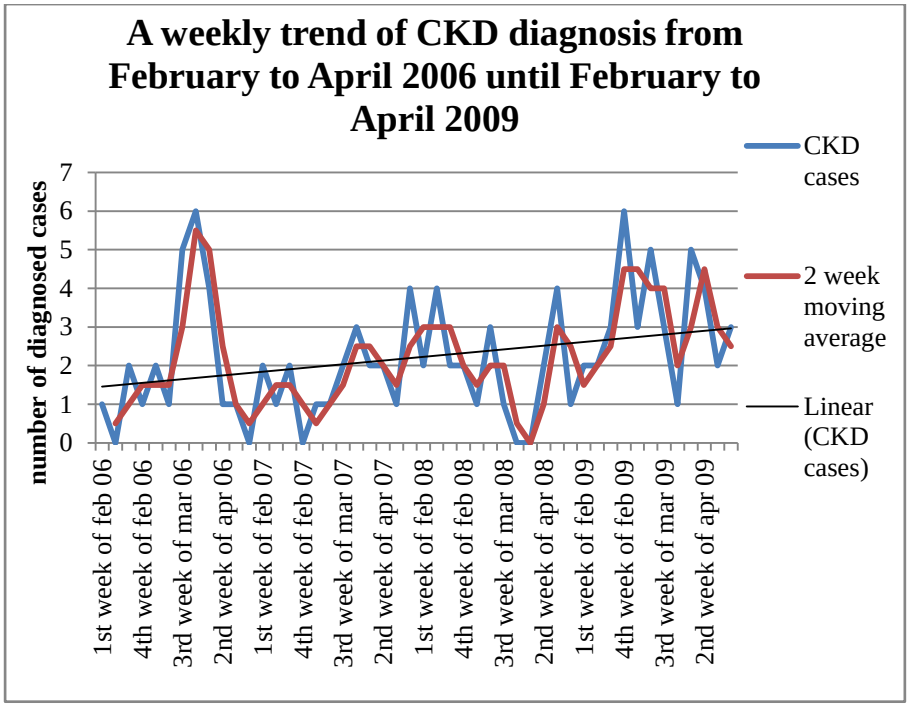

Figure 5.9: The trend for diagnosed CKD from February to April 2006 until February to April 2009

The result showed a steady increase in the number of diagnosed cases within the time periods (this is represented by the black straight line). The original time series (CKD cases) was represented by a blue line while the smoothed time series data, which is the 2-week moving average (represented by a red line). Using the 2-week moving average, the time series analysis indicated that there was a sharp rise in the number of diagnosed cases between the 3rd week of March 2006 and the 1st week of April 2006 (see Figure 5.9). This was followed by a sharp decline from the 2nd to the 4th week of April 2006; the number of diagnosed cases in 2007 around the same time period was rather low with just about half the number from the previous year. The number of diagnosed cases around the same period in 2008 showed a slight increase between the 1st and the 3rd week of February before recording a drop on the 4th week of February followed by a slight increase in the

2nd and 3rd week of March. The year 2008, recorded the lowest number of diagnosed cases amongst the four-time periods, as there was a sharp drop from the 4th week of March to the 1st week of April. The number of diagnosed cases in 2009 during the same time period was higher than the previous two years with a rise in the number of diagnosis from the 3rd week of February and the 1st week of March. There was however, a sharp drop in the number of diagnosed cases in the 4th week of March before sharply rising in the 1st week of April and peaking in the 2nd week of April.

To determine the frequency of the various stages of CKD among the diagnosed cases within these time periods, the stages of CKD for the 106 cases were cross-referenced with their corresponding months of diagnosis (see Table 5.24). The year 2006 had 24 diagnosed cases with one case classified as an unknown stage. Another case was diagnosed at stage 4 while the remaining 22 cases were diagnosed at stage 5 with the highest number of diagnosis recorded in March that year. The year 2007 had the first stage 2 cases diagnosed within that time period and this was in the month of March during the WKD period and the first stage 3 cases was also diagnosed that year in the month of February, a total of 21 cases were diagnosed within the months around the 2007 WKD. In 2008, no stage 2 CKD case was diagnosed but it registered the second stage 3 CKD case in February and a stage 4 CKD case in March, the remaining 20 cases were stage 5 cases. In 2009, there were a total of 39 cases, which was the highest number diagnosed within the four time periods. There was one stage 2

CKD and one stage 3 CKD cases diagnosed in February, however, within the three months there were a total of six stage 3 cases that were diagnosed while one stage 4 CKD was diagnosed in March and another in April.

Table 5.24: Diagnosed Stage of CKD within the months around the events for the World Kidney Day

	Diagnosed Stage of CKD within the months around World Kidney Days					
MONTHS	***Unknown***	***stage 2***	***stage 3***	***stage 4***	***stage 5***	***Total***
Feb 06	0	0	0	1	3	4
Mar 06	0	0	0	0	14	14
Apr 06	1	0	0	0	5	6
Feb 07	0	0	1	1	3	5
Mar 07	0	1	0	0	6	7
Apr 07	1	0	0	0	8	9
Feb 08	0	0	1	0	9	10
Mar 08	0	0	0	1	4	5
Apr 08	0	0	0	0	7	7
Feb 09	1	1	1	0	10	13
Mar 09	1	0	2	1	8	12
Apr 09	0	0	3	1	10	14
Total	**4**	**2**	**8**	**5**	**87**	**106**

The trend of diagnosed cases around these time periods indicated that there was a possibility that the awareness programme had an impact on the number of diagnosed cases each year especially just before and after the WKD. However, these impacts were usually short-lived as these increases in the number of diagnoses around these periods were usually followed by a decrease in the number of diagnoses within the following weeks or months. Although there are no studies on the trend of diagnosed cases before 2006, the common findings of previous studies have indicated that most cases have been diagnosed at the last stage of the disease (see section 1.1). A common belief among the nephrologists at UBTH was that the WKD had significantly improved

the number of diagnosed cases particularly at the earlier stages. Their belief was however misplaced since the findings above suggest this was not the case. It is therefore unlikely that the WKD had any serious impact on public awareness of CKD. Therefore a more permanent and consistent awareness programme should be put in place that can help make the general public and the health professional more aware of the issue of CKD within the state.

5.4.3 The CKD screening centre and the trend of diagnosed cases in Edo State

The University of Benin Teaching Hospital (UBTH), which is currently in charge of the treatment and management of CKD within the state, took on an initiative in 2008 to improve the awareness of CKD by offering free CKD screening for the public in the northern parts of the state. According to the nephrologists at the UBTH renal department who are in charge of the programme, part of the cost of running the screening centre is borne by the hospital while interested personnel within the renal department contribute the rest of the funds. They however, mentioned that the current model for the programme is being reviewed as the programme is too expensive to run and they are currently sourcing funds to keep the programme running. To notify the population residing within and around Ogbona community about the free screening programme, I was informed by management staff at the renal department that the people in Ogbona ward and surrounding communities are informed of the screening programme by their community leaders. They are also made aware of the programme by

UBTH medical staff that visit the areas before the programme starts and this is done usually by making announcements in public places, such as, markets and village squares within these areas.

The free CKD screening has run for 6weeks every year since 2008 but the dates each year changes due to different factors such as availability of funds from the hospital and medical staff of the renal department. In 2008 the screening ran between May and June for 6 weeks while in 2009, it ran between April and May for 6 weeks. There were no readily available documents to indicate the exact dates these screenings were carried out or the exact number of patients that were screened for CKD. This could be due to their assumption that every screened case that was positive for CKD was expected to travel down to Benin city to begin treatment at UBTH. However, none of the CKD cases used in this study showed any indication of being referred from the screening centre. Another reason could be that since the screening centre is part of the programme run by UBTH, it could be assume that the personnel that took down the diagnosed patients' details did not feel the need to indicate the screening centre as a CKD referral centre. Another assumption may be that the patient may have failed to indicate during the creation of his/her health file that he/she had been referred from the screening centre. However, these are just assumptions, which cannot be currently verified due to the nature of how the data was collected for the study. To evaluate how productive the availability of the free screening service is to the diagnosis of CKD within the state, a time series was carried out during the two

months in 2008 and 2009 when the screenings were known to have taken place. The diagnosed cases within the two months in 2008 and 2009 were aggregated into a weekly table, which was used to carrying out the time series analysis and the result was smoothed out using a two-week moving average. In order to identify the locations of diagnosed cases that were residing near the ward or LGA where the screening centre is located, the months used in the times series analysis were cross-referenced with LGAs and wards of CKD cases that were diagnosed during these months. This result gave an indication of the impact of the screening centre on the trend of CKD diagnosis within the state.

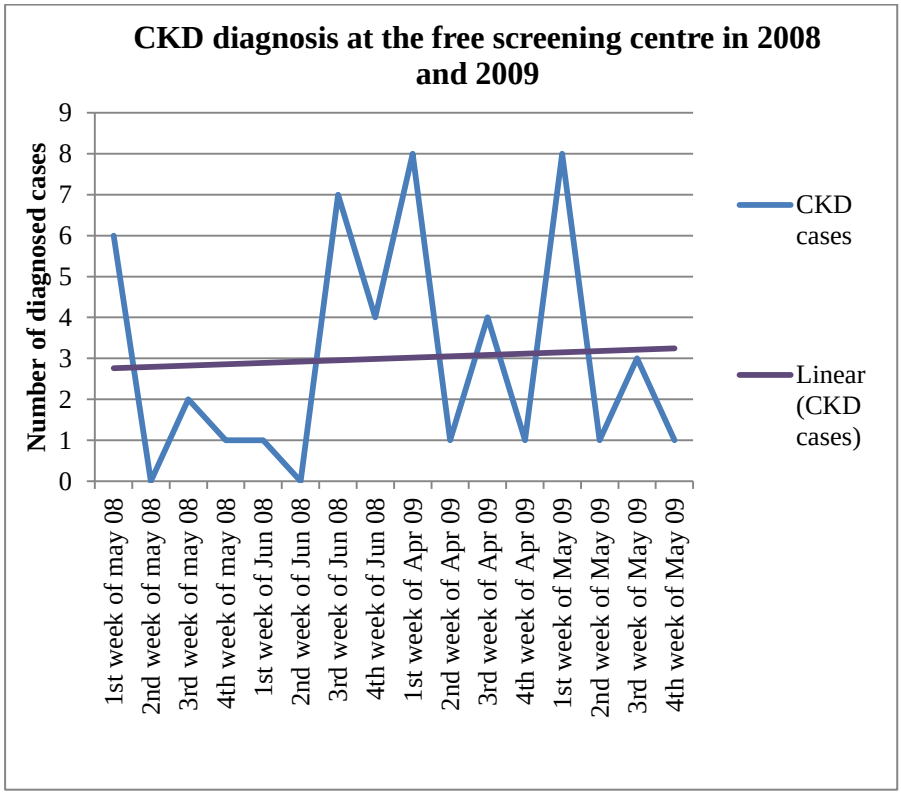

Figure 5.10: The trend of diagnosed CKD during the dates when the CKD screening centre gave free renal screening in 2008 and 2009

A total of 48 cases were diagnosed during the two annual screening sessions and these were aggregated into their corresponding week of diagnosis with a total of 16 weeks used for the analysis. The trend in the number of diagnosed cases during the two screening sessions showed a very slight increase across the two periods (see Figure 5.10) with the lowest number of diagnosed cases recorded between the 3rd week of May 2008 and the 2nd week of June 2008. The highest number of diagnosed cases was recorded in the 1st week of April 2009.

However, only two LGAs near the LGA where the screening centre was located, recorded any diagnosed cases during the screening periods (see Table 5.25). These were Esan North East and Esan West LGAs, with the closest LGA being Esan North East having one case diagnosed in the Efandion ward (see Table 5.26) in May 2008 and two cases both from the Uromi ward diagnosed in May 2009. The Esan West LGA had a total of six diagnosed cases recorded during the screening periods all of which were residing within Ekpoma ward. The remaining LGAs and their corresponding wards that had patients, who were diagnosed during the screening periods, were located closer to UBTH and these are located either within or around Benin City and as such they were not likely to have travelled up north to the screening centre to take part in the screening exercise.

The three wards that were located close to the screening centre are known to have urban towns within their boundaries, which might

explain the number of diagnosed cases registered within these wards. Given the absence of diagnosed CKD cases referred from the screening centre within the dataset, one might argue that the screening centre may be failing in its attempt at reaching out to the northern part of the state where majority of the rural areas are located. Giving the limited data or information on the number of diagnosed CKD cases from the screening centre during the course of this study, none of these assumptions could be readily verified. Therefore, an examination of the impact of the screening centre on it surrounding areas needs to be investigated further before a final decision can be made.

Table 5.25: The LGAs of the cases that were diagnosed during the period of the screening exercises in 2008 and 2009

LGA	May 08	Jun 08	Apr 09	May 09	Total
Egor	1	4	1	1	7
Esan north east	1	0	0	2	3
Esan West	1	3	1	1	6
Ikpoba Okha	3	4	8	7	22
Oredo	2	1	3	1	7
Ovia North East	1	0	1	1	3
Total	***9***	***12***	***14***	***13***	***48***

Table 5.26: The wards of the cases that were diagnosed during the period of the screening exercises in 2008 and 2009

Wards	May 08	Jun 08	Apr 09	May 09	Total
Aduwawa	0	0	1	2	3
Efandion	1	0	0	0	1
Ekpoma etc	1	3	1	1	6
Geretti	3	3	6	2	14
GRA	0	1	1	0	2
Igushodin	1	0	0	1	2
New Benin I	0	0	1	1	2
New Benin II	2	0	1	0	3
Ogbeson	0	0	1	1	2
Oregbeni	0	0	0	1	1
St. Saviour	0	1	0	0	1
Ugbeku	0	0	0	1	1
Ugbowo	1	0	1	0	2
Uromi	0	0	0	2	2
Uselu II	0	1	0	1	2
Utoka	0	0	1	0	1
Uwelu	0	3	0	0	3
Total	***9***	***12***	***14***	***13***	***48***

5.4.4 The proportion of diagnosed earlier stages of CKD and late stage of CKD across Edo State

Section 5.2.2 of this chapter has already established that there has been a steady increase in the number of early cases that were diagnosed between 2006 and October 2009 although the number of patients for 2009 is just from January to 14th October. However, there is still a large margin between the number of diagnosed cases with earlier stages of CKD and late stage of CKD. For the purpose of this analysis, the cases defined as early stage CKD were those diagnosed with stage 2 to stage four between January 2006 and 14th October 2009 (discussed earlier in section 5.2).

To identify areas that registered the presence of diagnosed CKD within their boundaries, the number of CKD cases within the wards in relation to the patients' stages of CKD at the time of diagnosis was examined. New Benin II and Geretti wards both had the highest

number of stage 2 CKD (with three cases), which is the earliest stage of the disease that has been diagnosed within the hospital while Uselu II ward, Ugbeku ward, Ogbeson ward, Obayantor ward, Otoruwa II ward, and Auchi ward each had a single stage 2 CKD case. For patients diagnosed with stage 3 CKD, it was observed that Geretti ward had the highest with five cases, Uselu I ward with four cases, New Benin II and Uwelu wards both had three cases respectively. Geretti ward had seven cases while Uselu I ward had three patients diagnosed with stage 4 CKD. A total of twelve cases were diagnosed with stage 2 CKD, stage 3 CKD had a total of thirty-eight diagnosed patients while a total of twenty-seven cases were diagnosed with stage 4 CKD. There were a total of eighty-eight early CKD stage cases from 2006 until October 2009 and Geretti ward had the highest number of cases diagnosed at an early stage with a total of eighteen cases followed by Uselu I ward, which had ten cases and New Benin II ward with eight cases (see Appendix F).

In summary, it can be observed that the distribution of diagnosed CKD patients indicate that most cases are concentrated within the urban areas, which brings up the question of why are most rural areas are still showing little changes in the number of diagnosed CKD cases. Another question, which the distribution of these cases raises, is whether the presence of these diagnosed cases was attributed to the impact of these awareness programmes that are currently active within and outside the state or whether it might be attributed to other factors. One could argue that due to the high number of stage 5 CKD cases

being diagnosed, there is the possibility that most medical health officials may not have the necessary skills required in the early diagnosis of CKD until the patients' condition worsens. However, there is still the possibility that the diffusion of information from a diagnosed patient(s) and their families to other members of their communities might have contributed to the increase of diagnosis within certain areas. All these assumptions can only be verified or rejected after further study has been carried out on the matter.

The results of this analysis indicated that the number of diagnosed CKD cases within the state appeared to be higher within the urban areas than in the rural areas since the number of diagnosed patients appeared to be concentrated mainly within the urban areas and not within the rural areas. Although this spatial pattern is analysed further against the underlying population within the LGAs and the wards (see chapter six), one could argue that the rural areas may not be adequately informed about the impact of the disease and this may account for the low number of diagnosed cases within these areas. One would therefore recommend that adequate CKD awareness programmes should be put in place that will be tailored to reach out to the rural areas probably in the native dialects of these areas as well as create training programmes for the health officials within the rural areas on the awareness of CKD and how it can be identified in patients.

Table 5.27: The frequency distribution of diagnosed stages of CKD from 2006 to October 2009

		Year Of Diagnosis				
		2006	2007	2008	2009	Total
Stage of CKD	Unknown	2	1	2	6	11
	stage 2	0	2	4	6	12
	stage 3	4	3	11	20	38
	stage 4	3	5	7	12	27
	stage 5	82	96	103	73	354
Total		91	107	127	117	442

5.5 Summary

The results of the statistical test on the association of the socio-demographic variables with the stages of CKD indicated that none of the socio-demographic variables was statistically associated to the stage of CKD at the time of diagnosis (see section 5.2.1 above).

Out of the four biological risk factors that were present in the CKD dataset, the only risk factor that was not significantly association with the stage of CKD at the time of diagnosis for a CKD patient was chronic glomerulonephritis. The other three risk factors were all highly significant in their relationship with the stage of CKD at time of diagnosis and they were found to be significant predictor variables in the regression model for the possibility of predicting the stage of CKD for a patient in Edo state. The forced entry method and the forward stepwise selection method of the logistic regression model both identified diabetes, hypertension, and toxic nephropathy as predictors of the severity of CKD at time of diagnosis. The results from this model indicate that there is a possibility that patients that develop CKD without previously being diagnosed with any of these biological risk factors are more susceptible to late diagnosis of CKD.

This statement was also supported by the positive coefficients associated with predictor variables for these biological risk factors. This finding supports other studies, which have already identified the presence of diabetes, hypertension, and toxic nephropathy as indicators for the likelihood of developing CKD (refer to literature review). This outcome has important implications for formulating renal health policies and designing research studies within the population. Therefore, in the development of strategies that might help in the early diagnosis of patients, this category of patients (i.e. those without any previously known risk factors) should equally be taken into account.

I should mention at this point that interaction variables such as an interaction variable for occupation and age or marital status and age, were excluded from the model, as neither of these variables were significant from the onset. In addition, other possible interactions could not be included within the model due to the presence of redundancies within the data when they were included. This could be attributed to the low sample within the categories of some of these variables.

The result from the time series analyses indicated that the number of diagnosed CKD cases within the state was increasing and this might be partly attributed to the awareness programme (WKD), which appeared to have an impact on the number of diagnosed cases recorded at certain times each year. However, these impacts were

usually momentary as the increase in the number of diagnoses around these periods was usually followed by a decrease in the number of diagnoses within the following weeks or months. This indicated that the impact of the awareness of CKD during the WKD was not strong enough at raising the awareness of CKD within the state. Therefore a more permanent and consistent awareness programme should be put in place that can help make the general public and the health professionals more aware of the issue of CKD within the state.

Chapter 6 Spatial pattern of chronic kidney disease (CKD) within Edo State

6.1 Introduction

This chapter addresses the fifth research question outlined at the beginning of this study:

"What is the spatial pattern of diagnosed CKD cases within Edo state?"

In this chapter, the spatial distribution of the disease across the study area was analysed in order to identify the areas where there are high and low numbers of diagnosed CKD cases. To determine the spatial pattern across the state, two main analyses were carried out on the geocoded CKD dataset.

The first section of this chapter began with the evaluation of the diagnosed rate of CKD across the state. This was calculated for each of the LGAs within the state. The spatial distribution of CKD across the wards showed that only 54 wards out of the 194 wards, registered the presence of CKD within their boundaries (see Figure 4.7). This meant that just 27% of the wards within the state had patients that were diagnosed with CKD from 2006 to October 2009. Therefore, it was not practical to produce a spatial distribution of the diagnosed rate of CKD across the wards.

The second section focused on the point analysis of CKD cases using the kernel density estimate to evaluate the spatial distribution of CKD cases within the state. This involved the analysis of the distribution of CKD cases in relation to their underlying population to determine the areas of high and low density of diagnosed CKD cases across the state.

The spatial distribution based on the outcome of both analyses could give an indication of the areas with high and low counts of the disease within the state as well as highlight areas of concern, which might explain the absence of diagnosed CKD cases within certain areas. The results from these analyses could provide more insight into the spatial distribution of diagnosed CKD within the state that would be useful in the creation of a suitable health policy that would be relevant for CKD management within the state.

6.2 The rate of diagnosed CKD in Edo state

It is apparent from various studies carried out on the prevention and management of CKD that the way forward is to focus on improving on the early detection of CKD in patients, such as carrying out routine screening (Bosa, 2006) and intensifying the awareness of CKD among the general public and the medical professionals. The main route taken by the country's health policy to combat the disease was by raising awareness of CKD among the general public. As discussed in chapter one, one of the forerunners in this campaign was the initiation of the

World Kidney Day in 2006 in which Nigeria was among the first countries in Africa to participate (ISN, 2006).

Although the identification and geographical location of the CKD patients gives an idea of the impact of the disease within the state, it is however, essential to assess the impact of the disease in relation to the population at risk within both the LGAs as well as the wards. Therefore, the population at risk of CKD had to be determined. It should be noted that although the age group recorded among the CKD patients ranged from 10 years to above 80 years (see Table 4.16), past studies have shown that CKD also occurs among younger children (Olowu, 2003; Mak and Bakris, 2010; Saland et al., 2010). Based on this notion as well as the outcome of the analyses carried out in section 5.2.1, the total population was regarded as the population at risk for CKD regardless of their sex or age group. Due to the limited resources available for the management of healthcare services within the state, it can be argued that the use of the state's population as the population at risk might not be very realistic. However, there is currently not enough evidence to identify those that are at a higher risk of CKD without clinically identifying those that have one of the known biological risk factors that are currently associated with CKD (discussed in section 5.5). Therefore, the outcome of the analysis based on the use of the whole population as the population at risk can be regarded as a baseline for determining the prevalence of CKD within the state.

In order to evaluate the diagnosed rate of CKD, the most recent census data on Edo state was used. As the study period was for CKD cases diagnosed from 2006 to 2009, the census data for 2006 was used as the risk population. The analyses were carried out using ArcMap in ArcGIS® and the results were displayed using a quartile classification to determine a four-class interval.

6.2.1 **The diagnosed rate of CKD within the LGAs**

In order to display the results of the diagnosed rate of CKD within the LGAs in the state, the number of diagnosed CKD cases within each LGA from 2006 to 14th October 2009 was determined and divided by the corresponding estimated population of their LGA. The diagnosed rate for CKD per 100000 of the population within each LGA was determined by multiplying the result for the diagnosed rate of CKD within each LGA by 100000.

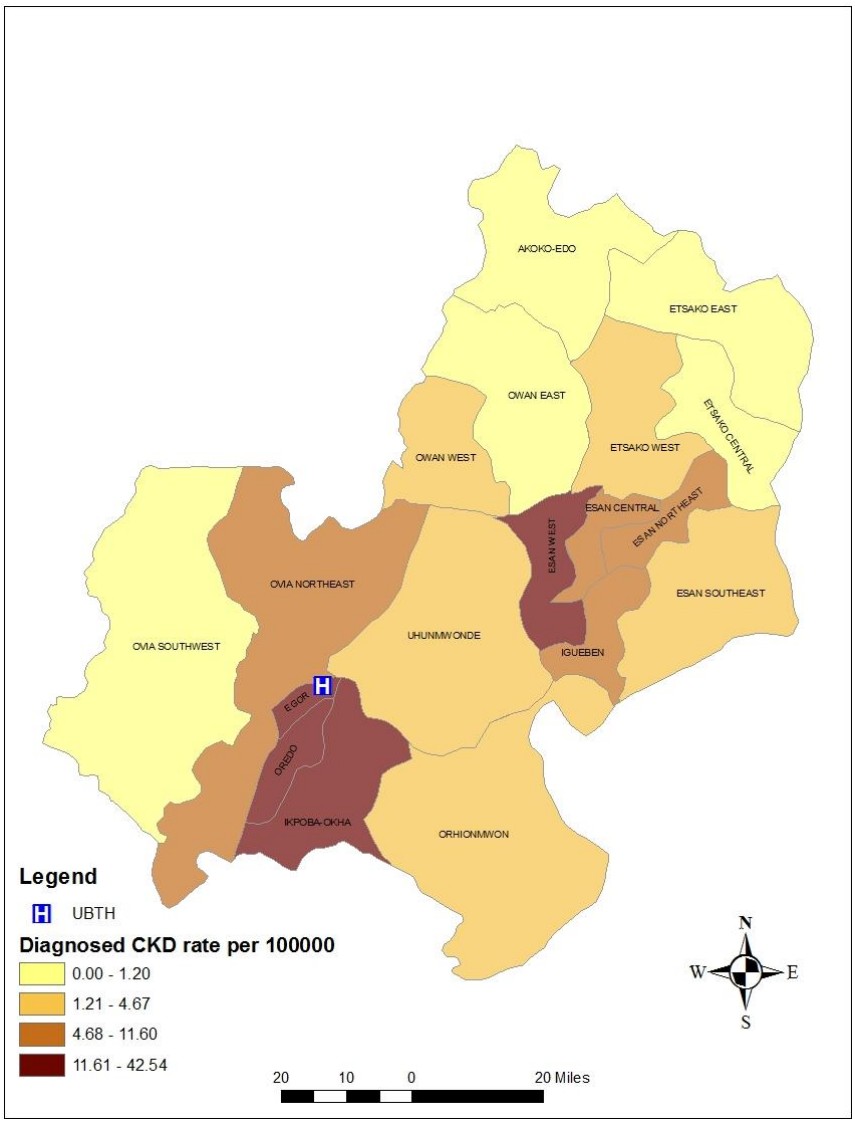

Figure 6.1: Diagnosed rate of CKD across the LGAs from 2006 to 14th October 2009 in Edo state

The diagnosed rate of CKD per 100000 across the eighteen LGAs in Edo state showed that four LGAs were classified within the upper quartile. Ikpoba-Okha LGA had the highest diagnosed rate with a total of 42.54 per 100000, Oredo LGA had 22.18, followed by Egor LGA with 21.46 while Esan west LGA had 16.87. The results showed that five LGAs were classified within the lower quartile (see Figure 6.1). However, there appears to be a considerable variability within the

results and this could be attributed to the small sample size (442 cases) that was used to estimate the diagnosed CKD rates for the study area.

Research indicates that estimates based on finite population sampling tend to be unstable due to the use of small samples especially within small areas (Farrell et al., 1997). Therefore, the variability present within the results of the spatial distribution of CKD rates within the LGAs might likely have errors associated with small sample sizes, which are sometimes called “the small area problem” (Anselin, 2003 p.60). In order to take into account the small CKD counts within the LGAs and correct the variance instability of the CKD rate, a smoothing procedure was applied. The smoothing technique used in this analysis was the Empirical Bayes estimation. This smoothing technique has been found to be useful in the estimation within small areas with populations at risk (Anselin, 2003; Farrell et al., 1997). The technique applies the estimation of the mean value of the rates in each area using the *method of moments* (Anselin, 2003; Bailey and Gatrell, 1995). The technique basically involves borrowing information from an area's neighbours, and generating an adjusted estimated CKD rate based on the average value of the area of interest and the overall mean of the study area (i.e. the global mean).

The GeoDa software was used to perform the Empirical Bayes estimates and a box map, which is a type of quartile map, was set as the map theme. The preference of the box map in this analysis is that it ensures that the resultant map highlights any outliers present within

the smoothed CKD rates. The values are classified as outliers if they are 1.5 times higher than the interquartile range (IQR)[27].

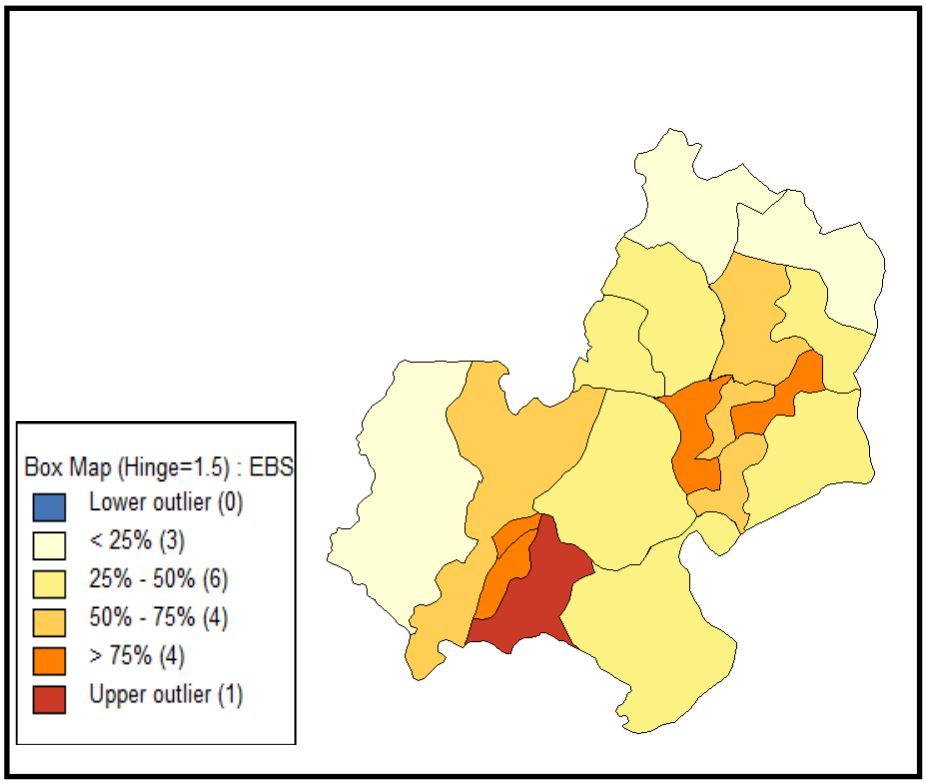

Figure 6.2: Empirical Bayes estimates of CKD morbidity in Edo state, highlighting the CKD rate within Ikpoba-Okha LGA as a high outlier

The spatial CKD pattern generated using the Empirical Bayes estimates, is broadly similar to the map for the crude rates. However, Ikpoba-Okha LGA has been identified as an outlier due to the relatively high rate recorded within its boundaries. In addition, Esan Northeast LGA has now been classified within the upper quartile once the outlier was taken into account. According to the CKD dataset, there was no diagnosed CKD case within Etsako-East LGA. However,

[27] Interquartile range IQR is the difference between the 75th percentile (Q3) and the 25th percentile (Q1) or Q3-Q1. It describes the range of the middle of the distribution since 25% of values are above the interquartile range and 25% below it (Anselin, 2003).

it was not classified as an outlier. This could be attributed to very low rates recorded within the lower quartile.

Although the UBTH hospital is located in Egor LGA, Ikpoba-Okha and Oredo LGAs both have a close proximity to Egor LGA. However, there may still be other factors that may account for the high rate of diagnosed CKD among these LGAs. The issue of the proximity of these LGAs to UBTH does not support the reason for the relatively high diagnosed CKD rate within Esan-West LGA and Esan-Northeast LGA, as they are not near UBTH. Neither was there any indication within the UBTH renal unit's health records stating that any health centre within Esan-West LGA and Esan-Northeast LGA referred patients to UBTH for diagnosis or treatment. Therefore, in order to determine if there is a significant association between diagnosed CKD cases and their accessibility to available healthcare, the geographical accessibility to the hospital is examined in chapter seven.

Although no CKD was diagnosed within the Etsako-East LGA, this does not necessarily rule out the possibility of CKD within the area. However, it brings up the subject for further investigation into that area as there is the possibility that there may be cases within that area that may not be diagnosed until it is too late.

The diagnosed rate of CKD within the LGAs showed that the rate of the disease was higher within the boundaries that contain urban settlements in comparison to those located within rural areas. This is made evident by the fact that Egor LGA, Ikpoba-Okha and Oredo

LGAs, all have Benin City located within their boundaries while Ekpoma town as well as the Ambrose Alli University is located within Esan West LGA and Uromi town is located within Esan Northeast LGA.

6.2.2 **Prevalence of CKD within the state**

Having determined the diagnosed rate of CKD within the LGAs, the period prevalence of diagnosed CKD using the CKD data for the study was calculated. This result would provide the estimated prevalence of diagnosed CKD within Edo state as this has not been calculated nor has any information on CKD at the state level been made available to the public. The period prevalence of CKD was carried out to estimate the proportion of the state's population that had been diagnosed with CKD over the study period, which was from 2006 to 2009. The population data that was used for this analysis was the census population for 2006. For comparative purposes, the period prevalence was estimated per million persons (pmp).

Period prevalence (pmp) = total CKD cases ÷ 2006 population for Edo state × 1000000

Period prevalence = 442 ÷ 3233366 × 1000000

Period prevalence = 137 pmp

The result indicated that within 2006 to 2009, it was estimated that the period prevalence of diagnosed CKD within Edo state was approximately 137 CKD cases per million persons. This result

appeared to be similar to the prevalence of CKD in central India, which was 181 per million population (Rajapurkar and Dabhi, 2010). The diagnosed CKD prevalence for the last stage of CKD within the dataset was also calculated which was estimated at 109 cases per million persons. The result of the prevalence of diagnosed CKD at the late stage appears to be lower than an estimated prevalence of 500 per million for Nigeria (Kidney Consultants International, 2007). This result indicates that the prevalence of stage 5 CKD in Edo state is likely to be lower than the national prevalence of stage 5 CKD.

6.3 A point pattern analysis of CKD cases in Edo state

As discussed in section 2.9, there have been a number of studies that have evaluated the spatial distribution of CKD and its associated outcomes within different regions particularly in Europe and USA. However, there is presently no known literature within Nigeria that has attempted to evaluate the disease from a spatial perspective.

In order to examine further the spatial distribution of CKD within Edo state, an estimation of the high and low density areas of diagnosed CKD within Edo state was carried out. This section discusses the analysis of the spatial distribution of the 442 CKD cases in relation to the underlying population within the study area so as to identify any pattern. A spatial statistics method (Moran's *I*) was applied together with a spatial analysis tool (kernel density estimation) in a GIS environment and these were used to analyse the spatial autocorrelation of the spatial distribution and the varying density of diagnosed CKD

cases across Edo state. The Moran's *I* and the density maps were created using CrimeStat® (Levine, 2004) and the results were displayed using ArcMap in ArcGIS 10® as the GIS platform.

6.3.1 Spatial Autocorrelation of CKD in Edo state

The concept of spatial autocorrelation indicates that events from locations near one another in space are more likely to be similar than events from locations remote from one another (Cliff and Ord, 1973). Spatial autocorrelation may be classified into three main groups namely - positive autocorrelation, negative autocorrelation, or noncorrelation / zero autocorrelation (O'Sullivan and Unwin, 2003). Positive spatial autocorrelation occurs when all similar observations are clustered together, while negative spatial autocorrelation occurs when observations from nearby locations appear to be different from each other. The zero auto correlation occurs when no spatial effect or pattern is noticeable and observations appear to vary randomly across the study area (O'Sullivan and Unwin, 2003). In order words, when no statistically significant spatial autocorrelation exists, the pattern of spatial distribution is considered random.

Therefore, before attempting to evaluate the spatial pattern of CKD within the state, the degree of autocorrelation present in the CKD pattern across the state was assessed. This is because the statistics of spatial autocorrelation provides a useful indicator of spatial patterns.

To accomplish this, a global spatial autocorrelation method known as Moran's I (Moran, 1950) was used to test whether the CKD cases

within the study area were spatially correlated or not. The Moran's *I* statistic is regarded as one of the oldest indicators of spatial autocorrelation and it is applied to zones or points (Levine, 2007). Since the Moran's *I* measures spatial autocorrelation based on feature locations and attribute values i.e. aggregated data, the dataset with the lowest aggregation size, which is the CKD cases at the ward level was used to compute the Moran's *I* statistic. However, the areas within the wards that had no diagnosed CKD case residing within their boundaries were also taken into account during the computation of the Moran's *I*. The values within these areas were classified as missing values and this was to ensure that only the wards with registered CKD cases were used in the analysis. I would add that due to the inability to verify whether the areas within the wards that had no diagnosed CKD case could be classified as missing values, I ran the analysis again including the areas within the wards that had no diagnosed CKD case and I arrived at a similar result. Strictly, the value of Moran's *I* is not constrained to ranges between -1.0 and +1.0. However, they can be adjusted to fall within the (-1,1) range (Bailey and Gatrell, 1995). When an observed Moran's *I* value is below the expected value of Moran's *I*, this indicates a negative spatial autocorrelation. A value that is negative and close to zero or equal to the expected Moran's *I* would indicate a spatially random pattern.

Results from the Moran's *I* test on the distribution of CKD cases across the wards in Edo state indicated that a positive spatial autocorrelation exists among CKD incidence within the study area.

The result for the Moran's *I* for CKD cases was 0.27 ($p<0.001$) while the Z score was 9.94. The result indicated that the spatial distribution of CKD cases in the area was more spatially clustered than would be expected if underlying spatial processes were random. Table 6.1 shows the result of Moran's *I* analysis. This suggested that CKD cases were positively spatially autocorrelated, which meant that wards with many CKD cases tended to be located close to wards that also had many CKD cases and, equally, wards with few cases tended to be located close to wards, which also had few cases. Therefore, it can be argued that the spatial pattern of CKD within the state is not randomly distributed. Given the significance of the result for the spatial autocorrelation, the spatial distribution of CKD within the state was evaluated further to draw out inferences from the outcomes of the spatial analyses of the CKD patterns within the state.

Table 6.1: The result of the spatial autocorrelation of CKD cases at the wards level- using Moran's 'I' statistics

Spatial Autocorrelation (Global Moran's I)	Value
Moran's I index	0.27
Z Score	9.94
significance level	0.001
Expected value	-0.005

6.3.2 **Kernel density estimation of CKD in Edo State**

Although the distribution of CKD cases within the state had already been aggregated and analysed in section 6.2 and also analysed above for spatial autocorrelation at the ward level, there are studies that have highlighted problems associated with the use of aggregated data (Duque et al., 2006; Holt et al., 1996; Jelinski and Wu, 1996). One of

the known problems associated with spatial analysis using aggregated data is the modifiable areal unit problem. The modifiable areal unit problem (MAUP) tends to occur when a more detailed dataset is aggregated to a less detailed dataset. As a result, any pattern that is observed across the various boundaries within the study area may be due to the function of the type of boundary chosen, as well as the underlying spatial distribution of attribute values (Bailey and Gatrell, 1995). For example, data collected on individuals might be aggregated to the neighbourhood level, ward level, state, or national level and when the original data are aggregated, the values for the various parameters used during the data collection will change because of the loss of information.

To adequately explore the CKD pattern and avoid the modifiable areal unit problem (MAUP), the kernel density estimation (KDE) technique was used to create a density map of diagnosed CKD cases in Edo state. As mentioned earlier in chapter three, *KDE is a non-parametric method of extrapolating point data over an area of interest without invoking MAUP or relying on fixed boundaries for aggregation* (Carlos et al., 2010 p.2). This involves placing a proportional surface over each point, calculating the distance from the point to a reference location based on a mathematical function, and summing the value of all the surfaces for that reference location. Then the procedure is repeated for all the reference locations within the study area (Levine, 2004).

The density maps were created using CrimeStat® (Levine, 2004) and the results were displayed using ArcMap in ArcGIS 10® as the GIS platform. In order to make use of a linear unit of measure during the analysis within CrimeStat, the geocoded dataset (see chapter three for details) was projected using the WGS 1984 UTM Zone 31N Projected Coordinate Systems before they were uploaded in CrimeStat for analysis. For the purpose of this study, the unit of interest was in miles, therefore, the areas and distances computed were computed using that unit.

Selection of kernel function / Method of Interpolation

To determine the most suitable function for the spatial pattern of the CKD cases, a Moran correlogram was plotted using the spatial autocorrelation tab in CrimeStat. The shape of the Moran correlogram and the spread is a good indicator of the type of kernel function to use (Levine, 2004). The Moran's correlogram involves plotting the indices of the Moran's *I* statistic at different distance intervals in order to indicate the distribution of the spatial autocorrelation of the dataset. To ensure that the *I* values for cases that were spatially close did not become exceptionally large or small, the small distances were adjusted therefore the maximum weighting was set at one. The Moran's correlogram was set to run 10 different distance intervals (this was the default) and to calculate approximately the confidence intervals around the *I* value, a Monte Carlo simulation, which inputs random data and calculates the "I" value was set to run 100 simulations.

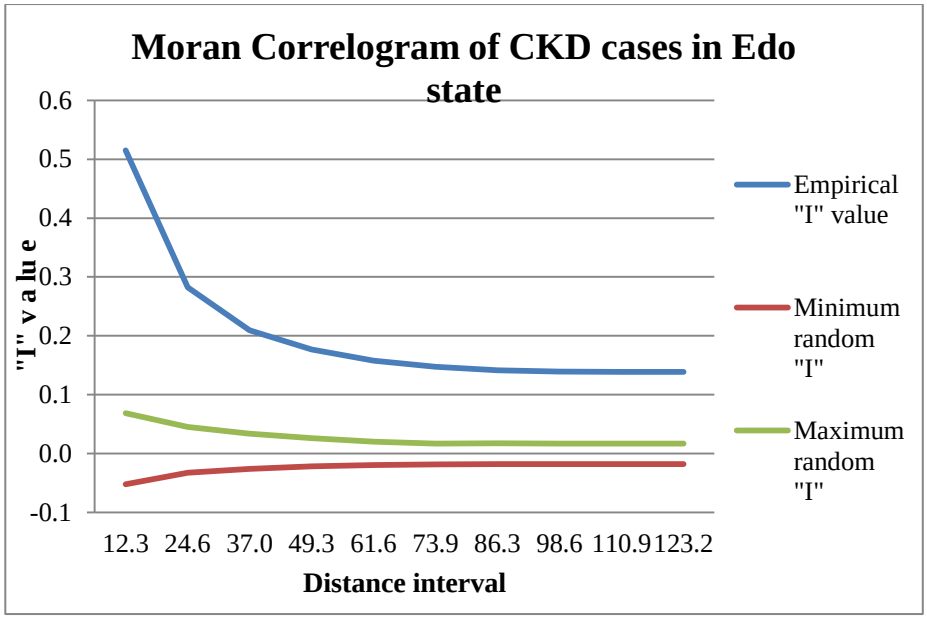

Figure 6.3: Moran's correlogram of CKD cases in Edo state

The plot of the Moran's correlogram indicated that the *I* value at distances of about 12.3 mile had the highest value of 0.5. As the distance increased (i.e., the search circle radius got larger), the *I* value dropped off until about 61.2 miles whereupon it approached the global *I* value. However, for all distance intervals, the empirical *I* value was higher than the maximum simulated *I* value with random data (Figure 6.3). This meant that because of the distribution of random *I* values, the empirical *I* values obtained for each of the distance intervals was not likely due to chance. A general overview of the plot indicated that the CKD appeared to be clustered at small distances but gradually dispersed as the distances between them increased.

The shape of the Moran correlogram and the spread, which is a good determinant of the type of kernel function to use, indicated that the quadratic kernel function was the most suitable function to use. This is because the quadratic kernel function applies added weight to CKD

cases closer to the centre of the bandwidth. It weights near points more than far points, but the fall off is gradual. The equation for the quadratic kernel function within a specified radius is shown below:

Equation 6.1 : A formula for a quadratic kernel function

$$g(x_j) = \sum \left\{ [W_i * I_i] * \left[\frac{3}{h^2 * \pi} \right] * \left[1 - \frac{d_{ij}^2}{h^2} \right]^2 \right\}$$

Source 6:1 CrimeStat manual: -
http://www.icpsr.umich.edu/CrimeStat/files/CrimeStatChapter.8.pdf

where $\mathbf{d_{ij}}$ is the distance between the location of an event (e.g. CKD case) and any reference point in the region, **h** is the radius of the search area (the bandwidth), $\mathbf{W_i}$ is a weight at the point location (e.g. number of CKD cases) and $\mathbf{I_i}$ (e.g. the number of population at risk) is an intensity at the point location.

Choice of bandwidth

There are two main choices of bandwidth that can be used in kernel density estimation, the fixed, and the adaptive bandwidths. Due to the variation in the distribution of diagnosed CKD cases across the study area, the adaptive bandwidth was used instead of the fixed bandwidth. This is because the adaptive bandwidth adjusts the bandwidth interval so that a minimum number of points are found and 'this has the advantage of providing constant precision of the estimate' over the study area (Levine, 2004, p. 8.15). Therefore, in areas that have a high concentration of points, the bandwidth is narrow whereas in areas where the concentration of points is more dispersed the bandwidth will be larger (Carlos et al., 2010; Levine, 2004). Given the sparse

distribution of the CKD cases outside the state's capital – Benin City, the sample size of the bandwidth interval was set to a minimum of 10 points per square mile within the bandwidth radius. The choice of using 10 cases as the minimum sample size was an attempt at identifying areas with a number of cases particularly outside the state's capital, which had a relatively high density of diagnosed CKD cases.

6.3.2.1 *Kernel Density Estimates of CKD cases in relation to Edo state's population*

The possibility of CKD patients travelling to other renal units in neighbouring states is not an option within Edo state because UBTH is currently the only health institution responsible for the treatment of CKD within the Niger-delta region. This therefore rules out the possibility of 'edge effects' around the state's boundary.

It was necessary to examine the density of CKD in relation to the underlying population and not just the concentration of the cases across the study area. This is because health outcomes generally involve people and the spatial patterns of these outcomes are likely to reflect the spatial distribution of the underlying population (Carlos et al., 2010). However, the inclusion of the underlying population or the population at risk requires a prior knowledge of the category of people that are susceptible to the health outcome that is being studied. In the case of CKD, while there have been studies that have noted some variation in the diagnosis of the disease between the males and females, the disease is not determined by sex (e.g. prostate cancer in

men and ovarian cancer in women). In regards to age, although there have been studies that have identified the prevalence of CKD within various age groups of the adult population, the disease is also diagnosed among children (Saland et al., 2010; Mak and Bakris, 2010; Staples et al., 2010). According to the 2010 USRDS Annual Data Report, the incidence in the United States of end-stage renal disease (ESRD) or the last stage of CKD in young people ages 0 - 19 years is 109 per million people (USRDS, 2010). As discussed in section 6.2, due to presence of the disease in both sexes and across the various age groups, the population at risk cannot be currently adjusted by sex or age therefore the whole population for the study area was used as the population at risk.

Choice for a GIS based population data for the underlying population in Edo state

The majority of the population datasets used in GIS analyses are in polygon format with a population count allocated to each polygon. These polygons are often irregular in shapes and sizes, and they lack data about how people are geographically dispersed within the polygon (Carlos et al., 2010). An alternative to polygon based population data is the LandScan™ 2008 Global Population Database, which was developed by the OakRidge National Laboratory (ORNL) using multiple techniques to disaggregate census counts within an administrative boundary and allocate the population distributions to a 30-second-by-30-second latitude/longitude grid (Dobson et al., 2000; Carlos et al., 2010).

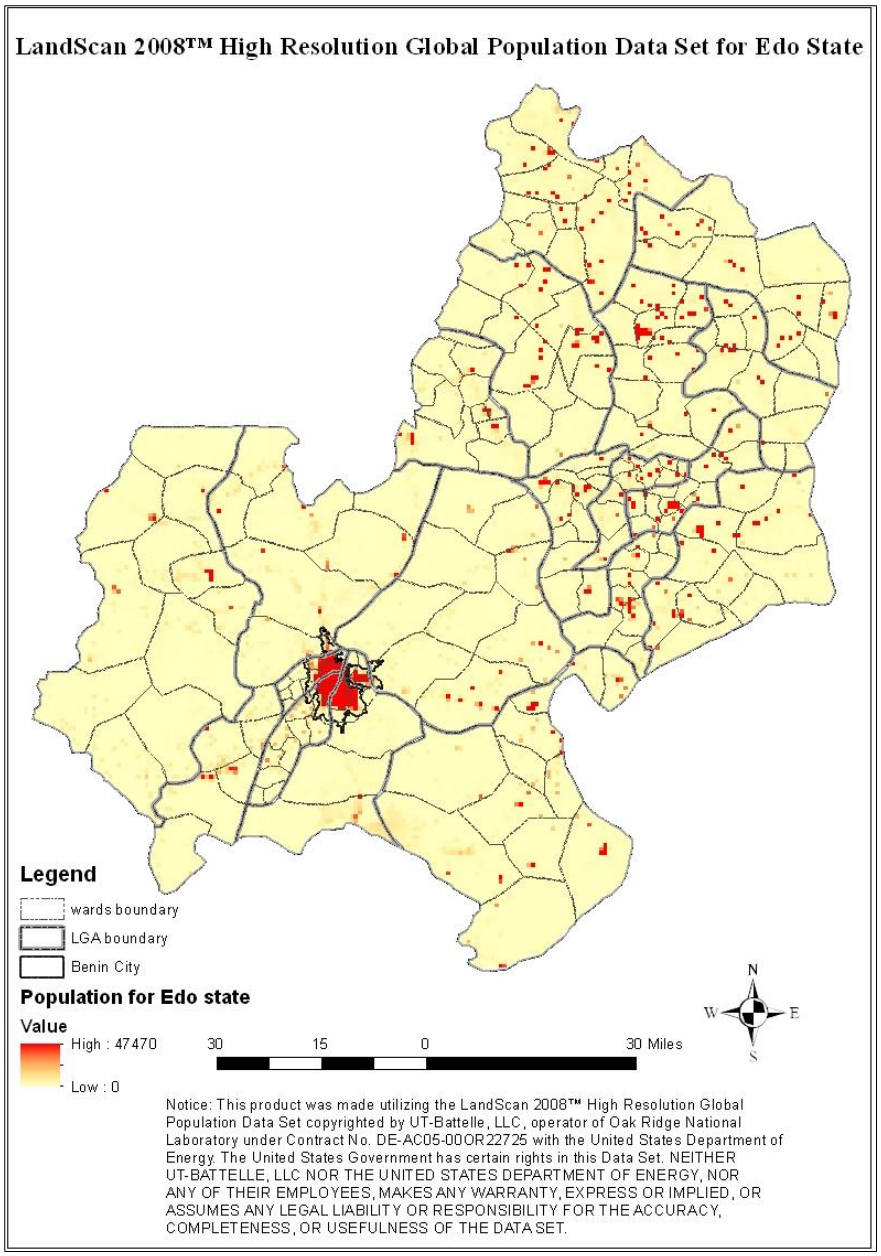

Figure 6.4: A LandScan™ 2008 Population Data set for Edo state, which was based on the Nigerian 2006 census

The LandScan population data was based on a census count done before or by July 2008 however, the last census in Nigeria was the 2006 census. Therefore, the population distribution for Edo state was based on the 2006 census and not on a projected population census for 2008 as LandScan population data was not based on a projected population (Dobson et al., 2000). There are a number of advantages of using the LandScan™ 2008 Global Population Data; one is its grid

format, which standardizes the areal unit for population values, unlike polygon formats representing administrative boundaries that vary in size. This makes population at different locations more spatially comparable and facilitates spatial analysis operations (Carlos et al., 2010). However, one of the shortcomings of the dataset is that it separates the population counts from the related demographic data, which were included in censuses (Carlos et al., 2010) and equally needed for demographic related studies. Since the density estimate for the CKD cases was an exploratory analysis in relation to the population in Edo state, the LandScan™ 2008 Global Population Data was a suitable population dataset to use (Figure 6.4). The outcome of the density map can then be compared with the results of the diagnosed rate of CKD at the LGAs in the state (discussed earlier in section 6.2 of this chapter).

The LandScan population for Edo state was extracted from the LandScan™ Global Population Dataset using the 'extract by mask' tool in the Spatial Analyst extension for ArcGIS.

Dual kernel density estimates of the rate of CKD within the population

In order to use the Landscan dataset in CrimeStat for the density analysis, the population dataset, which was in an ESRI Grid format, was converted to a point shapefile, with the population count within each of the 30″×30″ cells assigned to a point. A total of 23046 points was created to represent the LandScan population data for Edo State.

The dual kernel density routine in CrimeStat, which is applied to two point files (one file set as the primary file while the other is the secondary file) was used for this analysis. The primary file was the point file for the CKD cases while the secondary file was the point file for the LandScan population of Edo state, of which the population at each point was identified as an intensity variable. Since each point in the primary file represented one CKD case, the weight was set as one. As stated earlier, the quadratic kernel estimator was used as the method of interpolation due to the result of the Moran correlogram. The adaptive interval was used as the bandwidth for the density estimation with a sample size of the bandwidth interval set to a minimum of 10 points per square mile within the bandwidth radius. The adaptive bandwidth adjusts for the fact that there are fewer cases and census population at the edges of the state especially at the south and western part of the state. To estimate the CKD density within the state's population, the 'ratio of densities' was selected for the density calculation of the datasets, which ensured that the kernel density estimate for CKD was divided by the kernel density estimate for the Edo state population.

6.3.2.2 *Discussion of results for CKD density within Edo state*

Areas with the highest density were displayed with red shades, followed through to a pale orange to indicate areas with moderately low intensity, and a bright yellow colour to represent areas with the lowest density or absence of CKD.

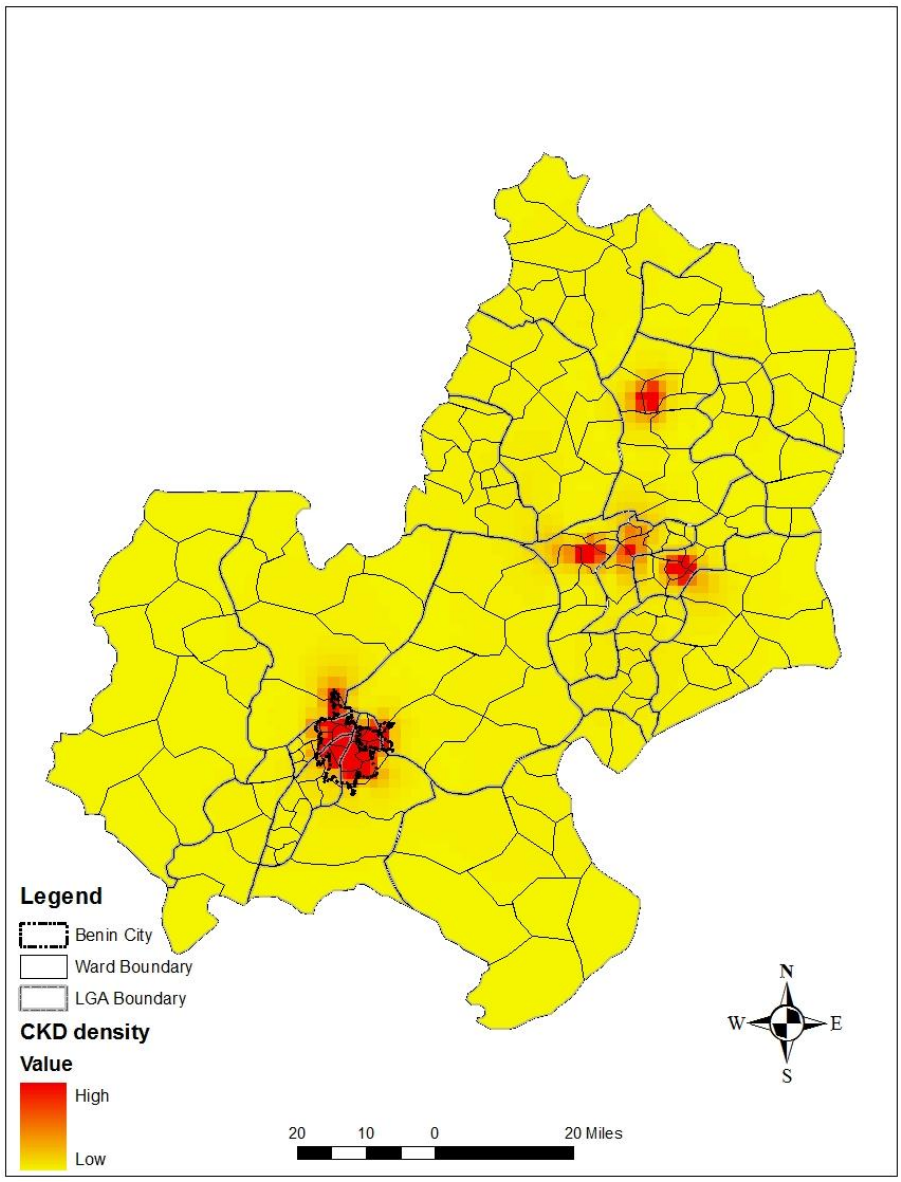

Figure 6.5: The spatial distribution of the kernel density estimate of CKD within Edo State

The effect of adjusting the CKD distribution for the underlying 'population at risk' highlighted the areas with high densities of diagnosed CKD. The density map for CKD indicated that a high density of diagnosed rates covered several miles at the southwestern part of the state. Three smaller locations registered high densities of the disease and these were located towards the central parts of Edo

state while another high density of diagnosed CKD was registered at a small area towards the northern area of the state.

In order to identify the locations where the disease was prevalent, the LGA and the ward boundaries were overlaid on the density map (Figure 6.5). This confirmed that the highest rate of diagnosed CKD was located within the LGAs and wards that were within the boundary of Benin City. The high rate of CKD located at the northern part of the state was found to be within the boundary of Etsako west LGA in two wards – Auchi *I* and Uzaire southeast wards. The three other high rates of CKD located at the central part of the state were located in Esan west LGA (in Ekpoma ward), in Esan north east LGA (in Uromi and Efandion wards), and at Esan central LGA (within Otoruwa *II* and Uwessan *II* wards). The moderately low rate was also registered in Esan central LGA within Ewu *I* and Ewu *II* wards.

It should be stated that the five locations with high rates of diagnosed CKD have relatively large populations within their boundaries. For example, both Otoruwa *II* and Uwessan *II* wards are located within a town called Irrua while the wards in Esan west LGA and Esan northeast LGA are all located within towns that bear the same name with them (see Figure 6.6).

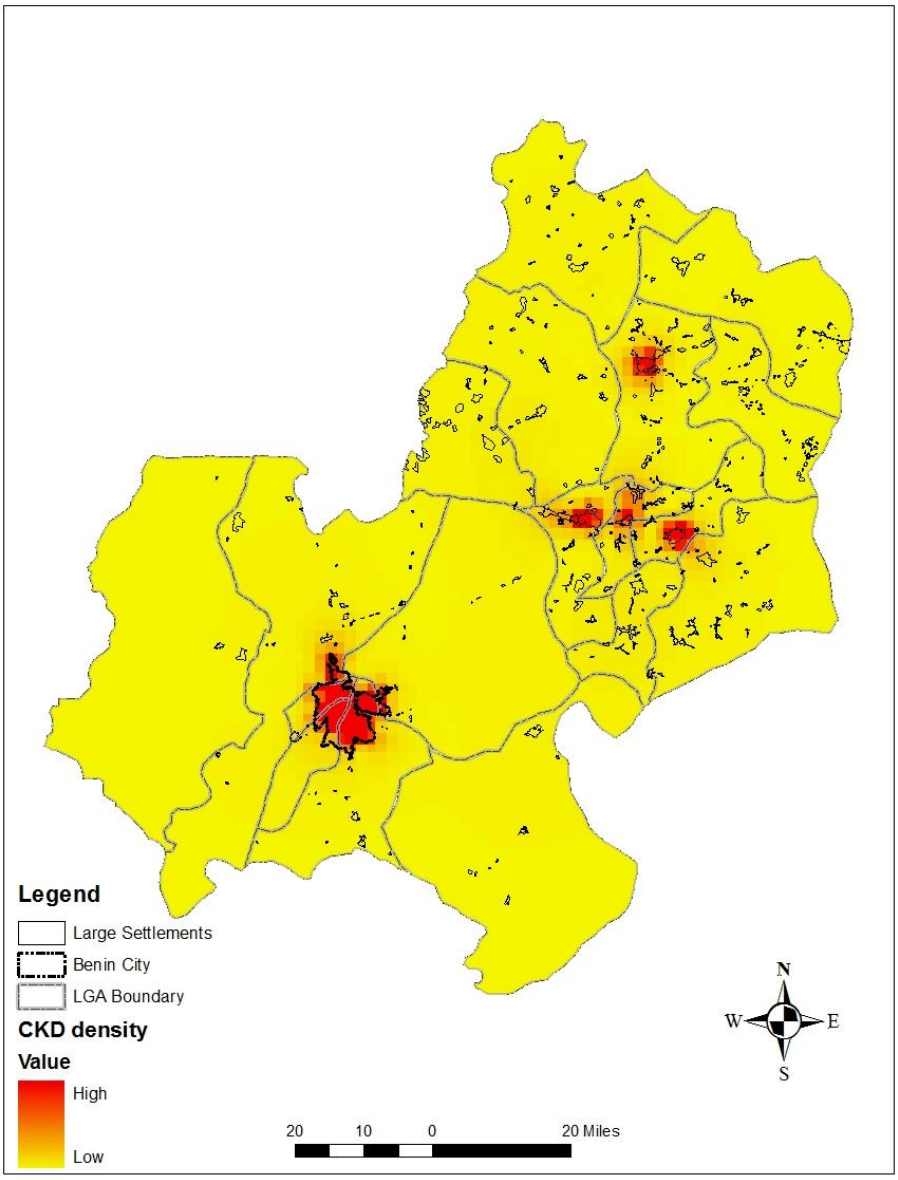

Figure 6.6: The spatial distribution of the kernel density estimate of CKD within the large settlements in Edo State

There is therefore a discrepancy in the rate of diagnosed CKD cases within the urban and rural areas. It can be argued that the discrepancy in the dissemination of information on CKD awareness between the rural and urban areas could have contributed to the low number of diagnosed cases within the rural areas. The ineffective dissemination of information in the rural area is likely to have affected both the general population within the rural areas and the health workers

residing within these areas. A survey carried out by the NPC[28] in identifying the level of awareness among the public as well as the most effective way of reaching the public, showed that most people within the rural area did not have access to mass media used in dispersing information to the general public. Their reports showed that within the rural areas there is a high reliance on "*interpersonal channels as sources of information*", a record of three-quarter of the rural communities hold community meetings where information is shared (NPC, 2005). These findings indicate that there is the probability that the CKD awareness programmes that are currently going on within the state as well as nation-wide may not be having the desired impact on the general public. This could be attributed to the use of the mass media as their primary approach of disseminating information about awareness programmes or campaigns on CKD to the general public. This may therefore account for one of the reasons why the number of CKD diagnosis is higher among the urban areas than the rural areas.

6.3.2.3 ***Kernel density estimate of CKD cases within Benin City***

Out of the 442 diagnosed CKD cases within the study area, 345 cases were residing within Benin City. Therefore, it became necessary to examine the spatial distribution of the density of diagnosed CKD within the city in order to have a more detailed outlook of the spatial distribution of the disease.

[28] NPC-National Population Commission

In order to carry out the analysis for the density of diagnosed CKD within Benin City, the total number of CKD cases residing within the city was extracted from the CKD dataset while the Landscan population data for Benin City was also extracted from the population dataset using the same methods discussed earlier.

Dual kernel density estimate of the rate of CKD within Benin City

A total of 227 points were created to represent the LandScan population data for Benin City.

The quadratic kernel estimator was used as the method of interpolation because the result of the Moran correlogram for Benin City was similar to the result of the Moran correlogram for Edo State (see Figure 6.3). The adaptive interval was used as the bandwidth for the density estimation with a sample size of the bandwidth interval set to a minimum of 10 points per square mile within the bandwidth radius. To estimate the CKD rate within the city's population, the 'ratio of densities' was selected for the density calculation of the datasets, which ensured that the kernel density estimate for CKD was divided by the kernel density estimate for the Benin City population.

Discussion of result for the rate of CKD within Benin City

The result was displayed using a quartile classification to determine a four-class interval. The four classes indicated the range of intensity of the rate of CKD within the city.

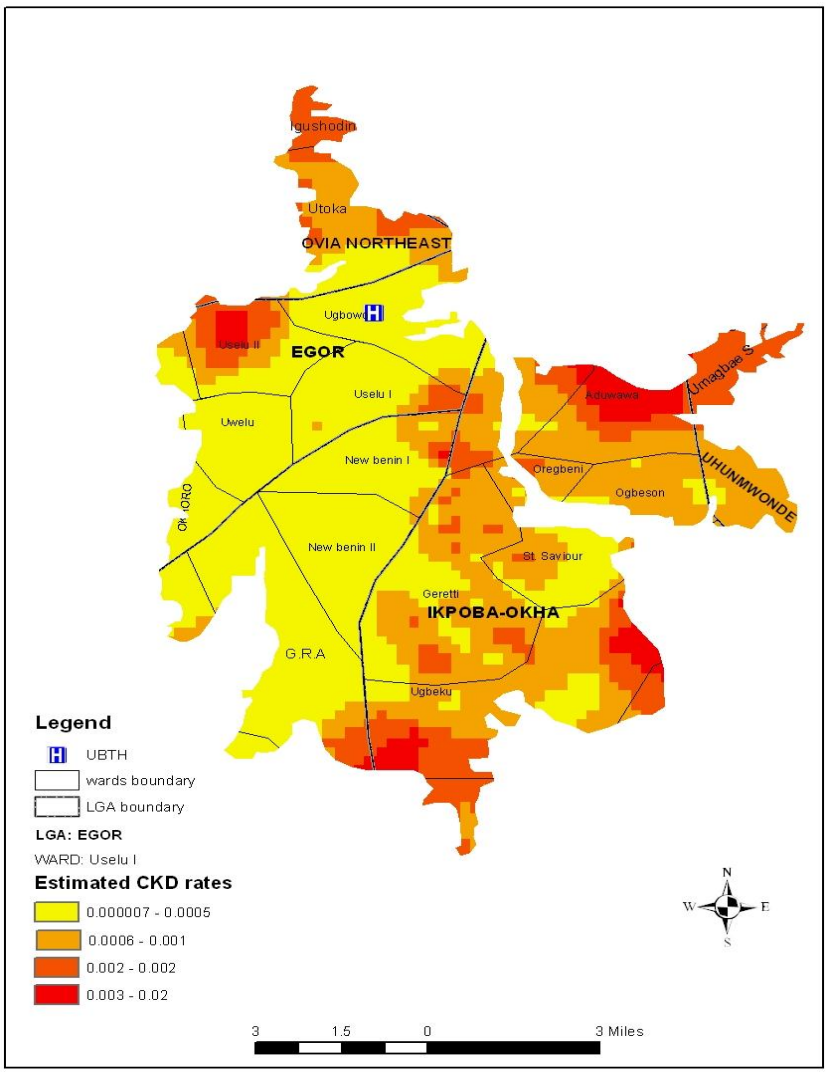

Figure 6.7: The spatial distribution of the kernel density estimate of diagnosed CKD within Benin City

The results indicated that Aduwawa, Ugbeku, and Uselu II wards registered within their boundaries, diagnosed CKD rates within the upper quartile of between 0.003-0.02 while Uselu II and Ugbeku wards registered a moderately high rate within their boundaries. Although UBTH is located within Ugbowo ward, the CKD density within the area was low and this was also the case for Uwelu ward, G.R.A ward and New Benin II ward.

In order to identify the areas within the city that have a high population density, a density map of Benin City using the Landscan population data was created (Figure 6.8).

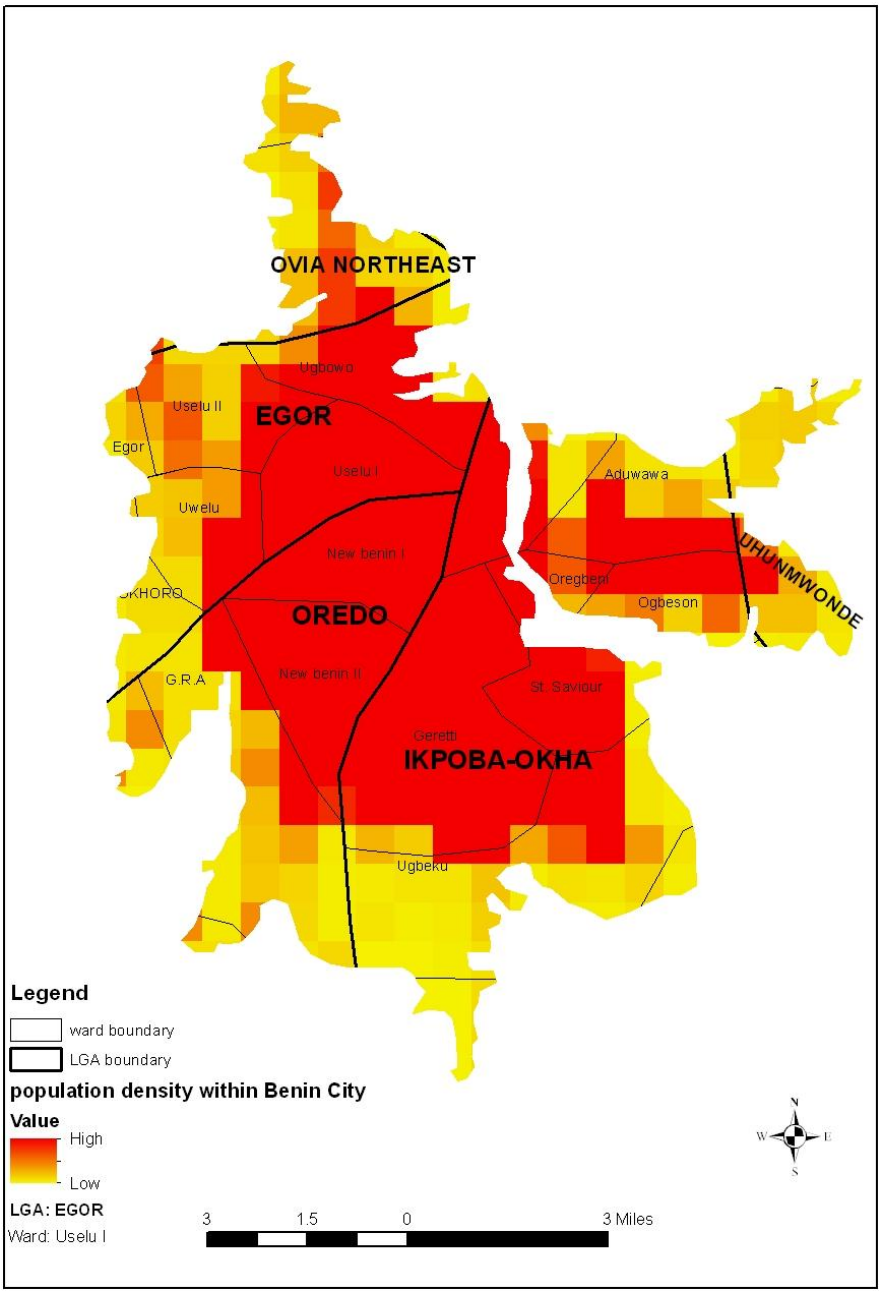

Figure 6.8: A LandScan™ 2008 Population Data set for Benin City, which was based on the Nigerian 2006 census

One of the most intriguing outcomes from the analysis was the moderate rate of diagnosed CKD within Geretti ward, which ranged

between 0.0006-0.002. Although the ward registered the highest number of diagnosed CKD cases with a total of 102 CKD cases (see Appendix F), there appeared to be no indication of a high rate of diagnosed CKD within the ward. This might be attributed to the relatively high population density within the ward (see Figure 6.8), therefore, when the underlying population was taken into account while estimating the density of diagnosed CKD, the proportion of diagnosed CKD within the ward was classified as moderate instead of falling within the upper quartile.

The result for the density rate of diagnosed CKD within the study area appeared to be similar to the result derived from the diagnosed rate, which indicated that Ikpoba-Okha LGA had the highest diagnosed CKD rate. This is because all the wards within this LGA registered relatively high rates within their boundaries, which ranged from the moderate or middle quartiles of between 0.0006-0.002 to as high as 0.02 in the upper quartile. One could suggest that the results from the density estimate analysis gives additional information on the spatial distribution of CKD within the state. This is because the KDE did not limit its analysis to the available administrative areas (i.e. the LGAs and the wards) during the course of the density analysis. Therefore, the technique was able to search for spatial patterns within small areas across the study area. The results generated from the KDE were therefore able to identify areas of concern within the state once the wards and even settlement boundaries were overlaid on the density maps.

Given the technique used by the kernel density estimate in determining the spatial distribution of the rate of CKD and its advantage of avoiding the modifiable areal unit problem, it can be argued that the result derived from using the kernel density estimate has provided a detailed outcome of diagnosed CKD rates within the state particularly at the wards level.

In summary, the spatial distribution of diagnosed CKD within Benin City and Edo state further points to the need for an extensive investigation of the spatial distribution of CKD in order to reach any meaningful conclusions regarding the association of the socio-demographic factors and underlying spatial processes on the impact of CKD within the study area. However, such an investigation cannot be carried out within the scope of this research study due to insufficient socio-demographic data as well as healthcare data for the city and the state in general. Therefore, it should be stressed that the outcomes presented here are preliminary assessment of the spatial distribution of CKD within the Edo State.

6.4 Spatial inequality of diagnosed CKD in the region

An observation that is evident in the spatial pattern of CKD within the study area is the variation of diagnosed CKD between the urban and rural areas. It is apparent that the urban areas registered a higher number of diagnosed CKD cases than the rural areas. However, one cannot rule out the possibility that there could be a significant number of undiagnosed CKD cases within the rural areas. Apart from the

earlier suggestion that the use of the mass media as the primary means of raising CKD awareness might not be effective especially within the rural areas, there are likely to be other contributing factors that might have led to the spatial pattern of diagnosed CKD within the study area. One such contributing factor could be that the higher diagnosed rate of the CKD in the urban areas could be attributed to the high population density within their boundaries as opposed to the rural areas. However, the density maps have taken this into account and this argument might not be the only reason for this CKD pattern within Edo state.

Another suggestion might be that the variation in the CKD pattern within the state could be due to the level of awareness of CKD both among the general population and among health practitioners. As such there are instances where the disease is not diagnosed until it gets to its late stage when it becomes both difficult and expensive to manage. One possible implication is that poor CKD awareness within the state may have had an impact on the rate of CKD diagnosis thereby leading to poor referral rates of patients to UBTH for treatment especially from the rural areas. If true, this would support previous findings that identified the importance of adequate access to vital health information, which is needed in improving the accessibility to available health services especially for rural dwellers (Agee, 2010; Awoyemi et al., 2011).

Another factor that might have contributed to the spatial distribution of CKD diagnosis is the accessibility to CKD healthcare within the study area. There is the possibility that some accessibility factors might have influenced the outcome of the spatial distribution of diagnosed CKD cases within the state. This assumption was further investigated in detail in the next chapter of this thesis.

Nevertheless, it should be stressed that the results and supporting arguments presented within this study are exploratory. Therefore, there is a need for a more extensive analysis of the underlying spatial processes that could have contributed to the distribution of CKD in order to reach any meaningful conclusions regarding the spatial distribution of CKD within the urban and rural areas.

6.5 Conclusion

Although the high rate of CKD and areas with high-density of diagnosed CKD within the LGAs and wards are known to have urban population within their boundaries, the CKD patterns raise some questions on the spatial distribution of the disease within the state. The foremost question has to do with the low number of cases registered within the rural areas as opposed to the urban areas. As previously mentioned, the majority of the awareness campaigns currently done within the country uses the mass media such as awareness campaigns on the radio and television as well as billboard advertisement to pass on information about public related issues. A report by the Nigerian Population Commission (NPC) has already indicated that the mass

media as a tool in disseminating information to the general public would not be completely effective (NPC, 2005). Therefore, it can be argued that the current dissemination of CKD awareness campaigns and programmes appears to favour mainly the population that have access to the mass media. It therefore indicates that those in the urban areas that have access to these media facilities are more likely to come forward for treatment than those in the rural areas. It can be argued that this finding is consistent with the presence of the inverse care law. This is because there is the possibility that access to vital information needed in identifying CKD patients as well as available options for CKD healthcare are not being accessed by rural dwellers that might have the disease.

However, the proportion of CKD distribution between the urban and rural areas can only be addressed with extensive investigations in order to draw out reasonable conclusions on the factors behind this pattern. Given the inadequate nature of the population data due to criticisms on the census process in Nigeria (Igah and Okpokpo, 1998; Okolo, 1999; Bamgbose, 2009), the results presented within this chapter should be interpreted as a broad view on the distribution of CKD, which still has important policy implications in addressing CKD within the state.

Chapter 7 Accessibility of CKD patients to healthcare

7.1 Introduction

Accessibility to healthcare involves a number of factors and processes including proximity to suitable service providers, transportation networks (over which distance, travel time and travel cost can be estimated), socioeconomic characteristics and decision-making strategies of the individuals, and their ability to pay for services (Meade and Earickson, 2000). Apart from the high cost of treatment for CKD (discussed in section 2.4.3.1), the distance to the hospital for treatment is likely to also have an impact on the effectiveness of CKD management within the state. Studies have already suggested that distance to healthcare services has an influence on the accessibility and utilisation of such services especially in developing countries (Buor, 2003). Given the fact that an increase in distance is likely to result in an increase in the cost of transportation, there is the tendency for the cost of transportation to become an impeding factor especially for CKD patients that reside outside the state's capital where the hospital is located. It can be argued that a service has to be accessible before it can be utilised. In order to analyse the impact of the accessibility and utilisation of the renal department in UBTH by CKD patients within the state, this chapter evaluates the service area for the hospital using the travel time to the hospital from various parts of the state. To examine the issue of accessibility to UBTH for CKD healthcare, the chapter begins by evaluating the referral rate of

patients from other healthcare services within the state. This is to determine whether geographical accessibility to UBTH might have influenced the number of health centres that referred CKD patients to UBTH as well as the spatial distribution of diagnosed CKD patients within the state. The outcome of these analyses is an attempt at addressing the final research question: "*Is the prevalence and distribution of CKD in the state appropriately serviced by the available CKD healthcare service*?"

7.2 Proportion of health care services within Edo state that refer CKD patients to UBTH

The University of Benin Teaching Hospital (UBTH) is the tertiary health institution used as a focal point of reference for most diseases by all other health institutions within Edo state. As such, the renal unit in the hospital is currently the only institute responsible for the treatment of CKD in the state and also has been found to treat some patients from neighbouring states. As discussed in chapter five, the state has a centre outside Benin City where free CKD screening is done at certain times of the year and this is located in Ogbona ward in Etsako Central LGA of Edo State.

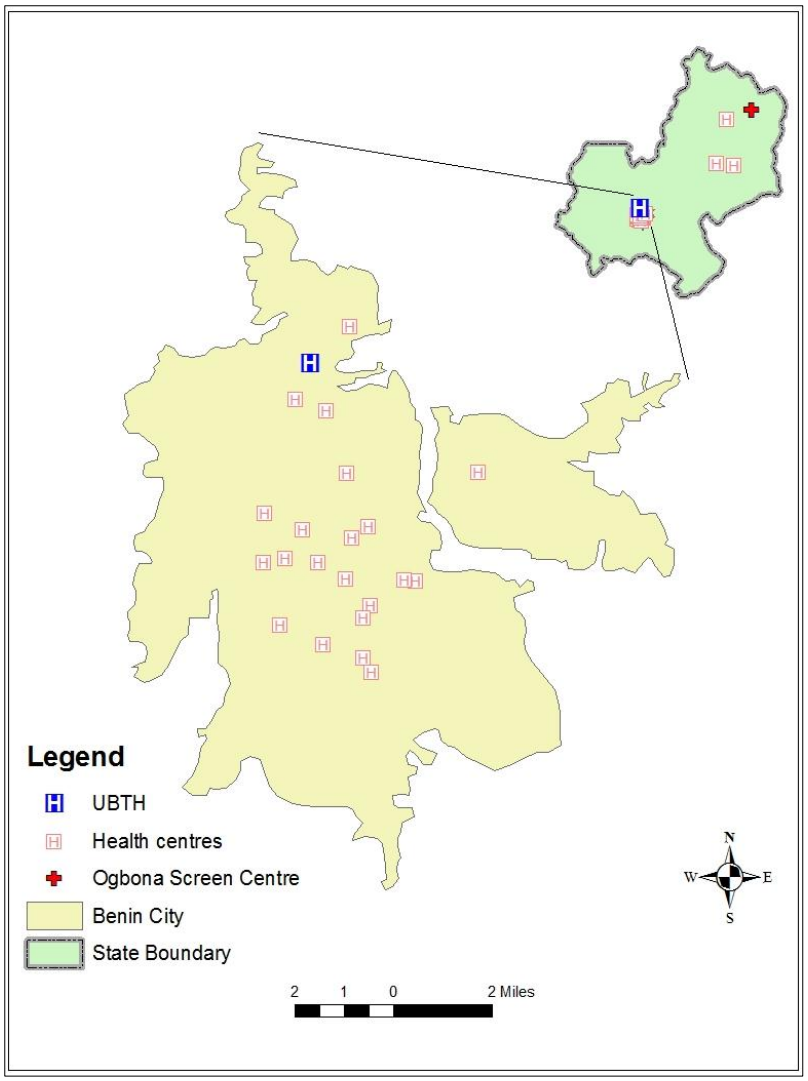

Figure 7.1: Location of UBTH and the 24 health centres in Edo State that referred CKD patients, including the location of the CKD screening centre at Ogbona ward in Etsako Central LGA

Twenty-four health centres that referred CKD patients to UBTH were identified and geocoded. Most of these centres were concentrated in Benin with only three health centres outside the state's capital (see Figure 7.1). Out of the twenty-four health centres, only twelve of them referred more than one patient to the renal department for CKD treatment within the study period and this included one of the three health centres located outside the city known as Irrua Specialist Hospital, which is located in Esan Central LGA.

Although twenty-one of the twenty-four health centres that referred CKD patients to UBTH, were located within Benin City, it was observed that they were unevenly distributed. Three of these centres were located within Egor LGA, nine were within Oredo LGA, and the remaining nine were within Ikpoba-Okha LGA. In regards to the three health centres located outside the city, it was discovered that each of them was located within three LGAs towards the northern and central parts of the state. The first of these three health centres outside Benin City is called Alafia specialist clinic and maternity, which is located within the Etsako west LGA in Auchi I ward. The second health centre was the Irrua Specialist Hospital, which is located within Esan central LGA in Otoruwa II ward while the last health centre was the St. Camillus hospital that is located within Esan northeast LGA in Efandion ward. The Alafia specialist clinic and maternity is a privately owned clinic located within a town called Auchi in Auchi I ward while Irrua Specialist hospital is a Teaching Hospital located in Irrua town within Otoruwa II ward. It is one of the three teaching hospitals within the state with the other two hospitals located within Benin City (i.e. UBTH and Benin Central Hospital). The last health centre was St. Camillus hospital, which is located within a town in Efandion ward called Uromi town and the hospital is currently owned by the Catholic Diocese of Uromi therefore the hospital was classified as a private hospital since it was not owned by the state or the federal government. This meant that only six LGAs out of the eighteen LGAs

within the state had health centres within their boundaries that referred CKD cases to the renal department at the hospital.

There is however, room for improvement in the number of registered healthcare centres that refer CKD patients to the renal unit in UBTH because according to the last publication by the Ministry of Health in Edo State in May 2007, there were 844-registered Health services in the state. The list of registered health services showed that the state has a total of 290 public health services and 554 private health services with Etsako central LGA (where the Ogbona CKD screening centre for the state is located) and Oredo LGA having the lowest and highest number of health services respectively (Table 7.1). This means that according to the UBTH's renal records, it can be estimated that during the study period, only 2.8% of all the registered health centres within the state referred CKD patients to the renal department at the hospital.

Table 7.1: Summary of Registered Hospitals/Health Centres in Edo State

LGA	Levels			Total	Types	
	Tertiary	Secondary	Primary		Public	Private
Akoko-Edo	0	6	33	39	32	7
Egor	2	49	71	122	7	115
Esan Central	1	2	15	18	12	6
Esan N. East	1	12	16	29	7	22
Esan South East	0	6	21	27	21	6
Esan West	0	13	30	43	19	24
Etsako Central	0	1	13	14	12	2
Etsako East	0	3	13	16	12	4
Etsako West	1	18	21	40	13	27
Igueben	0	6	7	13	8	5
Ikpoba-Okha	0	32	53	85	10	75
Oredo	1	77	144	222	9	213
Orhionmwon	1	4	26	31	26	5
Ovia N. East	1	1	27	29	27	2
Ovia S. West	0	2	21	23	17	6
Owan East	0	7	23	30	17	13
Owan West	0	6	31	37	18	19
Uhunmwonde	0	1	25	26	23	3
Total	**8**	**246**	**590**	**844**	**290**	**554**

Source 7:1: Edo State Government 2009

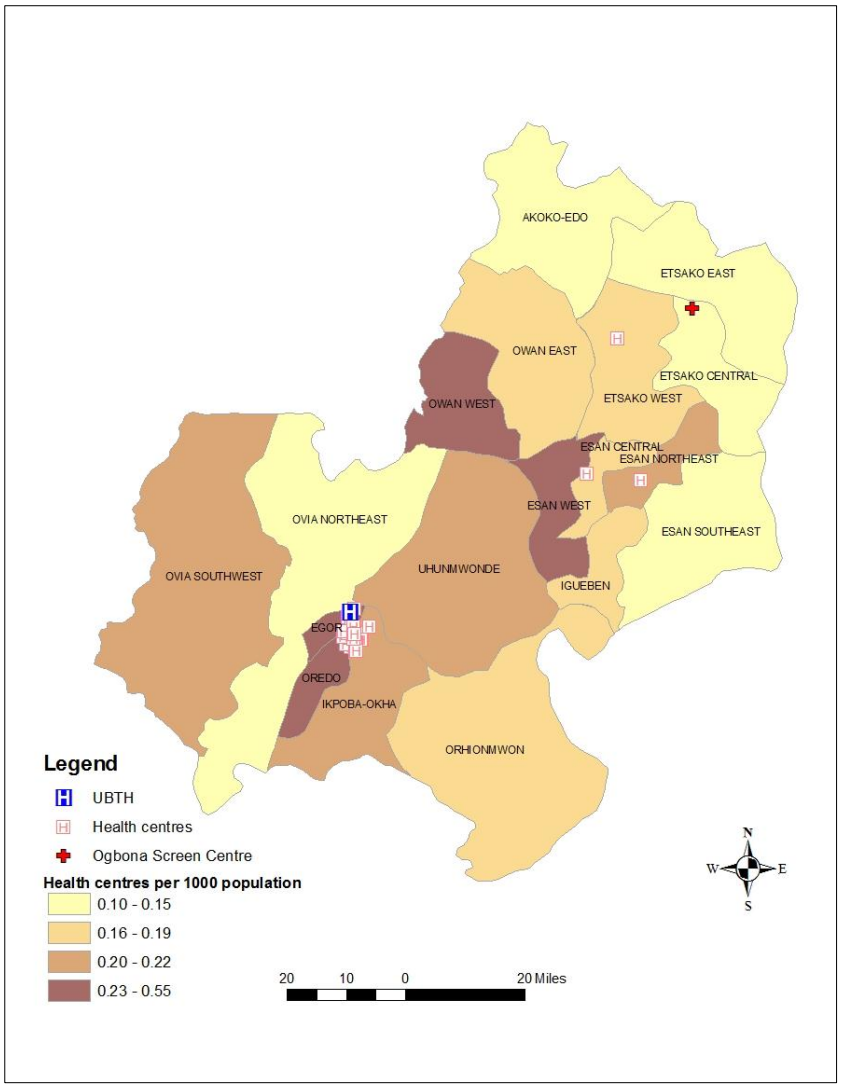

Figure 7.2: The location of the screening centre and the distribution of CKD referral centres in relation to registered Health care services per 1000 within each L.G.A in Edo State

Based on the data for the number of registered health services within the LGAs (see Table 7.1) and the number of health centres within each LGA that referred CKD patients, it was discovered that there was a very poor CKD referral rate present within the state. This is because the number of health centres that referred patients for treatment were rather small compared to the number of registered health centres within each LGA. The proportion of health centres that referred CKD

patients within Egor LGA was just 2.5%, Oredo LGA was 4.1%, Ikpoba-Okha LGA was 10.6%, Esan central LGA was 5.6%, Esan north east LGA was 3.6%, while Etsako west LGA was 2.5%.

Equally noticeable from the spatial distribution of the registered health centres and health centres that referred CKD patients to UBTH was that although there were a number of registered health centres in certain areas, there was an absence of health centres that referred CKD patients to UBTH particularly within the mid-region and boundary regions of the state. It was observed that these LGAs are predominantly rural areas.

The proportion of the health facilities within each LGA in relation to its corresponding population was found to be very low with less than one healthcare service to every 1000 persons within each LGA (See Figure 7.2). The spatial distribution of the health units that referred CKD patients to UBTH in relation to the total healthcare services available within their LGA, demonstrated that most health services within the state might have a poor knowledge of the impact of CKD within the state. This statement has been supported by the doctors at the renal department within UBTH. They indicated that the number of referred CKD patients is very small in relation to the number of CKD patients that are diagnosed within the hospital. As previously discussed, some of the doctors at the renal department suggested that the reason for the high number of late diagnosis among CKD patients could be attributed to poor knowledge of the disease by doctors in

many of the health centres within the state especially those residing in rural areas.

However, we cannot rule out the issue of accessibility to UBTH in order to receive CKD healthcare. This is because the health centres outside Benin City that referred patients to UBTH and the number of referred CKD patients were small. There were a total of 22 CKD patients from the three health centres outside Benin City that referred patients to UBTH. There is the possibility that the number of health centres that are located outside Benin City and are registered within the UBTH's renal records to have referred patients to UBTH, might be attributed to accessibility issues experienced by diagnosed CKD patients across the state especially in areas outside the state's capital. It is likely that there might be diagnosed CKD patients from health centres across various parts of the state that are not coming to UBTH for treatment due to accessibility issues and this could range from the issue of distance to UBTH to the cost of transportation to UBTH from their homes.

In summary, two issues are likely to have contributed to the number and the spatial distribution of the health centres that referred CKD patients to UBTH. The first has to do with the issue to CKD awareness among health professionals as this might have contributed to the poor referral rates among health centres particularly as one moves further away from the state's capital. However, this could not be examined in more detail within the scope of this study because this

study was based on secondary data therefore such data was not available within the health records that were used in this study. The second issue that might have contributed to the small number of health centres that referred CKD patients to UBTH, is the issue of geographical accessibility to UBTH from various parts of the state.

The next sections will therefore evaluate the issue of accessing UBTH from various areas within Edo State in order to examine whether the number and the spatial distribution of diagnosed CKD patients is associated with their accessibility to healthcare.

7.3 Evaluating the accessibility to CKD treatment within Edo state

Accessibility can be classified as the ability of an individual to get a service as and when needed (Schneider and Symons Jr., 1971; Kumar, 2004). As distance is likely to be an impeding factor to the accessibility of renal healthcare by CKD patients within the state especially those living further away from the city, the role of distance in the spatial access to the CKD department within UBTH was analysed. Studies have indicated that increased distance has an impact on healthcare accessibility and utilisation (Ensor and San, 1996; Ganatra and Hirve, 1994; Muller et al., 1998; Okafor, 1990). This is particularly true for those living in rural areas in developing countries (Buor, 2003). This section therefore investigates the spatial accessibility of the renal department located within the University of Benin Teaching Hospital (UBTH) by estimating within a travel model,

the average travel time of CKD patients that commute to UBTH from their home.

7.3.1 **Preparing the network dataset**

In order to evaluate the spatial accessibility to the renal department from various parts of the study area, a network dataset had to be built using the road network produced by RECTAS (1972).

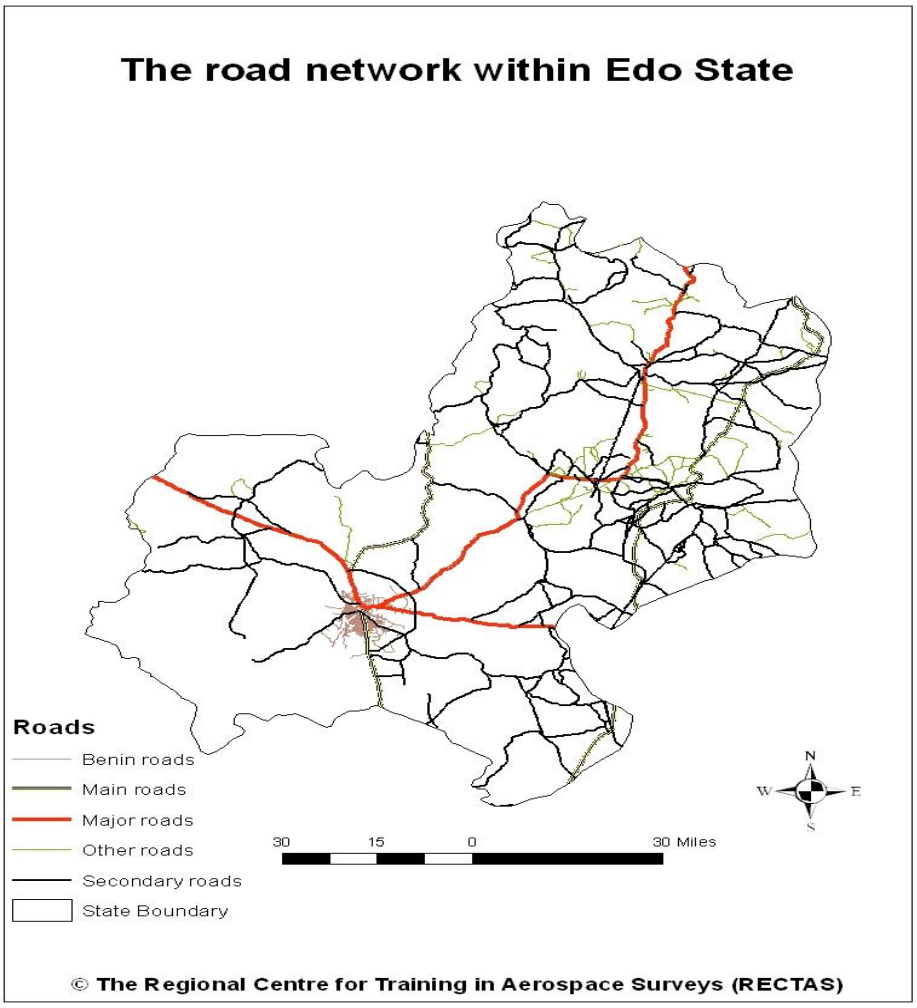

Figure 7.3: The road network within Edo state showing five different types of roads

The road network comprised of five road types, these included the Benin roads, major roads, main roads, secondary roads, and other roads. The Benin roads were the detailed road network for Benin City

and it comprised of the main roads and streets within the city. The major roads consisted of the three high ways within the state. The main roads were the expressways that traverses the state while the secondary roads were the roads that linked the major roads and main roads to most parts of the state. The other roads could be classified as access roads to various areas particularly rural settlements across the state. One of the problems faced with the available road network was the absence of roads within the south western boundary of the state. Efforts at retrieving an updated road network for that area proved unsuccessful, as the RECTAS institute had no road data for that region. Attempts at creating a road network for that region using Google Earth was equally unsuccessful as the satellite image was not visible enough to trace the road networks that might be present in that area. The absence of roads within that area therefore limited the results derived from the network analyst, as there were no results available for that area. A cross-examination with the residences of the CKD patients showed that none of them resided within this area. Therefore, the absence of network data did not restrict the results generated for the CKD patients. However, this was not the case when the travel model was used to analyse the population at risk (discussed in section 7.3.2).

Before the network dataset was built from the road network, a new field was created within its attribute table. This was the drive time field, which held the information on the length of time it took to traverse each road. In order to achieve this, an estimate of the number

of miles covered per hour for each road type within the network was carried out. Since the condition of each road was included within the dataset, the estimated time across each road type was not the same. For example, a tarred road within Benin City was given a drive time estimate of 30 miles per hour while an un-tarred road within the city was given a drive time estimate of 20 miles per hour. The choice of using low speed mileages and not higher mileages has to do with the poor condition of most un-tarred roads within the city and across the state (leadership, 2010; Okonta et al., 2002). Drive time across such roads could take longer in the rainy season when most roads get flooded and driving through would be slower and in worst situations, these roads are not accessible. The major and main roads were all in good conditions and therefore did not have different speed limits assigned to them while the 'other roads' were all in poor conditions and therefore had one speed limit assigned (Table 7.2). The table below shows the estimated speed limit for the different road types within the road network.

Table 7.2: Estimated speed limit used for the different roads within the road network

Road type	Tarred road	Un-tarred road
Benin roads	30 miles/hr	20 miles/hr
Major roads	50 miles/hr	N/A
Main roads	50 miles/hr	N/A
Secondary roads	40 miles/hr	30 miles/hr
Other roads	N/A	20 miles/hr

The unit for the drive time field was in minutes therefore the calculation is stated below:

Drive time = [road length in miles] × 60 ÷ [estimated speed limit for each road type]

The result for the field indicated the estimated drive time in minutes for each road within the network.

Once the field was included within the attribute table, the road network was then used to build a network dataset and the drive time (in minutes) was set as the cost attributes for the dataset. This was created using the network analyst tool in ArcGIS 10.

7.3.2 Evaluating the travel time to the CKD department in UBTH

Travel time was used instead of travel distance as the impedance because travel time is more likely to indicate a more realistic estimate of how long it would take to reach the hospital. In situations where the roads are poorly managed, the length of time it would take to cover the distance to the hospital would be longer. Furthermore, a longer distance would result in an extended travel time that would equally cost more in terms of transportation either by public transport or the cost of fuel (if using a personal vehicle). As such, travel time has been regarded as an appropriate indicator for geographical access (McLafferty, 1988).

The service area analysis within the network analyst tool was used to carry out the analysis. Within the analysis setting, the impedance was set to drive time (in minutes) while four default breaks were chosen to indicate the various travel time towards the hospital. These were 10 minutes, 30 minutes, 90 minutes, and 150 minutes.

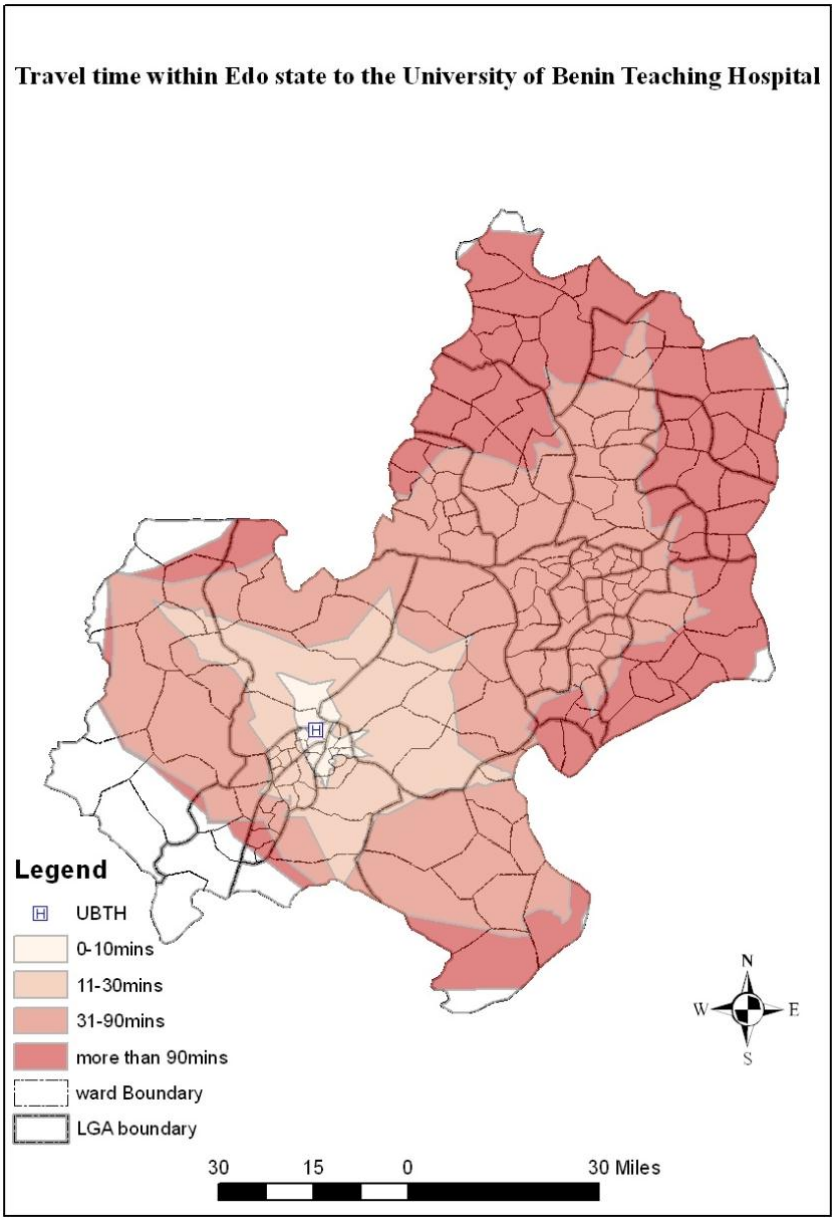

Figure 7.4: The distance in minutes it takes to travel to the hospital where the renal department is located from various parts of the state

As mentioned earlier, regions within the south western boundary of the state were excluded from the analysis as there were no road data for those areas. It could be safe to state that residents within those areas would likely exceed the furthest travel time of 145 minutes. It appeared that even though the maximum travel time that was included within the analysis setting was 150 minutes, the maximum time it would take the furthest areas that were accessible by road was 145

minutes (Figure 7.4). The travel estimation was based on the use of a vehicle as the mode of transport. This did not take into consideration other factors, such as those that use public transport e.g. waiting time at a public station for the vehicle to get enough passengers or interval stops in order to drop or pick up passengers. Also excluded from this analysis was the estimation of pedestrian travel time. This was because there were no pedestrian path data available for this analysis and using the available road data was not likely to give a realistic result for pedestrian travel time as most roads especially outside Benin City (such as the major and main roads) were not likely to have pedestrian paths. Even though these other factors were not taken into consideration during the analysis, the result gives a rough estimation of how long it would take for patients residing within different parts of the state to get to the hospital for renal treatment.

The result equally showed that within Benin City, two-travel time bands were created. A total of 304 out of 345 CKD patients lived within 10 minutes from the hospital while the remaining 36 CKD patients in the city were approximately 30 minutes away from the hospital.

The result of the various travel times to the hospital were cross-referenced with the residences of the CKD patients within the state. The mean travel time to the hospital for the diagnosed CKD cases within the dataset was approximately 29 minutes (see Appendix G). The result indicated that almost 70% of the CKD patients diagnosed

within the study period resided within 10-minute travel distance from the hospital, while 1.8% of the CKD patients had to travel for about 91 to 145 minutes in order to receive treatment at the renal department (see table 7.3).

Table 7.3: Travel distance in minutes for the 442 CKD cases within Edo state to the hospital for CKD treatment

Distance in minutes to Hospital	Number of CKD cases	Percentage of CKD cases
0 - 10mins	309	69.9
11 - 30mins	46	10.4
31 - 90mins	79	17.9
91 - 145mins	8	1.8
Above 145mins	0	0.0

In order to determine the amount of time spent travelling to the hospital for treatment by those who were diagnosed at either the earlier stages of CKD or at the late stage of the disease, both groups were cross-referenced with the result of the travel time to the hospital. The result for those that were diagnosed at the earlier stages of CKD indicated the average travel time to the hospital was 28 minutes (see Appendix H) and that 69.3% resided within a 10 minutes travel to the hospital while 1.8% had to travel for between 90 to 145 minutes to the hospital (see Table 7.4). Equally intriguing was the fact that there were more patients that resided between a 31 minutes to 90 minutes' drive than those that resided within an 11 minutes to 30 minutes' drive to the hospital. This could be attributed to the presence of a major urban centre (Ekpoma town) within that band as opposed to the rural settlements within the previous band of the travel time model as well as a network of secondary roads within that town that connects it to

Benin City. Based on my argument about the impact of geographical accessibility to UBTH, it is plausible that cases residing in urban areas that are further away from the hospital are more likely to be diagnosed than those residing in rural areas that are closer to UBTH due to available road networks.

Table 7.4: Travel distance in minutes to the hospital for patients diagnosed at the earlier stages of CKD

Distance in minutes to Hospital	Number of CKD cases at the earlier stages	percentage of earlier stages of CKD
0 - 10mins	61	69.3
11 - 30mins	10	11.4
31 - 90mins	16	18.2
91 - 145mins	1	1.1
Above 145mins	0	0.0

Patients diagnosed at the late stage of CKD indicated a decline in the number of cases as the travel time to the hospital increased with a mean travel time of 29 minutes (see Appendix I). Approximately 70% of the cases resided within a 10 minutes' drive to the hospital. However, there was a sharp decline in the number of diagnosed cases that resided within the next travel time band of 11 to 30 minutes and the number of diagnosed cases dropped as the time interval increased (see Table 7.5). As expected the patients that resided within the first two time bands (i.e. within a 30 minutes' drive) all resided within Benin City. It should be noted that this analysis only estimated for a single trip. Patients with stage 5 CKD or those that require regular dialysis will have to travel at least 3 times a week. Therefore, there is the possibility that some of these patients might have moved closer to the hospital (even though it was not indicated within their health

records). This might explain the large proportion of stage 5 patients residing within a 10-minute distance from UBTH. The assumption stated above that patients are moving closer to the hospital will require further investigation because the number of these patients is unknown. There is also the possibility that these patients represent only those that can afford to move closer to the hospital either because they have family/friends residing near the hospital or these patients themselves can afford to buy or rent accommodation near the hospital.

Table 7.5: travel distance in minutes to the hospital for patients diagnosed at the late stage of CKD

Distance in minutes to Hospital	Number of CKD cases at the late stage	Percentage of patients at the late stage of CKD
0 - 10mins	248	70.1
11 - 30mins	36	10.2
31 - 90mins	63	17.8
91 - 145mins	7	2.0
Above 145mins	0	0.0

7.3.3 **Comparison with Edo State's population**

To some extent, the location of CKD patients might be a function of the wider population geography of Edo state: even if there were no inverse care issues at play, we would expect that places with distinct concentrations of population such as towns and cities would have more CKD patients than more sparsely-populated areas, just because more people live in the former areas than in the latter. But this did not in fact account for the geography of diagnosed CKD patients' locations relative to the UBTH renal facility. This is confirmed by comparing the proportion of CKD patients in each band of travel time from UBTH with the proportion of the overall state population (based

on the estimated 2006 ward populations) in the same band (table 7.6). The two geographies – of patients and of the public – are quite different from each other. On average, the general population resided much further away from the hospital than did the CKD patients: the average mean travel time to the hospital for the state population at large was 90minutes. Approximately forty percent of the population lived about 31 to 90 minutes away from the hospital and approximately 11% resided within a 10 minutes' drive from the hospital while 5.3% resided more than 145 minutes away from the hospital (see Table 7.6). Only 11 wards out of the 193 wards had their centroids located within a 10 minutes' drive from the hospital. The relative differences in travel times to the hospital for patients and for the public at large are substantial, as illustrated by the last column in table 7.6, which expresses the percentage of all CKD patients living in each travel time band as a ratio of the equivalent percentage of the total population. The percentage of CKD patients living within 10 minutes of UBTH was 7 times higher than the percentage of the population doing so. But in all other travel time bands, the relative share of the state population living there exceeds the relative share of patients, and the under-representation of patients relative to the population as a whole worsens dramatically at increasing distance from the hospital.

Table 7.6: Travel distance in minutes to the hospital for the general population, the total diagnosed CKD cases, and the ratio between both datasets within Edo state

Distance in minutes to Hospital	Number of wards	Total population	percentage of the total population	percentage of the total diagnosed CKD cases	Ratio of all diagnosed CKD cases and the total population
0 - 10mins	11	367833	11.4	69.9	7:1
11 - 30mins	21	596874	18.4	10.4	0.6:1
31 - 90mins	94	1283490	39.7	17.9	0.4:1
91 - 145mins	60	817205	25.2	1.8	0.07:1
Above 145mins	8	171334	5.3	0	0.000:1

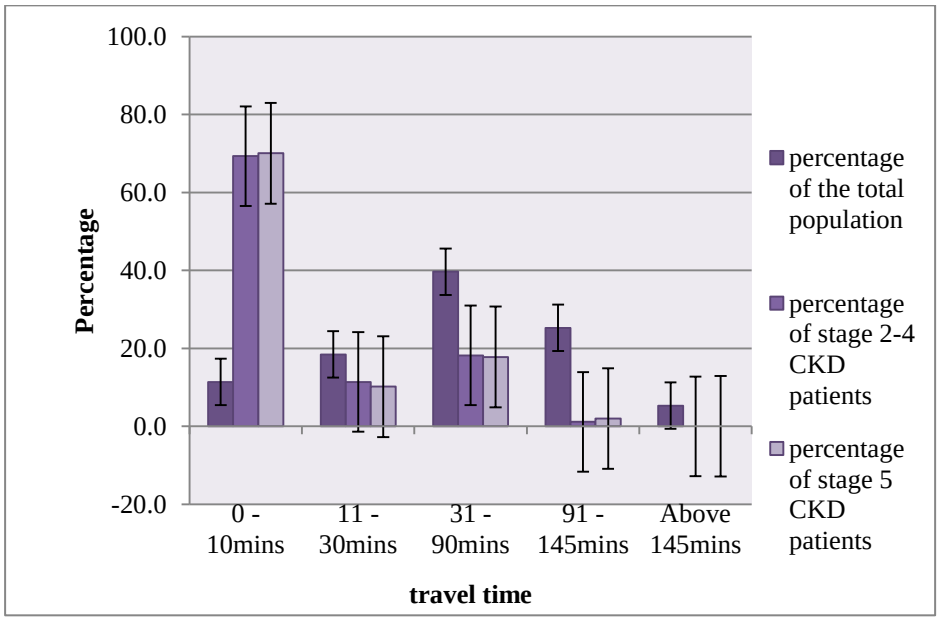

Figure 7.5: The travel time to the renal department at the University of Benin Teaching Hospital (UBTH) for CKD patients diagnosed at either stages of CKD as well as the general population within the state. The error bars show the standard error for each group

The outcome of these results further points to the possibility that distance is an impeding factor to the diagnosis of CKD. This is because the proportion of diagnosed cases with either stage of CKD residing in the various travel bands in relation to the proportion of the general population residing within the same travel bands appears to be

different. Since approximately 70% of both stages of CKD resided within 10 minutes from the hospital, one would have expected a similar proportion of the population to reside within the same travel time if distance was not an impeding factor to the diagnosis and treatment of the disease. Since this is not the case, there is the likelihood that there might be more CKD cases that may not be coming to the hospital for treatment because of the long distance. One might argue further that there might be the possibility that clinics and hospitals outside the city might actually be referring patients to the hospital for treatment but these patients might not be going to the renal department in UBTH once they considered the long trip. This assumption might also explain why there were no referred cases located within the CKD dataset from the screening centre located in Ogbona ward (previously discussed in section 5.4.3). The distribution of both stages of CKD across the travel time bands gives an indication of the impact of travel time on the spatial access of CKD patients to renal health care at the hospital. The travel time evidence displays a steep distance decay effect in access to healthcare at the renal department by patients diagnosed at either stages of the disease. Furthermore, the slight increase in the number of CKD patients in the third travel band is not an indication of some deviation from the distance decay effect as the overall population also increases in this band compared to the 11-30 minute band. However, the relative increase in patient numbers is smaller than that for the population as a whole: so even taking this into account, considerably fewer patients

live in this band than expected in relation to the general population within the same band (Table 7.6).

CKD patients are over-represented relative to the general population in the travel time band nearest the hospital, but are noticeably under-represented in all the other bands. The question that arises is *why does this happen*? There are at least two possibilities: the first possibility could be that there is a strong inverse care process where only those living very close to the hospital have a realistic chance of being diagnosed. This could be because proximity to the hospital results in increased CKD awareness for the general population as well as medical professionals that refers patients to UBTH for treatment (discussed in sections 5.4.4 and 6.4). The second possibility is that individuals diagnosed with CKD from elsewhere in the state move into Benin City and live with friends/relatives or rent/buy accommodation when they realise they need treatment at UBTH. Therefore, it is difficult to ascertain how many people from the rural areas can rent/buy accommodation or still have friends/relatives in Benin City that they can live with when they realise they need treatment at UBTH and who can help them with the cost of the CKD treatment. Therefore, due to the limitation of my research data, I do not have the evidence to decide which of the two possible explanations could have accounted for the over-representation of diagnosed CKD cases relative to the general population in the travel time band nearest the hospital. However, I would argue that both circumstances are likely to have contributed to the spatial distribution

of diagnosed CKD cases within the state. This can be attributed to the fact that geographical accessibility as well as affordability of CKD treatment is likely to be responsible for the spatial distribution of diagnosed cases within the state. Although there is the assumption that those that are able to easily access the renal unit would be diagnosed and ultimately get access to CKD treatment, we cannot rule out the possibility that only those who can afford the treatment will be willing to access the renal unit for treatment. This could therefore explain why the diagnosed CKD cases appear to be disproportionately drawn from the more affluent parts of that society even though there is no substantial evidence that indicates that the prevalence of CKD is higher among those from more affluent parts of the society (see section 2.5.4). In other words, the inverse care law applies.

Although the travel time model to the hospital took into consideration the speed limit for the road types, one could argue that the settlement type within the travel bands of the model might have also influenced the number of diagnosed cases for both stages of CKD. It was observed that the sharp decline in the number of diagnosed cases in the travel bands away from the hospital were found to have only rural settlements within their boundaries. Equally intriguing was the fact that these rural areas where the sharp drop in diagnosed cases where registered, happened to be the rural settlements surrounding Benin City. However, the slight increase in the number of diagnosed cases registered within the travel band(s) away from Benin City in the travel time model indicated that urban areas were located within those travel

bands. For example, Ekpoma town, which is an institutional town, is located within the 60minutes to 90 minutes band of the travel time model. However, the settlements located within the previous travel band of the travel time model, only consisted of rural settlements.

This result highlights the problem of accessible road networks in rural areas compared to their urban counterparts. One could argue that another factor that might have contributed to the poor number of diagnosed CKD within the rural areas might be due to the problem of accessible road networks within the state. According to a study on rural roads within Nigeria, it was reported that more than 70% of rural roads are in deplorable conditions and their accessibility can be classified as seasonal due to the obstruction of these roads during the rainy season (Ipingbemi, 2008). Because these rural roads serve as feeder roads that connect to the rest of the road network (see section 7.3.1), the problem of inaccessibility from these rural areas using these feeder roads might account for the poor number of diagnosed cases that are being registered. This might also explain why there appears to be more diagnosed CKD cases from urban areas that are further away from Benin City than the rural areas that are closer to the city.

7.4 Determining the location of suitable satellite centres for CKD treatment

Given the assumption that was discussed in the previous sections of this chapter, which suggests that accessibility to CKD healthcare might have contributed to the spatial distribution of diagnosed CKD, one has to look at ways of improving access to CKD healthcare within the state. In recent years, significant progress has been made in the research and development of methods for the efficient allocation of healthcare resources (Mitropoulos et al., 2006; Syam and Côté, 2010). Given the results from section 7.3, which indicates that there is the possibility that travel time is an impedance to effective CKD management in the state, there is the need to examine the prospect of locating other CKD centres that can serve as satellite centres for CKD treatment within the state. These satellite centres will not be newly built health centres but already established health centres where CKD healthcare services can be integrated with the health services they offer to the residents in their areas. In order to identify a suitable site for the location of a satellite CKD centre, a location-allocation model was created using ArcGIS 10. A location-allocation model seeks to simultaneously determine optimal facility locations and the assignment of demand to the selected facilities (Syam and Côté, 2010).

7.4.1 Determining the location for more CKD facilities within Edo state to cater for the treatment of earlier stages of CKD

As mentioned in the previous chapters, a number of studies have already established that one of the ways of addressing the issue of CKD is by carrying out routine screening so as to detect the disease at an earlier stage when it is cheaper and easier to treat. There is the possibility that physicians and health officials in other health centres can help to screen the population for CKD, diagnose, and also manage CKD patients at the earlier stages of the disease instead of referring all diagnosed cases to UBTH. As such, there might be the need to set up interim CKD facilities within the state that are also cost effective in the management of the earlier stages of CKD within the state. The idea behind the establishment of such CKD facilities would be to reduce the distance between the patients and accessible CKD healthcare facilities. Previous analyses on the available CKD facilities within the state such as the screening centre in Ogbona ward (see chapter five) and the UBTH accessibility issues discussed in section 7.3, both indicate that the current structure for CKD management might not be adequate. However, given the fact that it would not be financially feasible to establish several new CKD facilities within the state, I would suggest that already established health centres within certain areas of the state could be chosen to offer CKD screening to the general public and treatments for CKD at the earlier stages. These centres can also be equipped to carry out awareness programmes within their local vicinities, which would help improve CKD

awareness among the public and this could lead to an improvement in the diagnosis of CKD at the earlier stages. Therefore, in order to minimise the distance between CKD patients and CKD healthcare facilities, there was the need to carry out a location-allocation analysis in order to locate satellite CKD centres close to population centres for each LGA, which would serve as population thresholds for the satellite CKD facilities. This objective was based on the argument that people tend to attend nearby health facilities than attend those that are farther away. This argument is based on the results from the previous section (see Table 7.3) that indicated a sharp drop in the number of diagnosed CKD cases after a certain limit.

7.4.1.1 *Criteria for new CKD healthcare services*

For the optimal location for the CKD facilities, one main factor was considered. This was the travel time to these CKD facilities from population centres within the study area. The objective is reflected in the minmax criterion where the aim is to minimise the maximum distance that CKD patients must travel to access healthcare treatment (Marsh and Schilling, 1994; Mitropoulos et al., 2006). Based on the argument stated above that the CKD facilities should be located from already established health centres within the state (either hospitals or clinics), the model for the location of the CKD facilities was based on the following assumptions:

- The number of established health centres that could potentially offer CKD healthcare services were specified in advance

- The existing demand for the CKD healthcare services can be satisfied either at a clinic or hospital
- The patients would choose to travel to the closest CKD healthcare service

At this point, I must highlight that the intention of locating these CKD healthcare services is to cater for the CKD screening of the general public and also the management of patients with earlier stages of CKD where the possibility of needing specialised renal treatment is low and likely to be absent. This is because the physicians within these healthcare service areas could adequately manage the patients at these earlier CKD stages. Using the average travel time derived from the travel time model (see sections 7.3.2), the pre-specified threshold value for the maximum allowable travel time was set at 29 minutes.

In order to ensure that the general population could have access to these CKD healthcare services, the centroids of the wards were chosen as the demand points for the model and their populations were assigned as weights. The choice of using the general population and not the number of diagnosed CKD patients was because any member of the population could develop CKD and also these facilities would serve as CKD screening centres for the population. However, this led to another problem, as not all the wards could be located within the model. This was because of the problem mentioned earlier in section7.3.1, as the network dataset was incomplete and as such, the wards located at the south western boundary of the state could not be

located within the model. This meant that 188 wards out of 195 wards were included within the model. Therefore, approximately 3.6% of the population within the state were excluded from the analysis.

An alternative would be to use the Euclidean distance, as this would not exclude areas without road networks. However, this technique was not considered in this study because it does not incorporate access to transportation and transportation networks (Alvanides and Gilmore, 2004). Therefore, the results generated might not be as close to reality as those produced using road networks because people are more likely to travel along transport routes than in a straight line especially across long distances where transportation and transportation networks are available.

Determining the number of CKD healthcare services

The actual number of CKD healthcare services that could be included within this model is a rather subjective decision. However, in order to create a sense of objectivity, one CKD healthcare service was assigned to each LGA within the state, this meant that 18 CKD healthcare services were to be included in the model in order to assess whether the presence of these facilities would improve the accessibility of the population to CKD healthcare within the state. The option of what type of healthcare service to use i.e. whether it is a hospital or a clinic, or whether it is a privately or publicly owned health facility, was not considered within this model. This was due to the absence of data on the spatial location of all the health facilities

within the state as well as the lack of data on the resources within these facilities.

Since the spatial location of the health services within each LGA could not be determined, the centroid of each LGA was used as the spatial location for the health services that would serve as potential CKD healthcare services within the model. To ensure that these locations were accessible, the locations were snapped to their nearest road or road junction before carrying out the analysis.

7.4.1.2 *Analysis and results for the location of CKD healthcare services that could manage patients with earlier stages of CKD*

Since the objective of the analysis was to locate CKD healthcare services while minimising the travel time, the maximal covering location problem (MCLP) known as the "maximise coverage problem" in ArcGIS 10 (see chapter three) was used to solve the problem within a location-allocation model. The MCLP was chosen instead of the p-median problem because of the limitation associated with the p-median problem. As mentioned in chapter three the p-median problem does not take into account the worst-case scenario as the results from the *p*-median model, may be forcing a few users to travel far to receive CKD healthcare (Harper et al., 2005; Rahman and Smith, 2000). Another advantage of the MCLP is that it attempts to locate the facilities so that as few people as possible lie outside the desired travel time to a service.

The model began by first solving the optimal distance to UBTH based on the average travel time (in minutes) as impedance for the analysis. A linear impedance transformation was used in solving the problem. This ensured that ArcGIS used a linear decay in calculating people's propensity to seek CKD treatment at a CKD healthcare service. The results were then compared with the results derived from the model that analysed the inclusion of the 18 CKD healthcare services that would serve the LGAs within the state.

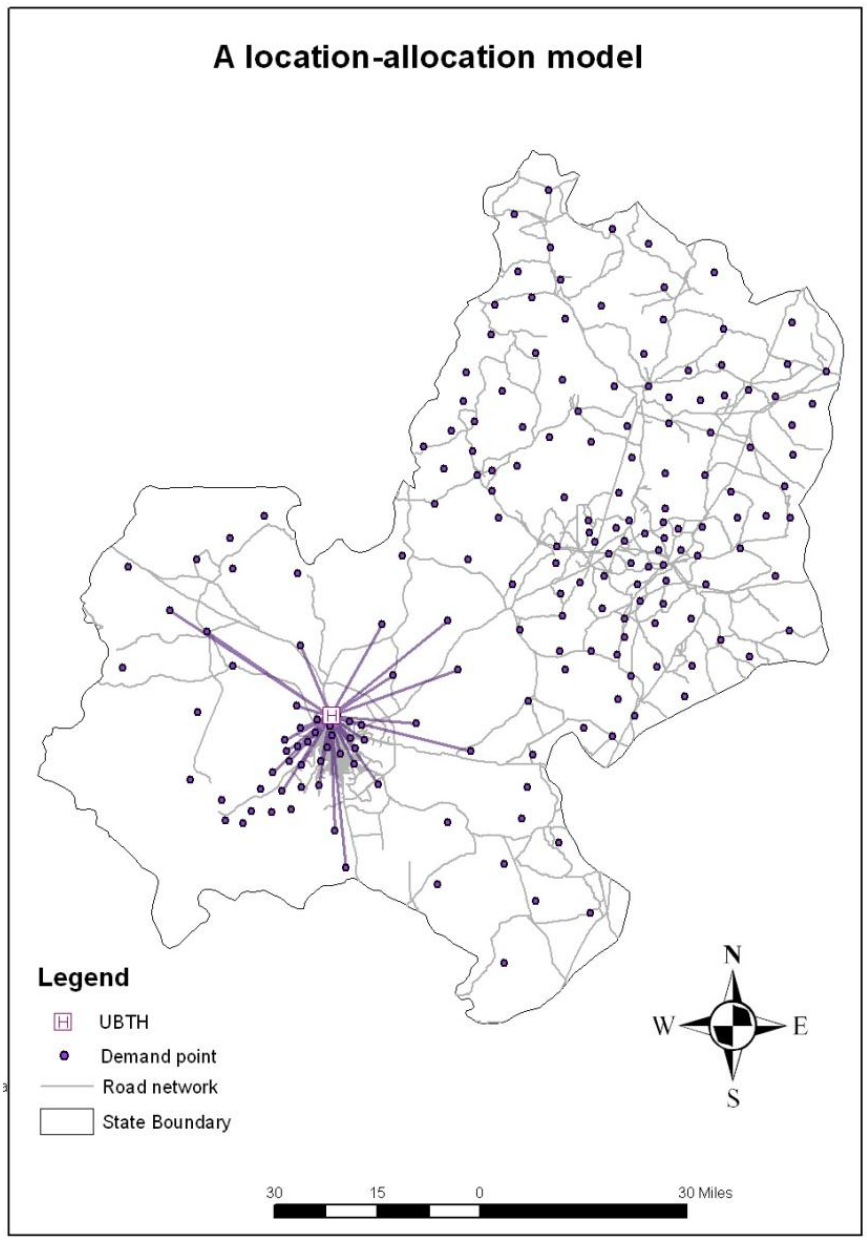

Figure 7.6: The current optimal demand to UBTH using travel time as impedance, which based on a 29-minute threshold value

The result of the model for the optimal travel time to UBTH, showed that given the assumptions stated in section 7.4.1.1, only 36 wards out of the 188 wards within the model would optimally access UBTH for CKD treatment. I should mention at this stage that although seven wards were not included within the study, their inclusion within the model were not likely to have increased the number of wards that

could optimally access UBTH. This is because these seven wards are not located within the threshold value of 29 minutes distance from the hospital. The result also stated that the total population that optimally had access to the hospital was approximately 1072244.

In order to minimise the travel time while increasing the demand within the available CKD healthcare services, the centroid for the 18 LGAs, which represented the sites for the possible CKD health facilities, were included within the model.

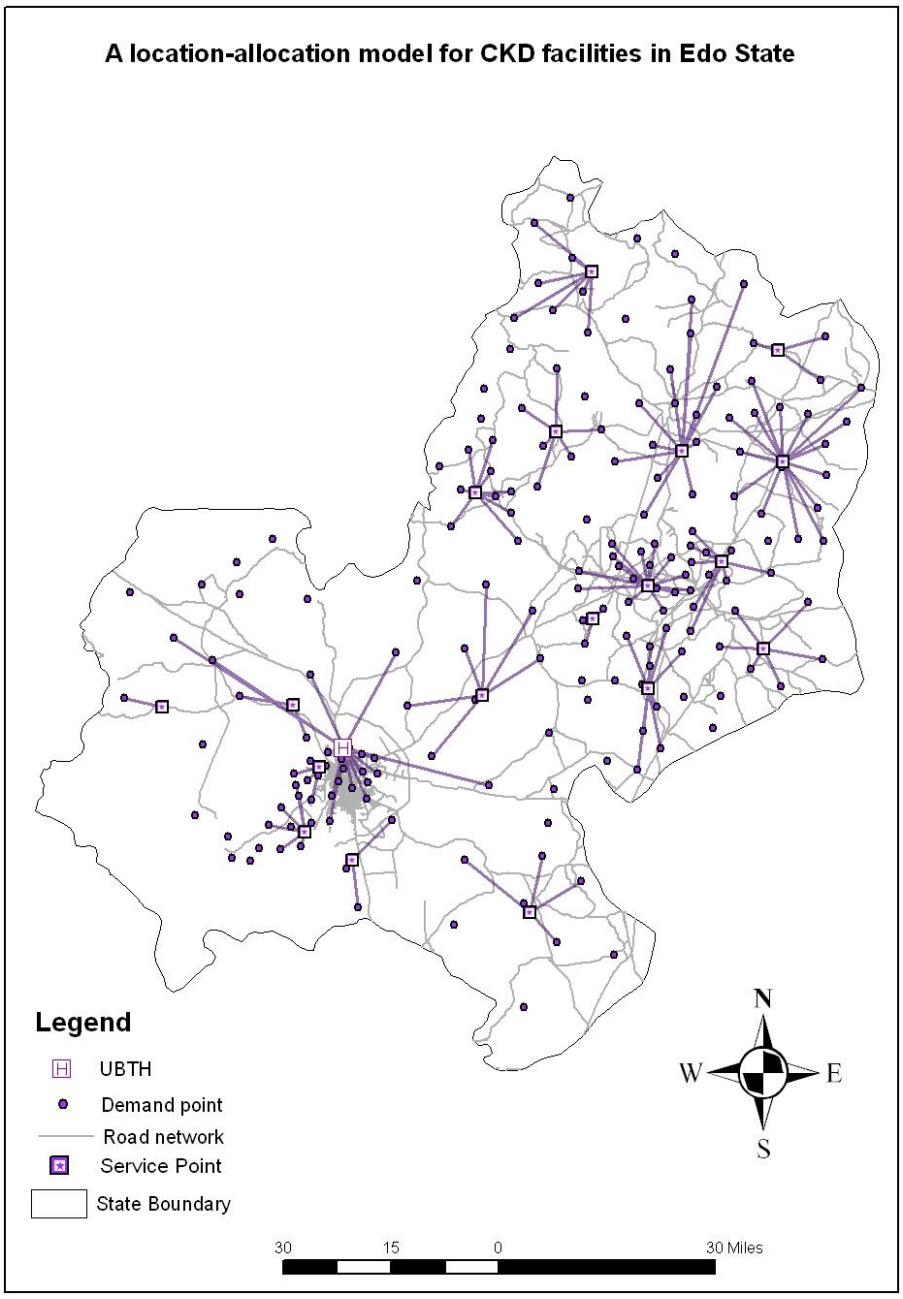

Figure 7.7: The predicted scenario using the LGA centroid as the service points for the potential CKD healthcare services that would cater for earlier stages of CKD

Once the 18 locations for the potential CKD facilities were included within the model, the results indicated that the number of wards that would optimally access UBTH for renal treatment had reduced to 18 wards instead of the 36 wards originally identified when UBTH served as the only CKD facility within the state. The total number of wards that would adequately have access to the 19 potentially

available CKD healthcare services had increased from 36 wards to 150 wards. This meant that the total population that would potentially have access to CKD healthcare had increased from 1072244 people to approximately 2731076 people.

However, it was discovered that in spite of the inclusion of the other 18 potential CKD healthcare services that would cater for CKD patients at the earlier stages, UBTH still had the highest allocated demand for its CKD healthcare service (see Appendix L). The potential site for the CKD healthcare service in Ovia southwest had the lowest allocated demand with just 1 ward and approximately 31493 people allocated to it. According to the Ministry of Health's records, there are a total of 23 healthcare services within Ovia southwest LGA. Two of these are secondary healthcare services while the remaining twenty-one are primary healthcare services. Given the low numbers allocated to the CKD healthcare service within this LGA, I would argue that either of the secondary healthcare services within the LGA would be suitable as a potential site for including a CKD healthcare service.

Due to the lack of data on the capacity of these healthcare services and also the ownership of these health services (i.e. whether it is privately owned or publicly owned), the actual choice on where to locate the CKD healthcare services within these LGAs would require further investigations as well as other considerations such as financial and political considerations.

7.4.1.3 *An alternative method for determining the location of CKD healthcare services that could manage patients with the earlier stages of CKD*

A problem with using the LGA centroid as the service locations was the possibility of locating a centre within an unpopulated area. This appeared to be the case for three of the LGA centroids – Esan west LGA, Esan north east LGA, and Etsako west LGA (see Table 7.7).

Table 7.7: The LGA centroids located within an unpopulated area

LGA	LGA Head Quarters	Settlement within or around the location of the LGA centroid
Esan west	Ekpoma	Ugbiyokha (closest settlement to unpopulated location)
Esan northeast	Uromi	Awo (closest settlement to unpopulated location)
Etsako west	Auchi	Ayeri-Ubiane (closest settlement to unpopulated location)

Therefore, to improve on the outcome of the model, a different criterion for choosing the locations for the potential CKD services to cater for patients with the earlier stages of CKD was selected. Instead of using the LGA centroids as the locations for the potential CKD services, suitable road junctions within each LGA were used as the location for the potential CKD services.

Another technique that was considered but not employed in this thesis was to generate population-weighted centroids for the LGAs, which would represent the potential CKD healthcare facilities. Although this can be classified as the most appropriate technique to use, it could not be done because the data needed for this technique were not available.

Criteria for choosing a suitable road junction as the location for the CKD healthcare services to cater for patients with the earlier stages of the disease

There were 4022 junctions represented within the road network dataset. To determine the junctions that could be included within the model as a suitable location for the CKD healthcare service within each LGA, a number of criteria had to be considered. The first criterion for selecting the appropriate junction was that the junction had to be linked to a major, minor, or a secondary road as these roads were in relatively good condition and also had a higher level of accessibility than the *other* roads. Another criterion was that the junction had to be located within a populated area.

In order to ensure these criteria were met, the road junctions were exported to Google Earth and overlaid on the study area. Once the criteria was met within a LGA, the appropriate road junction was selected for that area and a total of eighteen junctions were selected as the potential location of the CKD healthcare service within the Edo state (see Table 7.8). Equally intriguing, was the fact that only four out of the eighteen locations were within an urban centre. This therefore improves the access to CKD healthcare in the rural areas as this meant that 77.8% of the potential CKD health services could be located within rural areas where accessibility has been very poor.

Although it can be argued that most healthcare staff might not be willing to relocate to a rural area, which could defeat the purpose of

assigning one of these rural centres as a CKD health facility. I would argue that these CKD facilities are only to screen for CKD, diagnose, and manage patients at the earlier stages of CKD. This does not require the need for a renal specialist, such as a nephrologist or a renal nurse. Rather, the available health workers in these health centres are given the necessary training required for screening for CKD and managing patients with earlier stages of CKD, referring patients to a nephrologist when their conditions deteriorate beyond the capability of the health centre.

Table 7.8: The eighteen selected junction used in the model

Junction ID	Settlement within the location of the junction	LGA
12	Iguobazowa	Ovia southwest
600	Oluku	Ovia northeast
966	Ibiwe	Oredo
1127	Ugbowo	Egor
2632	Oka	Ikpoba-okha
3608	Sabon-Gida	Owan west
3623	Ehor	Uhunmwonde
3635	Ugo	Orhionmwon
3661	Isokka	Owan east
3686	onumu	Akoko-edo
3753	Akahia	Esan west
3805	Irrua	Esan central
3809	Ebele town	Igueben
3858	Ayeri-Ubiane	Etsako west
3925	Amendhokian	Esan northeast
3957	Ugun	Esan southeast
3965	Imiegba	Etsako east
3989	Ogonmeri	Etsako central

7.4.1.4 *Analysis and results for using the road junctions to determine the location of CKD healthcare services that could manage patients with earlier stages of CKD*

Using the same criteria for the location-allocation models discussed in section 7.4.1.1, a similar analysis was carried out using the selected road junctions as the potential locations for the CKD healthcare services. This meant that the maximise coverage problem in ArcGIS 10 was used to analyse the CKD health services within a location-allocation model.

In order to minimise the travel time while increasing the number of demand within the available CKD healthcare service, the 18 potential locations /suitable junctions, which represented the settlements where

the CKD health services could be located were included within the model. I should point out that the location-allocation analysis, which had just UBTH within the model was not repeated in this section, as the result would be the same as the previous analysis. However, the outcome from the analyses in this section was compared with the outcome from the analyses that used just UBTH to create the model.

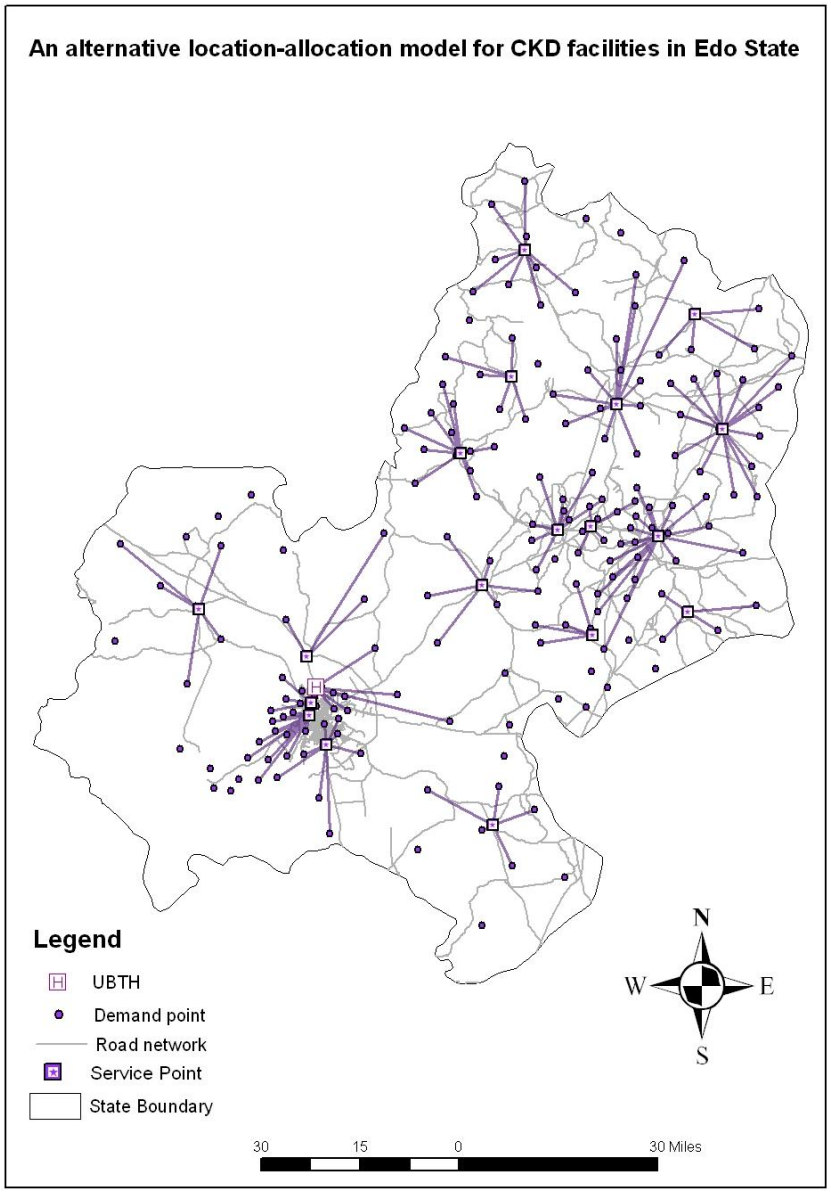

Figure 7.8: The predicted scenario using a suitable junction within each LGA as the service points for the potential CKD healthcare services that would cater for earlier stages of CKD

When the 18 locations for the potential CKD facilities were included within the model, the results indicated that the number of wards that would optimally access UBTH for renal treatment had reduced to 9 wards instead of the 36 wards originally identified when UBTH served as the only CKD facility within the state. The total number of wards that would adequately have access to the 19 potentially available CKD healthcare services had increased from 36 wards to 159 wards. This represented a considerable increase.

The potential site for the CKD healthcare service in Ovia Northeast LGA had the lowest allocated demand with just three wards and a total of approximately 49487 people allocated to it. According to the Ministry of Health's records, there are 29 healthcare services within Ovia Northeast LGA. It has one tertiary hospital, one secondary healthcare service, and the remaining twenty-seven are primary healthcare services. Given the low demand allocated to the CKD healthcare service within this LGA, I would argue that either the tertiary hospital or the secondary healthcare service within the LGA would be suitable as a potential site for including a CKD healthcare service.

The variations in results generated in this chapter highlight the problem of data availability and its impact on the outcome generated within a study that relies on a limited dataset. This is one of the problems faced by health geographers and other researchers working within a developing country where relevant data are not usually

readily available. Given the fact that the scope of this study does not include a detailed field investigation of all the registered healthcare services within the study area, the alternative approach utilised in this location-allocation analysis appears to have produced an outcome that can be regarded as a plausible result. This is because this approach took into account the relevant criteria needed in locating an accessible site.

In conclusion, I would recommend that the travel time to the location of potential CKD healthcare services must be included during the proposal for additional CKD healthcare services that would cater for the CKD screenings in the state and the management of CKD at the earlier stages of the disease.

7.4.2 Determining the location for a CKD facility within Edo state to cater for the treatment of patients at the late stage of CKD

The establishment of an optimal CKD health service that caters to the treatment and management of patients with the late stage of CKD can be regarded as a capital and structurally intensive project. This is because such a health service requires certain facilities in place, such as the establishment of RRT facilities (e.g. renal dialysis machines) as well as the employment of an adequate number of renal health staff (e.g. nephrologists, renal nurses and medical technicians to manage the dialysis equipment). Therefore, it would not be financially feasible to allocate this type of facility within each LGA within the study area. Based on these circumstances, another option has to be considered

where some facilities are already available within an established healthcare centre, preferably a tertiary health institute. According to the state's health ministry, there are currently eight tertiary hospitals within the state (see Table 7.1). Since one of these tertiary hospitals is the University of Benin Teaching Hospital (UBTH), the location of another CKD health service would have to be chosen from the other seven hospitals. UBTH is located within Egor LGA and according to the report by the state's health ministry, there are two tertiary health services within that LGA but according to my investigation, the second tertiary health service was a Psychiatry hospital. This therefore meant that the remaining six LGAs that had a tertiary hospital within their boundary could be considered within the location-allocation model. These were Irrua specialist hospital in Esan central LGA, Uromi central hospital in Esan north east LGA, Auchi central hospital in Etsako west LGA, Specialist Hospital Ossiomo in Orhionmwon LGA, the Benin central hospital in Oredo LGA, and Ovia north east LGA. Further investigation showed that the Specialist Hospital Ossiomo is a Leprosarium and Haematology hospital, therefore the hospital was removed. This therefore meant that apart from UBTH, only five tertiary hospitals could be considered. However, certain criteria had to be met before any of these listed hospitals were included in the analysis.

7.4.2.1 *Criteria for locating another CKD health service for managing the late stage of CKD*

The objective of the analysis is to locate one more facility in any of the other tertiary hospitals, which would serve as another specialist CKD health facility in addition to the UBTH renal unit. Because UBTH is located within the south western region of the state, the main criteria for locating another CKD facility would be that it must not be spatially close to UBTH. Therefore, it should not be within Benin City. In addition, the new facility should ideally be more centrally located so that it could cater for other patients that reside further away from the state's capital where UBTH is located. Based on these criteria, the tertiary health service in Oredo LGA was excluded from this analysis, as it was located within Benin City. It was discovered that one of the referral centres included within this study was classified as one of the remaining four tertiary hospitals that could be included within the analysis. This was the Irrua specialist hospital, which is located within Esan central LGA (see section 7.2). Therefore, its geographical co-ordinates were used instead of the LGA centroid Esan central. The other four hospitals were geocoded and mapped.

Determining the appropriate problem for the location-allocation model

The "maximise attendance" model was considered for the location-allocation analysis. The objective of this model was considered appropriate for solving the stated problem (see section 7.4.2.1). This is

because, according to the originators of this model, the model aims to solve three main problems (Holmes et al., 1972):

- Determine the maximum distance that people are willing to travel to secure a service
- Maximise the number of people served by the facilities
- Minimise the average distance travelled per person in relation to the proportion of the total population which is served

Given that the maximise attendance model can determine the facility that can be allocated to the maximum number of people while reducing the average distance travelled for each person, therefore the facility that had the highest demand allocated to it apart from UBTH was classified as the optimal centre for locating another CKD centre.

7.4.2.2 *Analysis and results for the location of another CKD health service that could manage patients with the late stage of CKD*

The model was set to choose only two facilities from five facilities included in the model. Within the parameters for the facilities included within the model, the status of UBTH was set as a required facility while the remaining four facilities were classified as candidates. This was to ensure that UBTH was included in the results while attempting to find another tertiary hospital that would be the optimal location for another CKD healthcare service that provides specialised healthcare for CKD patients.

The travel time variable was used as impedance in solving the problem of identifying another CKD healthcare service for patients

with CKD at the late stage of CKD. Using the same parameters discussed in section 7.4.1.1, the pre-specified threshold value for the maximum allowable travel time and travel cost, were set to 29 minutes. This was done in order to model the maximum distance that people were willing to travel to the proposed CKD centre.

Just like the previous location-allocation analyses, a linear impedance transformation was used in solving the problem, which ensured that ArcGIS used a linear decay in calculating people's tendency to seek CKD treatment at any of the CKD healthcare service.

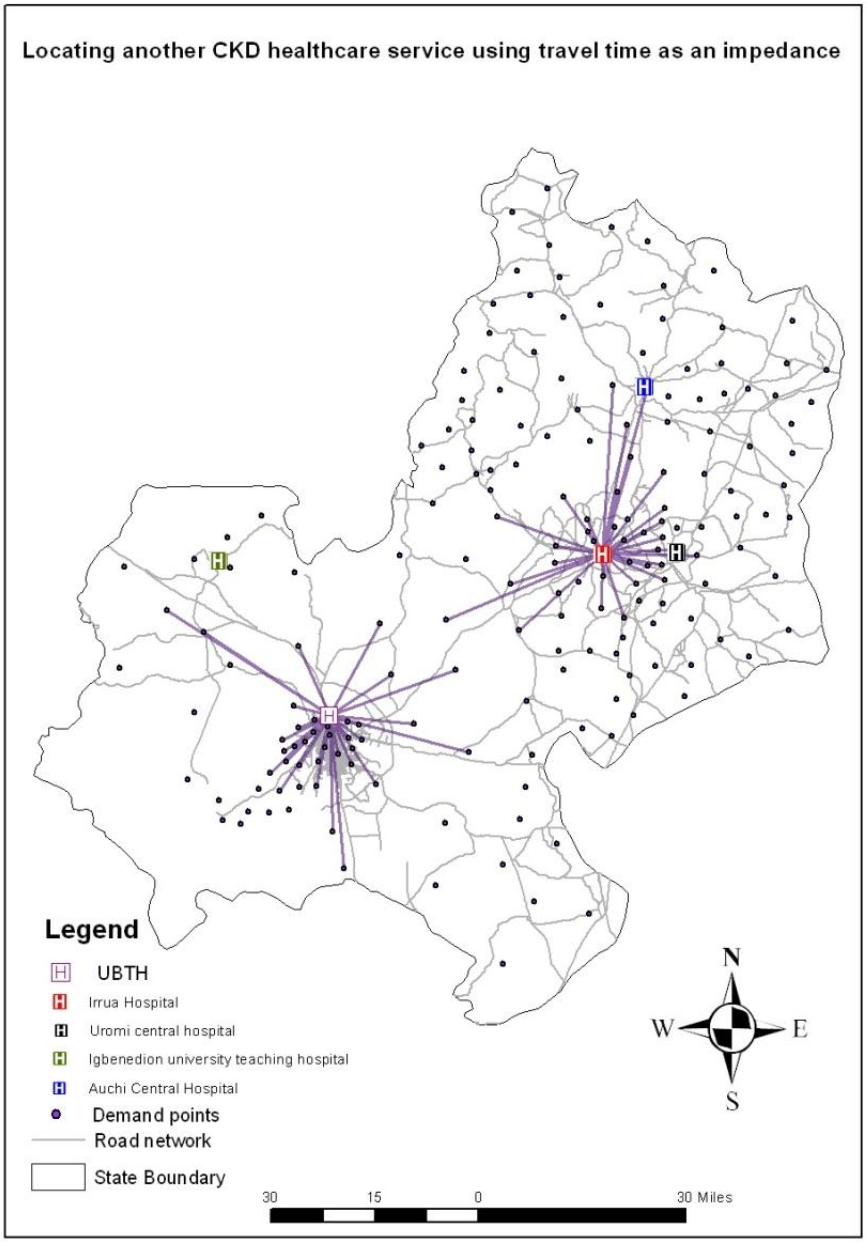

Figure 7.9: Predicted scenario for the optimal location for another CKD service that would cater for patients with the late stage of CKD and offer specialised CKD healthcare for the state

The result from the model showed that apart from UBTH, Irrua Hospital, which is located in Esan Central LGA, had the highest demand with a total of 35 wards allocated to it. Although UBTH was allocated 35 wards, it had a higher population demand of approximately 527253 people, while Irrua hospital was found to have approximately 207013 people. This result indicates that Irrua hospital

is likely to cater for a higher number of patients than the other four candidate tertiary hospitals, which were also considered for the establishment of a CKD healthcare service.

The result of the predicted scenario for the optimal location for another CKD service that would offer specialised CKD healthcare along with UBTH, indicate that 70 wards and approximately 734267 people would be catered for in this scenario. It is apparent from using travel time as impedance that Irrua hospital appeared to be the most likely location to establish another CKD service that would cater to CKD patients with the last stage of the disease.

Exploring the capacity of Irrua hospital and the available resources needed to establish the CKD service within the hospital is currently beyond the scope of this thesis. This is primarily due to the absence of readily available data on the issue. However, a detailed investigation into the available resources that can be used in the establishment of another CKD service within state (preferably within Irrua hospital) should be considered in future studies.

7.4.3 **Limitations associated with the location-allocation models.**

A major limitation of the outcomes generated from these location-allocation models is the lack of data to indicate the capacity of the healthcare services within the state. As a result, the model failed to take into consideration whether these healthcare services that were identified as the optimal locations for the CKD facilities could

adequately manage the demand (i.e. the estimated population in the wards) assigned to them if or when they come for CKD screening.

Another limitation is that the models did not take into account all the population within the study area as 3.6% of the population had to be excluded from the analyses because of the missing road network data for the south western boundary of the state.

Furthermore, there have been some apprehensions that have been raised about the suitability of capturing the complexities of real-life location issues by adopting these accessibility models. Such limitations include the inability to capture the unpredictability in patients' mode of transport, distances, travel times, and uncertainty over patient preferences for travelling to different centre locations, and complexities over consideration of healthcare services involving multiple services rather than a single service (Harper et al., 2005).

Another shortcoming of the use of accessibility models in evaluating service accessibility problems such as CKD healthcare facility within the state is that an optimal solution cannot be guaranteed. This is because real-life location planning is subject to various constraints and other factors, such as political considerations (Harper et al., 2005). In many developing nations, decisions pertaining to resource allocations and facilities locations are generally taken locally by government officers or by local elected leaders or by both and in the absence of any formal analysis and generation of alternatives, the final decision may be made on political or practical considerations (Rahman and

Smith, 2000). As a result, the decisions made regarding the location of another CKD health service might be far from optimal because it cannot solve the problem but only inform decision makers.

7.5 Conclusion

This chapter began by suggesting that proximity to UBTH could likely be an impedance that resulted in the low number or absence of diagnosed CKD in certain areas especially among rural dwellers within the state. The travel time model to the hospital has indicated that those residing further away particularly rural dwellers are more affected by the spatial accessibility to the renal department within UBTH. This may have resulted in patients not seeking medical treatment even though they might have been diagnosed with CKD by the medical practitioner within their community.

Furthermore, the limitations associated with the data and the unpredictability of patients cannot be measured within a static model such as the ones created within this study. Therefore, the outcome of the results discussed within this chapter can only serve as a baseline on which further investigations on the suitability of an optimal location for CKD healthcare service can be implemented. The outcomes from the models could help health planners to evaluate the organization of the available CKD services and the impact on the spatial distribution of the population, both from the managers of the healthcare service and patients' viewpoints.

The next chapter summarises the main findings of this thesis and also discusses the recommendations that would address the research questions that have been outlined in this thesis.

Chapter 8 Concluding statements

8.1 Introduction

This concluding chapter focuses on the implications of the findings of this research study. Therefore, the implications of the findings from both the research process and results of the study are discussed in line with the structure of the thesis.

The first section of this chapter begins with a summary of key findings. The methodological limitations of the research as well as the possible effects of sample bias due to missing records and non-response within the CKD dataset are outlined in section 8.3. Section 8.4 focuses on the discussion of the implications of the findings from the research study. The recommendations for future study are discussed in section 8.5 while some concluding comments are outlined in section 8.6.

8.2 Summary of findings

This study attempted to answer the following six research questions:

- *Is there an association between socio-demographic factors and the severity of CKD at first presentation?*
- *Is there a relationship between the severity of CKD at first presentation in Edo state and known biological risk factors of CKD?*
- *What factors are likely to lead to the late diagnosis of CKD among patients in Edo State?*

- *What is the trend of diagnosed CKD within Edo state?*
- *What is the spatial pattern of diagnosed CKD cases within Edo state?*
- *Is the prevalence and distribution of CKD in the state appropriately serviced by the available CKD healthcare service?*

The results from this study showed that there was no significant association between the socio-demographical characteristics of the patient and the severity of CKD at the time of diagnosis. However, more detailed socio-demographical data (for both the general population and CKD patients) as well as health data on CKD within the state is needed to explore this further.

There appeared to be a significant association between the severity of CKD at the time of diagnosis and three out of four of the main biological risk factors of CKD. The highly significant biological risk factors were diabetes, hypertension, and toxic nephropathy. Although previous studies had identified chronic glomerulonephritis as one of the leading risk factors of CKD in Nigeria, chronic glomerulonephritis was not found to be independently associated with the severity of CKD at time of diagnosis. Based on the results from the logistic regression, there was evidence that the absence of diabetes, hypertension, or toxic nephropathy in a patient increases the odds of being diagnosed at the late stage of CKD and decreases the odds of being diagnosed at the earlier stage of CKD.

The trend of diagnosed CKD within the study period appeared to be increasing. However, there were indications that the majority of the CKD cases were still diagnosed at the last stage when it was too expensive to treat. In addition, there were indications that the impact of the CKD awareness programmes particularly the World Kidney Day (WKD) programme, appeared to have only a momentary impact on the number of CKD cases diagnosed each year. Furthermore, the number of patients diagnosed at the final stage of the disease was found to be relatively too high in comparison to the number of patients diagnosed at the earlier stages of the disease.

The result of the spatial pattern of diagnosed CKD within the state indicated that the majority of the diagnosed cases were located within urban areas with few cases diagnosed in rural areas. However, further investigations into the reason behind the spatial pattern of the disease needed to be explored as there are indications that there might be more rural dwellers with CKD who are not diagnosed or receiving treatment.

The final key finding of the study appeared to indicate that the current structure for CKD management within the state is very inadequate. This might be due to the issue of accessibility from various parts of the study area. There are indications that the travel time to the hospital for CKD treatment might be a contributing factor to the number of diagnosed CKD cases currently observed in the state. These findings appear to indicate that spatial inequalities and access to CKD

healthcare are critical issues that need to be addressed in order to manage the disease effectively.

8.3 Limitations of the Research

In the previous chapters, particularly in chapters three and four, the limitations experienced during the course of the research study were discussed. Below is a summary of the limitations of the datasets used in the study. Recommendations on how to resolve these limitations are subsequently discussed in section 8.5.

8.3.1 Limitations to the datasets

This research study was limited to the CKD data that was made available for Edo state. Given the diversity of the population within the country, the inferences that can be made from this study, can only be used loosely for the rest of the states in Nigeria until an in-depth study is carried out.

Another limitation is that only secondary data was taken into account in the course of this study. However, as the research progressed, I became aware that other data sources would be valuable. For example, a qualitative approach (particularly the use of interviews and group discussions of CKD patients) was not incorporated into my research design. Therefore, as the research progressed, I discovered that the use of secondary data within a quantitative approach could not give a detailed account for some of the outcomes derived during the course of my study. An example is the relatively low number of patients diagnosed at the fourth stage of CKD as opposed to those diagnosed at

the third stage of the disease (see chapter four). This pattern within the CKD dataset required further investigation, which could not be verified within the scope of my research design. Such an investigation would require the use of a mixed approach (i.e. using quantitative and qualitative approaches) so as to extensively draw out reason(s) behind this pattern of diagnosed CKD within the state.

One of the main limitations of the CKD dataset was the absence of data for some of the variables especially within the socio-demographical variables such as education, religion and ethnicity (see chapter four). This limitation in the data is likely to have affected the statistical outcome derived from the regression model as an attempt to include such variables resulted in the occurrence of redundancies within the model.

Another limitation was the absence of census data at the ward level for the study area. There were no demographical data available at the ward level and the total counts for the population data were only estimated figures. This resulted in less detailed analyses at the ward level.

8.3.2 **Possible effect of sample bias in CKD dataset**

Given the problem of retrieving CKD data, which was discussed in chapters three and four of the thesis, there is the possibility that the missing data might have affected the outcome of this study. Even though the subsequent dataset was used to evaluate the possible presence of structural bias within the CKD dataset, one cannot rule out

the likelihood that the quality of the data might have improved if the missing data were included. For example, the inclusion of these missing records might have reduced the occurrence of redundancy within the regression analysis when certain variables were included within the model.

Another possibility that should be considered is that the missing data might actually represent rural dwellers that had been diagnosed with CKD. Should this be the case, this might have an impact on the outcome of the spatial analyses carried out within this study.

8.4 Implications of findings

The main contributions of this study are its information on the trend and spatial distribution of diagnosed CKD in Edo state.

The first main finding of this study is that patients that develop CKD without previously having been diagnosed with known risk factors such as hypertension, diabetes, and toxic nephropathy are more susceptible to a late diagnosis of CKD. These findings have important implications for formulating renal health policies and designing research studies within the population. This is because there is the probability that people without these risk factors might be overlooked when creating renal health policies, which might lead to the late diagnosis of CKD among such people. Therefore, in the development of strategies that might help in the early diagnosis of patients, this category of patients (i.e. those without any previously known biological risk factors) should equally be taken into account. One way

that this might be accomplished is by ensuring that in the creation of adequate CKD awareness programmes and the establishment of routine CKD screening exercises, people without these risk factors should also be encouraged to partake in the CKD screening exercises.

Another of the main findings of this study was the relatively high number of patients that were diagnosed at the last stage of the disease, when it is too expensive to treat and unaffordable by most of the patients. The high number of diagnosed cases at the last stage of CKD supports previous studies that were carried out before the inception of the nation-wide CKD awareness programmes that began officially in 2006 (discussed in section 5.4). Although the outcomes were from different states and periods, the relatively high numbers of late diagnosis of CKD were still present in all studies. Therefore, it can be argued that the result from this study further highlights the burden of CKD both at the state level and at the national level given the fact that late diagnosis of CKD is more expensive to treat and unaffordable by the majority of the population.

Another outcome from this study was the low level of referral of CKD cases to the renal department in UBTH from other health institutions within the state. This might be attributed to a poor understanding among medical personnel within these health institutions about CKD and its health implications. The lowest referral rates were found to be among clinics that *ideally* are regarded as the first point of call once a person experiences any health symptoms. However, it would appear

that the clinics in the state might have a very poor knowledge of the disease in comparison to other healthcare centres, which may have resulted in the very low number of referrals from these clinics. Therefore, in the strategies that might be put in place, there should be avenues that include the training of medical staff particularly at clinics to be more aware of the disease in order to diagnose the disease early among their patients and refer them early to nephrologists for treatment. This would help reduce complications that are usually associated with late diagnosis of CKD as well as enable the patient to have a better chance of survival due to the possibility of affordable treatments that are available at the earlier stages of the disease.

It is worth adding at this point that some of the biological risk factors of CKD are also risk factors for other serious conditions such as cardiovascular disease. Therefore, it would be beneficial that these risk factors are detected early as this could help reduce the impact of such diseases in the society.

8.4.1 Implications of findings on the spatial pattern of diagnosed CKD cases within the state

The results of the analyses indicated that the proportion of diagnosed CKD cases within the state appeared to be higher within the urban areas than in the rural areas since the number of diagnosed patients appeared to be concentrated mainly within the urban areas and not within the rural areas. Does this mean that CKD is more prevalent in the urban areas than the rural areas? I argue that the answer is no! A

previous study carried out within the southern-eastern part of the country, found a higher CKD prevalence among the rural population as opposed to the urban areas (Ulasi et al., 2009). This was similar to another study, which reported a prevalence of 19.9% of undetected renal diseases including CKD in a rural area in western Nigeria (Kuteyi et al., 1999). There is therefore the possibility that most rural dwellers that have CKD are not being diagnosed while more urban dwellers that have access to CKD treatment facilities have been diagnosed.

Based on the outcomes from this study, two main factors could be attributed to the disparity in the prevalence of CKD between the urban and rural areas. Although this spatial analysis took into account the underlying population (discussed in chapter six), one could argue that the rural areas may not be adequately informed about the impact of the disease. This might be attributed to the methods currently used in the dissemination of kidney awareness programmes within the country. There is the probability that the approach of using the mass media as the primary means by which the information is disseminated to the public might not be effectively reaching out to the majority of the population. Therefore, better efforts and resources may need to be focused toward dissemination activities by the Nigerian Ministry of Health, medical associations (e.g., the Nigerian Association of Nephrology (NAN) and the Nigerian Medical Association (NMA)), and charities affiliated with kidney diseases to increase awareness of CKD among medical practitioners and in the general public. The

focus should not only be those with known risk factors but also those who are less likely to be aware, such as those without diabetes, toxic nephropathy, or hypertension, and those without regular access to healthcare particularly within the rural areas.

There have been suggestions put forward to help in the improvement of CKD both within and outside Nigeria, especially since the inception of the WKD programme. One such suggestion is that the government should be persuaded to support policies of prevention, early detection, and treatment using humane grounds, plus cost effectiveness as good reasons, estimates of which should factor in delay of disability and death among members of society (Smith et al., 2008). This is because the government does not currently consider CKD as a national health concern even though studies indicated otherwise and as such, there are no government funded CKD programmes or policies in place within the country.

Another factor might be the problem of the accessibility of CKD healthcare services within the study area particularly between the urban and rural areas. This could be attributed to poor CKD awareness, inability to afford treatment, and poor proximity or inaccessibility to CKD healthcare by rural dwellers. These may account for the low number of diagnosed cases within these rural areas.

One would therefore recommend that adequate CKD awareness programmes should be put in place that will be tailored to reach out to

the rural areas probably in the native dialects of these areas as well as creating training programmes for the health officials within the rural areas on the awareness of CKD and how it can be identified in patients. Equally, the establishment of satellite CKD healthcare centres should be considered in order to cater for a higher proportion of members of the public as this would improve the accessibility issues to CKD healthcare within the state.

8.4.2 **Theoretical Implications**

As discussed in section 2.2, the inverse care law suggests that populations with the poorest health outcomes also tend to have poorer access to high-quality healthcare. This thesis has highlighted the possibility that access to CKD healthcare could have contributed to the spatial pattern of diagnosed CKD cases within the state. This is because there is the likelihood that the large proportion of diagnosed CKD cases (approximately 70%) that reside close to the only hospital in the region which provides services for CKD could be as a result of one of the two factors discussed in section 7.3.3. Given the large proportion of rural dwellers, approximately 70% of the total Nigerian population (NPC, 2005), the possibility that a significant proportion of these rural dwellers will have family or friends within Benin City able and willing to help them in bearing the cost of treatment and accommodation is unlikely. This has been compounded further by the absence of reliable data on the socio-economic status and migration data between the urban and rural areas within the state and the country, which makes it difficult to determine the reasons for and/or

number of those who have actually migrated as a result of their diagnosis. This has therefore made it difficult to estimate how many diagnosed CKD patients from rural areas actually relocated to Benin City in order to have better access to CKD treatment because they could afford to do so or because they still had family or friends in Benin City with adequate resources to help them. Establishing which of the assumptions discussed in section 7.3.3 that is the most likely, could have significant policy implications. On one hand, if most of those diagnosed with CKD can move to Benin City to receive treatment, the argument for locating additional renal centres in other parts of the states is less compelling. However, given the possibility that many diagnosed CKD patients from rural areas could be unable to relocate to Benin City because they cannot afford it or may not have family or friends in Benin city with enough resources to help them, then in the presence of either the first or second assumptions, there is a strong argument for locating other renal centres elsewhere in the state. Due to the non-availability of data regarding the prevalence rate of CKD within the country as well as the migratory patterns within the state and the country as a whole, it is not currently possible to decide which of the two assumptions currently influences access to healthcare by CKD patients within the state. Regardless of the stated assumptions, we cannot rule out the possibility that limited accessibility from rural areas to Benin City where the renal healthcare is currently available could have played a role in the current spatial pattern of diagnosed CKD within the state. In addition, the current

mode of information dissemination on CKD awareness does not favour rural dwellers and this could have led to rural dwellers with CKD having poorer access to available CKD healthcare. The findings from this study supports previous studies that identified that distance to improved healthcare need to be reduced to enhance accessibility to improved health services by various socio-economic groups in the country as well as the need for locally-tailored knowledge about healthcare access for CKD patients across the state (Agee, 2010; Antai et al., 2010; Awoyemi et al., 2011).

In summary, this study has attempted to investigate the applicability of the inverse care law by showing that it is not only in the probability of a late or early diagnosis of a CKD patient that healthcare is found to be unequal but also the dissemination of vital health information that could prevent CKD or lead to early diagnosis.

8.5 Recommendations for further study

Although none of the socio-demographic variables was found to be statistically significant determinants of the severity of CKD at time of diagnosis, the influence of these variables cannot be ruled-out as the current extent of this research study is limited in its approach.

I would recommend that a different approach to the study of CKD might be more efficient, preferably a longitudinal study and the use of a mixed approach. This involves the use of quantitative and qualitative approaches within this longitudinal study, where data would be collected directly from patients and not relying completely

on information in their health files. This is because the use of the mixed approach in the data collection process could improve the data that is used as the primary source of information for CKD patients. Using the life course approach to study CKD patients is likely to be regarded as a relevant framework that can be utilised for such a study thereby resulting in a more extensive study of the outcome of the disease. This approach requires information that dates from a patient's childhood to their present status, but this approach requires more time, which was beyond the time-scale of this research study. However, the life course approach might be able to shed more light on the outcome of CKD than what has been currently evaluated within the scope of this research study. This is because the approach could deduce other factors that had not been considered within this research, such as the patients' diet, their source of water supply, and also their cultural life style all of which might have individually or collectively contributed to the development of CKD in the patients.

Another approach could be the evaluation of the biological risk factors from a behavioural concept. This involves the study of the association of the behaviour of CKD patients with the presence of these risk factors in order to identify behavioural factors that might have influenced the development of these risk factors. For example, studying the diet behaviours of diabetic CKD patients, the cultural life styles of CKD patients with hypertension or toxic nephropathy, the outcome of this study could shed more light on the development of

CKD and this could be termed the study of the "*causes of the causes*" (Marmot, 2006 p.3).

In addition, a participatory and interdisciplinary nature of the research should be considered in order to gain a wider view of the impact of CKD within the country. Participatory in the sense that the population should be actively involved in the course of the research study in order to understand their behavioural or lifestyle patterns and how it relates to the development of CKD in individuals. In regards to interdisciplinarity, various sectors within the society such as health officials, policy makers, and health geographers should be included within a more detailed study of CKD to explore how the disease can be effectively managed and even reduced in the society. This could result in the development of more practical solutions to the problem of CKD prevalence especially since the stakeholders are involved in the research study process.

8.5.1 Recommendations for improving on healthcare data collection

Due to the problems experienced during the data collection process in UBTH, it became clear that a better structure is needed to improve the storage and retrieval of patients' data within the renal department and other departments within the hospital. The management of the hospital will need to consider an investment in the installation of a reliable digital database and the employment of a data entry officer to log patients' data. This investment will contribute to the development of reliable and current health data in the state. This can be regarded as a

starting point to the development of a CKD register as the establishment of a national CKD registry cannot be over-emphasised. This is because a national CKD registry could help in the effective monitoring of the disease and conducting CKD prevalence studies and risk factors within the country.

8.5.2 Recommendations for prevention and early detection of CKD

Medical and government policies need to agree about recommendations for screening and early detection of CKD. The majority of evidence from CKD screenings should come from individuals of all ages, and recommendations about whether to modify these proposals in older individuals will have to come from analysing subsets of older individuals that took part in the CKD screenings. Furthermore, future studies of CKD awareness should focus on intervention by examining patient, health provider, and societal (e.g., public relations campaigns) factors that can lead to better CKD awareness (Plantinga et al., 2008).

There is an increase in the number of research studies on known risk factors of CKD such as hypertension and diabetes within Nigeria (Kayode et al., 2010; Okeahialam et al., 2011). However, there are no readily available registers on these diseases within the country. I recommend that similar spatial studies on risk factors such as hypertension and diabetes should be equally carried out within the state in order to compare the spatial patterns of these diseases with the spatial pattern of CKD. The outcome of these analyses might be able

to indicate a more detailed pattern of the population that are medically regarded as being more at risk of developing CKD. Although the findings of this study indicated that there are other predictors of CKD apart from these noted biological risk factors, I believe the spatial analyses of these mentioned risk factors could serve as a baseline in highlighting the spatial distribution of the risk population of CKD until a more comprehensive CKD database is established within the state.

In addition, other methods, such as modelling CKD outcomes across the state, could be used to determine how best to structure the health policy that would effectively manage early detection of CKD within the state. However, it is not enough to develop recommendations. These recommendations must be promoted to both patients and their health providers in order to make a significant impact within the population (Frame, 2001).

8.5.3 Recommendations for additional CKD health centres

The results from this study have been able to highlight the problems associated with having just one major CKD health care service within the state. Although there are plans by some health practitioners to build privately owned renal centres within the state, which have been in the pipeline for a while now, the issue of accessibility and affordability are major factors that must be taken into consideration. The establishment of a well-equipped renal centre is capital intensive. Therefore, the option of locating such a facility anywhere without

taking into consideration its accessibility and affordability by the targeted population might not reduce the current impact of the disease within the state. Given the high cost of establishing a fully equipped renal centre, I would recommend that already established health centres across the state particularly within the rural areas should be upgraded with the necessary amenities to cater for the screening and treatment of earlier stages of the disease. However, there should be plans in place to provide another fully functional renal health service outside Benin City in the near future so as to improve the accessibility to CKD healthcare within the state. Such a facility should be centrally located within the state, as this would reduce the travel time by CKD patients within the state to receive treatment. According to the result from the location-allocation model discussed in chapter seven, a possible candidate for the establishment of another renal health centre would be Irrua Specialist Teaching Hospital, which is located in Irrua town within Otoruwa II ward. This is because it is centrally located within the state and it is an established hospital that can be appropriately equipped to support the establishment of a renal department including on-site kidney consultants/nephrologists without having to refer complicated cases elsewhere. I must however, mention at this stage that this is just a theoretical proposition as other factors need to be considered such as the cost of infrastructure for establishing a renal department within this hospital as opposed to another location entirely. There is also the issue of the cost of training of available staff to help in the management of the renal department as

well as the employment of specialised staff such as nephrologists and renal nurses.

Finally, the government would need to consider the possibility of subsidising the cost of healthcare including renal treatment as this might encourage patients to come to the hospital where the disease can be diagnosed earlier and managed effectively.

8.6 Conclusion

The results of this thesis have highlighted the spatial distribution of diagnosed CKD and evaluated the likely predictors for the severity of CKD at time of diagnosis in Edo State by examining the socio-demographic and known biological risk factors such as diagnosed hypertension, and diabetes. It has also highlighted the areas of concern regarding the spatial distribution of diagnosed CKD within the state. There is therefore a clear indication that more needs to be done in the management of the disease within the state especially among the rural areas, which appear to be neglected in the current approach of CKD management within the state. There is also the possibility that this situation within Edo state might be similar to other states within the country and as such, more needs to be done within the rural areas in the country, as there is the probability that many cases are left undetected until it is too late. Although it can be argued that CKD might not be currently classified as a serious threat to the health status of Nigeria because of other diseases such as malaria and HIV/AIDS that need immediate attention, we cannot rule out the advantages of

preventive measures on health outcomes in the society. Early preventive measures for CKD such as the location of accessible CKD screening centres and easier access to vital health information could contribute in improving the health status of the society in the near future.

The findings derived from this research study would be helpful both in the policy-making decisions that pertain to the health sector and the development of a health care accessibility model for CKD patients that could be beneficial in the location of new healthcare centres. Further work using population projections, and the future prevalence and distribution of known risk factors, will enable the development of a model that can predict future prevalence patterns within the state as well as the country. This could ultimately lead to the improvement of treatment outcomes and the quality of life of patients with CKD.

This study has indirectly highlighted the advantages as well as the challenges faced in the application of spatial analyses in the health sector within a Nigerian context. This study has shown that it is possible to utilise GIS within the health sector of a developing country where data is limited because spatial processes, which had previously been overlooked, can now be examined in better detail. This approach can therefore help in the development of insightful health policy-decisions that would lead to the adequate management of healthcare issues within the study area.

In summary, this study can be classified as a preliminary research study on the spatial analysis of CKD in one of the states in Nigeria. The outcome of this study can therefore pave the way for more extensive investigations on the spatial pattern of CKD within Nigeria.

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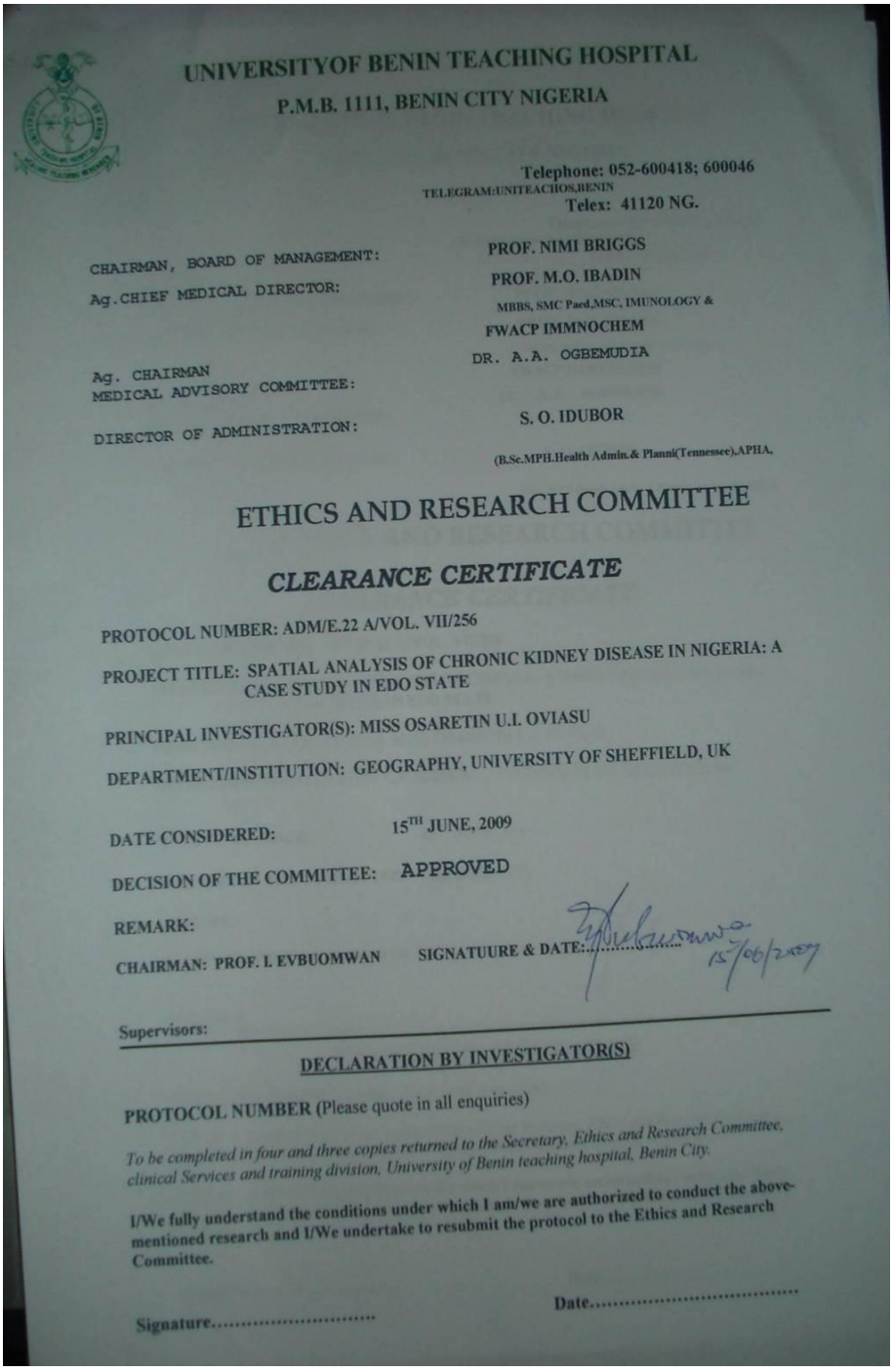
Appendices

Appendix A: A photocopy of the ethics approval form from the University of Benin Teaching Hospital (UBTH)



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ETHICS AND RESEARCH COMMITTEE

CLEARANCE CERTIFICATE

PROTOCOL NUMBER: ADM/E.22 A/VOL. VII/256

PROJECT TITLE: SPATIAL ANALYSIS OF CHRONIC KIDNEY DISEASE IN NIGERIA: A CASE STUDY IN EDO STATE

PRINCIPAL INVESTIGATOR(S): MISS OSARETIN U.I. OVIASU

DEPARTMENT/INSTITUTION: GEOGRAPHY, UNIVERSITY OF SHEFFIELD, UK

DATE CONSIDERED: 15TH JUNE, 2009

DECISION OF THE COMMITTEE: APPROVED

REMARK:

CHAIRMAN: PROF. I. EVBUOMWAN SIGNATUURE & DATE: 15/06/2009

Supervisors:

DECLARATION BY INVESTIGATOR(S)

PROTOCOL NUMBER (Please quote in all enquiries)

To be completed in four and three copies returned to the Secretary, Ethics and Research Committee, clinical Services and training division, University of Benin teaching hospital, Benin City.

I/We fully understand the conditions under which I am/we are authorized to conduct the above-mentioned research and I/We undertake to resubmit the protocol to the Ethics and Research Committee.

Signature..... **Date**.....

Appendix B: A template used in the data collection process at UBTH

Template for CKD data collection at UBTH	
Hospital number	
Sex (Male/Female)	
marital status	
Date of birth	
age	
Place of birth	
Address	
L.G.A	
Ethnic group	
Occupation	
Religion	
Education	
First date on patient's file	
Definitive diagnosis	
Chronic glomerulonephritis (Y/N)	
Diabetes mellitus (Y/N)	
Hypertension (Y/N)	
Toxic nephropathy (Y/N)	
Other Risk factors	
Stage of CKD at time of diagnosis	
HIV (Y/N)	
Type of referral centre	
Name of referral centre	
Admitted/outpatient	
Dialysis taken (Y/N)	
Reason for not taking dialysis	
Steps taken when dialysis was refused	
Date of 1st dialysis	
Number of dialysis session	
Management outcome (*is the patient on follow-up, deteriorating, or deceased.)*	
Date of death	
Cause of death	

Appendix C: A list of the biological risk factors documented within the health files of the CKD patients

Biological risk factors	Frequency	Per cent
Missing cases/unknown causes	20	4.52
Acute pulmonary oedema	1	0.23
Anaemia	1	0.23
chronic glomerulonephritis and diabetes	1	0.23
Chronic glomerulonephritis and Chronic Lung Disease	1	0.23
congenital kidney disease	1	0.23
Diabetes and obstructive uropathy	1	0.23
Diabetes and toxic nephropathy	1	0.23
Diabetes and uremic nephropathy	1	0.23
HBB	1	0.23
HIV associated Nephropathy	1	0.23
hyperlipidaemia	1	0.23
Hypertension and anaemic heart failure	1	0.23
Hypertension and Benign prostatic hyperplasia	1	0.23
Hypertension and HIV associated nephropathy	1	0.23
Hypertension and multiple myeloma	1	0.23
Hypertension and polycystic kidney disease	1	0.23
Hypertension, chronic glomerulonephritis and uremic nephropathy	1	0.23
Hypertension, diabetes and autonomic neuropathy	1	0.23
Hypertension, toxic nephropathy, and obstructive uropathy	1	0.23
lupus nephritis	1	0.23
toxic nephropathy and HIV associated nephropathy	1	0.23
chronic glomerulonephritis and toxic nephropathy	2	0.45
Hypertension and obstructive uropathy	2	0.45
Hypertension, chronic glomerulonephritis, and toxic nephropathy	2	0.45
Hypertension, diabetes and uremic nephropathy	2	0.45
Hypertension, toxic nephropathy, and uremic nephropathy	2	0.45
Uremic encephalopathy	2	0.45
HIV associated nephropathy and Chronic glomerulonephritis	3	0.68
Hypertension and toxic nephropathy	3	0.68
Nephrotic syndrome	3	0.68
Polycystic Kidney Disease	3	0.68
sickle cell nephropathy	3	0.68
Toxic nephropathy and uremic nephropathy	3	0.68
Uremic nephropathy	3	0.68
Hypertension and uremic nephropathy	4	0.90
Hypertension, diabetes, and toxic nephropathy	4	0.90
chronic glomerulonephritis and uremic nephropathy	4	0.90
Hypertension, diabetes, and chronic glomerulonephritis	5	1.13
HIV associated nephropathy	10	2.26
toxic nephropathy	12	2.71
obstructive uropathy	18	4.07
Hypertension and chronic glomerulonephritis	20	4.52
Hypertension and diabetes	22	4.98
Diabetes	35	7.92
Hypertension	102	23.08
chronic glomerulonephritis	132	29.86
Total	**442**	**100.00**

Appendix D: the case summaries showing the standard residual and deviance statistics for the logistic regression model

Case Summaries						
Case Number	Logit residual	Predicted group	Predicted probability	Difference between observed and predicted probabilities	Standard residual	Deviance value
1	-5.75256	Late stage of CKD	0.82616427	-0.82616427	-1.88465	-1.87064
2	-5.75256	Late stage of CKD	0.82616427	-0.82616427	-1.88465	-1.87064
3	-5.75256	Late stage of CKD	0.82616427	-0.82616427	-1.88465	-1.87064
4	-2.21741	Late stage of CKD	0.54902338	-0.54902338	-1.30247	-1.26201
5	-2.41478	Late stage of CKD	0.58588421	-0.58588421	-1.34286	-1.32786
6	-2.41478	Late stage of CKD	0.58588421	-0.58588421	-1.34286	-1.32786
7	-2.41478	Late stage of CKD	0.58588421	-0.58588421	-1.34286	-1.32786
8	-2.41478	Late stage of CKD	0.58588421	-0.58588421	-1.34286	-1.32786
9	-2.41478	Late stage of CKD	0.58588421	-0.58588421	-1.34286	-1.32786
10	-2.41478	Late stage of CKD	0.58588421	-0.58588421	-1.34286	-1.32786
11	-2.41478	Late stage of CKD	0.58588421	-0.58588421	-1.34286	-1.32786
12	-2.41478	Late stage of CKD	0.58588421	-0.58588421	-1.34286	-1.32786
13	-2.41478	Late stage of CKD	0.58588421	-0.58588421	-1.34286	-1.32786
14	-2.41478	Late stage of CKD	0.58588421	-0.58588421	-1.34286	-1.32786
15	-2.41478	Late stage of CKD	0.58588421	-0.58588421	-1.34286	-1.32786
16	-2.41478	Late stage of CKD	0.58588421	-0.58588421	-1.34286	-1.32786
17	-2.41478	Late stage of CKD	0.58588421	-0.58588421	-1.34286	-1.32786
18	-2.41478	Late stage of CKD	0.58588421	-0.58588421	-1.34286	-1.32786
19	-1.36241	Earlier stage of CKD	0.26600623	-0.26600623	-0.80685	-0.78645
20	-1.36241	Earlier stage of CKD	0.26600623	-0.26600623	-0.80685	-0.78645
21	-1.36241	Earlier stage of CKD	0.26600623	-0.26600623	-0.80685	-0.78645
22	2.209028	Earlier stage of CKD	0.45268785	0.547312146	1.289369	1.259009
23	2.209028	Earlier stage of CKD	0.45268785	0.547312146	1.289369	1.259009
24	2.209028	Earlier stage of CKD	0.45268785	0.547312146	1.289369	1.259009
25	2.209028	Earlier stage of CKD	0.45268785	0.547312146	1.289369	1.259009
26	2.209028	Earlier stage of CKD	0.45268785	0.547312146	1.289369	1.259009
27	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
28	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
29	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
30	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
31	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
32	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
33	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
34	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
35	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
36	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
37	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
38	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
39	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
40	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
41	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
42	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
43	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575

Case Number	Logit residual	Predicted group	Predicted probability	Difference between observed and predicted probabilities	Standard residual	Deviance value
44	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
45	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
46	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
47	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
48	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
49	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
50	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
51	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
52	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
53	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
54	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
55	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
56	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
57	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
58	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
59	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
60	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
61	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
62	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
63	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
64	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
65	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
66	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
67	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
68	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
69	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
70	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
71	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
72	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
73	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
74	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
75	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
76	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
77	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
78	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
79	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
80	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
81	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
82	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
83	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
84	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
85	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
86	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575

Case Number	Logit residual	Predicted group	Predicted probability	Difference between observed and predicted probabilities	Standard residual	Deviance value
87	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
88	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
89	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
90	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
91	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
92	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
93	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
94	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
95	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
96	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
97	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
98	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
99	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
100	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
101	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
102	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
103	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
104	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
105	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
106	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
107	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
108	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
109	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
110	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
111	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
112	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
113	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
114	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
115	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
116	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
117	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
118	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
119	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
120	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
121	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
122	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
123	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
124	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
125	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
126	1.309703	Late stage of CKD	0.76353177	0.236468228	0.737065	0.734575
127	1.359914	Late stage of CKD	0.73534055	0.264659446	0.798309	0.784119
128	1.359914	Late stage of CKD	0.73534055	0.264659446	0.798309	0.784119
129	1.359914	Late stage of CKD	0.73534055	0.264659446	0.798309	0.784119

Case Number	Logit residual	Predicted group	Predicted probability	Difference between observed and predicted probabilities	Standard residual	Deviance value
130	1.359914	Late stage of CKD	0.73534055	0.264659446	0.798309	0.784119
131	1.359914	Late stage of CKD	0.73534055	0.264659446	0.798309	0.784119
132	1.359914	Late stage of CKD	0.73534055	0.264659446	0.798309	0.784119
133	1.359914	Late stage of CKD	0.73534055	0.264659446	0.798309	0.784119
134	1.359914	Late stage of CKD	0.73534055	0.264659446	0.798309	0.784119
135	1.359914	Late stage of CKD	0.73534055	0.264659446	0.798309	0.784119
136	1.359914	Late stage of CKD	0.73534055	0.264659446	0.798309	0.784119
137	1.359914	Late stage of CKD	0.73534055	0.264659446	0.798309	0.784119
138	1.359914	Late stage of CKD	0.73534055	0.264659446	0.798309	0.784119
139	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
140	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
141	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
142	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
143	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
144	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
145	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
146	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
147	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
148	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
149	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
150	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
151	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
152	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
153	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
154	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
155	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
156	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
157	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
158	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
159	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
160	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
161	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
162	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
163	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
164	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
165	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
166	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
167	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
168	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
169	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
170	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
171	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
172	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975

Case Number	Logit residual	Predicted group	Predicted probability	Difference between observed and predicted probabilities	Standard residual	Deviance value
173	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
174	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
175	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
176	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
177	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
178	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
179	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
180	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
181	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
182	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
183	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
184	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
185	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
186	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
187	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
188	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
189	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
190	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
191	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
192	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
193	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
194	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
195	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
196	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
197	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
198	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
199	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
200	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
201	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
202	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
203	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
204	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
205	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
206	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
207	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
208	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
209	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
210	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
211	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
212	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
213	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
214	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
215	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975

Case Number	Logit residual	Predicted group	Predicted probability	Difference between observed and predicted probabilities	Standard residual	Deviance value
216	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
217	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
218	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
219	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
220	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
221	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
222	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
223	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
224	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
225	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
226	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
227	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
228	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
229	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
230	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
231	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
232	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
233	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
234	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
235	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
236	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
237	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
238	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
239	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
240	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
241	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
242	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
243	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
244	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
245	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
246	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
247	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
248	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
249	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
250	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
251	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
252	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
253	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
254	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
255	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
256	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
257	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
258	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975

Case Number	Logit residual	Predicted group	Predicted probability	Difference between observed and predicted probabilities	Standard residual	Deviance value
259	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
260	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
261	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
262	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
263	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
264	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
265	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
266	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
267	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
268	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
269	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
270	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
271	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
272	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
273	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
274	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
275	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
276	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
277	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
278	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
279	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
280	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
281	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
282	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
283	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
284	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
285	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
286	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
287	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
288	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
289	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
290	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
291	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
292	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
293	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
294	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
295	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
296	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
297	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
298	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
299	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
300	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
301	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975

Case Number	Logit residual	Predicted group	Predicted probability	Difference between observed and predicted probabilities	Standard residual	Deviance value
302	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
303	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
304	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
305	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
306	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
307	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
308	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
309	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
310	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
311	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
312	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
313	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
314	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
315	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
316	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
317	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
318	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
319	1.092195	Late stage of CKD	0.91558725	0.084412751	0.420802	0.419975
320	-1.82711	Earlier stage of CKD	0.45268785	-0.45268785	-1.12442	-1.09794
321	-1.82711	Earlier stage of CKD	0.45268785	-0.45268785	-1.12442	-1.09794
322	-1.82711	Earlier stage of CKD	0.45268785	-0.45268785	-1.12442	-1.09794
323	-3.77844	Late stage of CKD	0.73534055	-0.73534055	-1.66004	-1.63053
324	-3.77844	Late stage of CKD	0.73534055	-0.73534055	-1.66004	-1.63053
325	-3.77844	Late stage of CKD	0.73534055	-0.73534055	-1.66004	-1.63053
326	-3.77844	Late stage of CKD	0.73534055	-0.73534055	-1.66004	-1.63053
327	-3.77844	Late stage of CKD	0.73534055	-0.73534055	-1.66004	-1.63053
328	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
329	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
330	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
331	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
332	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
333	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
334	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
335	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
336	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
337	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
338	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
339	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
340	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
341	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
342	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
343	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
344	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999

Case Number	Logit residual	Predicted group	Predicted probability	Difference between observed and predicted probabilities	Standard residual	Deviance value
345	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
346	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
347	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
348	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
349	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
350	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
351	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
352	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
353	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
354	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
355	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
356	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
357	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
358	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
359	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
360	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
361	1.210413	Late stage of CKD	0.82616427	0.173835729	0.622629	0.617999
362	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
363	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
364	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
365	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
366	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
367	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
368	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
369	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
370	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
371	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
372	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
373	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
374	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
375	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
376	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982

377	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
378	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
379	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
380	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
381	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
382	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
383	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
384	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
385	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
386	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
387	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982

Case Number	Logit residual	Predicted group	Predicted probability	Difference between observed and predicted probabilities	Standard residual	Deviance value
388	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
389	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
390	-4.2289	Late stage of CKD	0.76353177	-0.76353177	-1.70395	-1.6982
391	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
392	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
393	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
394	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
395	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
396	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
397	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
398	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
399	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
400	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
401	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
402	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
403	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
404	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353

405	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
406	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
407	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
408	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
409	-11.8466	Late stage of CKD	0.91558725	-0.91558725	-2.22791	-2.22353
410	1.706822	Late stage of CKD	0.58588421	0.41411579	1.045734	1.034053
411	1.706822	Late stage of CKD	0.58588421	0.41411579	1.045734	1.034053
412	1.706822	Late stage of CKD	0.58588421	0.41411579	1.045734	1.034053
413	1.706822	Late stage of CKD	0.58588421	0.41411579	1.045734	1.034053
414	1.706822	Late stage of CKD	0.58588421	0.41411579	1.045734	1.034053
415	1.706822	Late stage of CKD	0.58588421	0.41411579	1.045734	1.034053
416	1.706822	Late stage of CKD	0.58588421	0.41411579	1.045734	1.034053
417	1.706822	Late stage of CKD	0.58588421	0.41411579	1.045734	1.034053
418	1.706822	Late stage of CKD	0.58588421	0.41411579	1.045734	1.034053
419	1.706822	Late stage of CKD	0.58588421	0.41411579	1.045734	1.034053
420	1.706822	Late stage of CKD	0.58588421	0.41411579	1.045734	1.034053
421	1.706822	Late stage of CKD	0.58588421	0.41411579	1.045734	1.034053
422	1.706822	Late stage of CKD	0.58588421	0.41411579	1.045734	1.034053
423	1.706822	Late stage of CKD	0.58588421	0.41411579	1.045734	1.034053
424	3.75931	Earlier stage of CKD	0.26600623	0.733993767	1.669621	1.627412

Appendix E: A case summary for the leverage and the DFBeta residuals of the logistic Regression model

Case Number	DFBETA for constant	DFBETA for Dtm(1)	DFBETA for HTN(1)	DFBETA for Toxic_nep(1)	Analog of Cook's influence statistics	Leverage value
1	-0.03398	0.064139	-0.03532889	-0.017196534	0.071465431	0.014814
2	-0.03398	0.064139	-0.03532889	-0.017196534	0.071465431	0.014814
3	-0.03398	0.064139	-0.03532889	-0.017196534	0.071465431	0.014814
4	-0.12574	0.048715	-0.01871685	0.096130502	0.079312663	0.061164
5	-0.04864	0.046389	0.01829703	-0.006221753	0.032142892	0.022215
6	-0.04864	0.046389	0.01829703	-0.006221753	0.032142892	0.022215
7	-0.04864	0.046389	0.01829703	-0.006221753	0.032142892	0.022215
8	-0.04864	0.046389	0.01829703	-0.006221753	0.032142892	0.022215
9	-0.04864	0.046389	0.01829703	-0.006221753	0.032142892	0.022215
10	-0.04864	0.046389	0.01829703	-0.006221753	0.032142892	0.022215
11	-0.04864	0.046389	0.01829703	-0.006221753	0.032142892	0.022215
12	-0.04864	0.046389	0.01829703	-0.006221753	0.032142892	0.022215
13	-0.04864	0.046389	0.01829703	-0.006221753	0.032142892	0.022215
14	-0.04864	0.046389	0.01829703	-0.006221753	0.032142892	0.022215
15	-0.04864	0.046389	0.01829703	-0.006221753	0.032142892	0.022215
16	-0.04864	0.046389	0.01829703	-0.006221753	0.032142892	0.022215
17	-0.04864	0.046389	0.01829703	-0.006221753	0.032142892	0.022215
18	-0.04864	0.046389	0.01829703	-0.006221753	0.032142892	0.022215
19	-0.07159	0.023585	0.011383857	0.048859134	0.019042628	0.049921
20	-0.07159	0.023585	0.011383857	0.048859134	0.019042628	0.049921
21	-0.07159	0.023585	0.011383857	0.048859134	0.019042628	0.049921
22	0.098415	0.009406	-0.02280338	-0.096257994	0.05901195	0.046538
23	0.098415	0.009406	-0.02280338	-0.096257994	0.05901195	0.046538
24	0.098415	0.009406	-0.02280338	-0.096257994	0.05901195	0.046538
25	0.098415	0.009406	-0.02280338	-0.096257994	0.05901195	0.046538
26	0.098415	0.009406	-0.02280338	-0.096257994	0.05901195	0.046538
27	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
28	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
29	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
30	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
31	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
32	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
33	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
34	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
35	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
36	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
37	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
38	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
39	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
40	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
41	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
42	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
43	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743

Case Number	DFBETA for constant	DFBETA for Dtm(1)	DFBETA for HTN(1)	DFBETA for Toxic_nep(1)	Analog of Cook's influence statistics	Leverage value
44	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
45	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
46	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
47	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
48	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
49	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
50	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
51	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
52	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
53	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
54	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
55	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
56	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
57	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
58	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
59	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
60	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
61	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
62	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
63	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
64	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
65	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
66	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
67	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
68	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
69	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
70	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
71	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
72	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
73	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
74	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
75	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
76	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
77	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
78	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
79	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
80	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
81	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
82	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
83	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
84	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
85	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
86	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743

Case Number	DFBETA for constant	DFBETA for Dtm(1)	DFBETA for HTN(1)	DFBETA for Toxic_nep(1)	Analog of Cook's influence statistics	Leverage value
87	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
88	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
89	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
90	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
91	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
92	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
93	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
94	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
95	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
96	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
97	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
98	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
99	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
100	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
101	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
102	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
103	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
104	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
105	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
106	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
107	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
108	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
109	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
110	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
111	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
112	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
113	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
114	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
115	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
116	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
117	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
118	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
119	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
120	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
121	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
122	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
123	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
124	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
125	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
126	-0.00073	0.005524	-0.00704753	0.004095234	0.002102456	0.006743
127	0.035878	0.004751	0.009036195	-0.043224375	0.013144579	0.035235
128	0.035878	0.004751	0.009036195	-0.043224375	0.013144579	0.035235
129	0.035878	0.004751	0.009036195	-0.043224375	0.013144579	0.035235

Case Number	DFBETA for constant	DFBETA for Dtm(1)	DFBETA for HTN(1)	DFBETA for Toxic_nep(1)	Analog of Cook's influence statistics	Leverage value
130	0.035878	0.004751	0.009036195	-0.043224375	0.013144579	0.035235
131	0.035878	0.004751	0.009036195	-0.043224375	0.013144579	0.035235
132	0.035878	0.004751	0.009036195	-0.043224375	0.013144579	0.035235
133	0.035878	0.004751	0.009036195	-0.043224375	0.013144579	0.035235
134	0.035878	0.004751	0.009036195	-0.043224375	0.013144579	0.035235
135	0.035878	0.004751	0.009036195	-0.043224375	0.013144579	0.035235
136	0.035878	0.004751	0.009036195	-0.043224375	0.013144579	0.035235
137	0.035878	0.004751	0.009036195	-0.043224375	0.013144579	0.035235
138	0.035878	0.004751	0.009036195	-0.043224375	0.013144579	0.035235
139	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
140	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
141	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
142	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
143	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
144	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
145	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
146	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
147	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
148	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
149	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
150	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
151	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
152	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
153	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
154	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
155	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
156	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
157	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
158	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
159	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
160	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
161	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
162	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
163	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
164	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
165	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
166	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
167	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
168	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
169	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
170	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
171	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
172	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927

Case Number	DFBETA for constant	DFBETA for Dtm(1)	DFBETA for HTN(1)	DFBETA for Toxic_nep(1)	Analog of Cook's influence statistics	Leverage value
173	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
174	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
175	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
176	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
177	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
178	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
179	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
180	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
181	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
182	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
183	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
184	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
185	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
186	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
187	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
188	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
189	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
190	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
191	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
192	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
193	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
194	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
195	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
196	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
197	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
198	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
199	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
200	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
201	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
202	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
203	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
204	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
205	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
206	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
207	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
208	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
209	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
210	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
211	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
212	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
213	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
214	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
215	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927

Case Number	DFBETA for constant	DFBETA for Dtm(1)	DFBETA for HTN(1)	DFBETA for Toxic_nep(1)	Analog of Cook's influence statistics	Leverage value
216	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
217	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
218	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
219	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
220	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
221	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
222	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
223	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
224	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
225	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
226	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
227	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
228	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
229	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
230	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
231	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
232	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
233	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
234	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
235	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
236	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
237	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
238	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
239	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
240	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
241	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
242	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
243	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
244	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
245	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
246	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
247	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
248	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
249	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
250	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
251	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
252	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
253	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
254	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
255	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
256	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
257	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
258	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927

Case Number	DFBETA for constant	DFBETA for Dtm(1)	DFBETA for HTN(1)	DFBETA for Toxic_nep(1)	Analog of Cook's influence statistics	Leverage value
259	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
260	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
261	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
262	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
263	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
264	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
265	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
266	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
267	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
268	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
269	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
270	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
271	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
272	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
273	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
274	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
275	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
276	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
277	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
278	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
279	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
280	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
281	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
282	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
283	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
284	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
285	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
286	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
287	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
288	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
289	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
290	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
291	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
292	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
293	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
294	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
295	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
296	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
297	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
298	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
299	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
300	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
301	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927

Case Number	DFBETA for constant	DFBETA for Dtm(1)	DFBETA for HTN(1)	DFBETA for Toxic_nep(1)	Analog of Cook's influence statistics	Leverage value
302	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
303	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
304	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
305	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
306	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
307	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
308	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
309	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
310	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
311	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
312	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
313	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
314	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
315	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
316	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
317	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
318	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
319	-0.00371	0.002046	0.003649375	0.002315636	0.000363448	0.003927
320	-0.0814	-0.00778	0.018860927	0.079616038	0.040370811	0.046538
321	-0.0814	-0.00778	0.018860927	0.079616038	0.040370811	0.046538
322	-0.0814	-0.00778	0.018860927	0.079616038	0.040370811	0.046538
323	-0.09969	-0.0132	-0.02510653	0.120096358	0.101472633	0.035235
324	-0.09969	-0.0132	-0.02510653	0.120096358	0.101472633	0.035235
325	-0.09969	-0.0132	-0.02510653	0.120096358	0.101472633	0.035235
326	-0.09969	-0.0132	-0.02510653	0.120096358	0.101472633	0.035235
327	-0.09969	-0.0132	-0.02510653	0.120096358	0.101472633	0.035235
328	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
329	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
330	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
331	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
332	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
333	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
334	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
335	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
336	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
337	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
338	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
339	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
340	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
341	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
342	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
343	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
344	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814

Case Number	DFBETA for constant	DFBETA for Dtm(1)	DFBETA for HTN(1)	DFBETA for Toxic_nep(1)	Analog of Cook's influence statistics	Leverage value
345	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
346	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
347	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
348	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
349	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
350	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
351	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
352	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
353	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
354	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
355	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
356	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
357	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
358	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
359	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
360	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
361	0.007149	-0.0135	0.007433659	0.003618375	0.003164035	0.014814
362	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
363	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
364	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
365	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
366	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
367	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
368	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
369	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
370	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
371	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
372	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
373	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
374	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
375	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
376	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
377	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
378	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
379	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
380	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
381	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
382	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
383	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
384	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
385	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
386	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
387	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743

Case Number	DFBETA for constant	DFBETA for Dtm(1)	DFBETA for HTN(1)	DFBETA for Toxic_nep(1)	Analog of Cook's influence statistics	Leverage value
388	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
389	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
390	0.002353	-0.01784	0.022755743	-0.013223093	0.021919745	0.006743
391	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
392	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
393	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
394	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
395	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
396	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
397	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
398	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
399	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
400	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
401	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
402	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
403	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
404	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
405	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
406	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
407	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
408	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
409	0.040187	-0.02219	-0.03958313	-0.025116662	0.042758855	0.003927
410	0.03438	-0.03279	-0.01293274	0.004397671	0.016058499	0.022215
411	0.03438	-0.03279	-0.01293274	0.004397671	0.016058499	0.022215
412	0.03438	-0.03279	-0.01293274	0.004397671	0.016058499	0.022215
413	0.03438	-0.03279	-0.01293274	0.004397671	0.016058499	0.022215
414	0.03438	-0.03279	-0.01293274	0.004397671	0.016058499	0.022215
415	0.03438	-0.03279	-0.01293274	0.004397671	0.016058499	0.022215
416	0.03438	-0.03279	-0.01293274	0.004397671	0.016058499	0.022215
417	0.03438	-0.03279	-0.01293274	0.004397671	0.016058499	0.022215
418	0.03438	-0.03279	-0.01293274	0.004397671	0.016058499	0.022215
419	0.03438	-0.03279	-0.01293274	0.004397671	0.016058499	0.022215
420	0.03438	-0.03279	-0.01293274	0.004397671	0.016058499	0.022215
421	0.03438	-0.03279	-0.01293274	0.004397671	0.016058499	0.022215
422	0.03438	-0.03279	-0.01293274	0.004397671	0.016058499	0.022215
423	0.03438	-0.03279	-0.01293274	0.004397671	0.016058499	0.022215
424	0.197531	-0.06508	-0.03141159	-0.134817517	0.144986646	0.049921

Appendix F: wards in Edo State showing the stages of diagnosed cases for the 442 CKD patients within their boundaries

Ward	Unknown	stage 2	stage 3	stage 4	stage 5	Total
Aibiokunla 1	0	0	0	0	1	1
Amaho etc	0	0	0	0	1	1
Ewohimi I	0	0	0	0	1	1
Fugar III	0	0	0	0	1	1
Idganke E	0	0	0	0	1	1
Igarra II	0	0	0	0	1	1
Iguobazuwa E	0	0	0	0	1	1
Isi N	0	0	0	0	1	1
Okedo	0	0	0	0	1	1
Otoruwa I	0	0	0	0	1	1
Ozalla	0	0	0	0	1	1
Ubierumu	0	0	0	0	1	1
Ugbegun	0	0	0	0	1	1
Ugbeka	0	0	0	0	1	1
Ugboko	0	0	0	0	1	1
Uhen	0	0	0	0	1	1
Uhi	0	0	0	0	1	1
Uzebba 1	0	0	0	0	1	1
Uzebu	0	0	0	0	1	1
Obayantor	0	1	0	0	0	1
Oluku	0	0	1	0	0	1
Okhoro	0	0	0	1	0	1
Idogbo	0	0	0	0	2	2
Igarra I	0	0	0	0	2	2
Ubiaju I	0	0	0	0	2	2
Uke etc	0	0	0	0	2	2
Umagbae S	0	0	0	0	2	2
Uokha	0	0	0	0	2	2
Uwalor	0	0	0	0	2	2
Sabon-gida	0	0	1	0	1	2
Ewu I	0	0	0	1	1	2
Ewu II	0	0	0	0	3	3
Idigun	0	0	0	0	3	3
Uromi	0	0	1	1	2	4
Otoruwa II	0	1	1	0	4	6
Utoka	0	0	2	0	4	6
Igushodin	1	0	2	0	4	7
Oregbeni	0	0	0	1	6	7
St. Saviour	0	0	1	0	7	8
Efandion	0	0	0	2	6	8
GRA	2	0	0	0	7	9
Ugbowo	0	0	2	0	8	10
Auchi I	1	1	2	0	6	10
Ogbeson	0	1	2	0	7	10
Uwelu	0	0	3	2	5	10
Aduwawa	0	0	2	0	11	13
Iwogban	0	0	0	2	11	13
Ugbeku	0	1	0	2	12	15
Uselu II	0	1	2	2	11	16
Ekpoma etc	0	0	2	2	17	21
New Benin II	1	3	3	1	28	36
Uselu I	3	0	4	3	32	42
New Benin I	0	0	2	0	41	43
Geretti	3	3	5	7	84	102
Total	**11**	**12**	**38**	**27**	**354**	**442**

Appendix G: The average distance to the hospital for all the diagnosed CKD patients

Statistics	
Distance in minutes to the hospital for all CKD patients	
Mean	28.91
Std. Error of Mean	1.64
Std. Deviation	34.43

Appendix H: The average distance to the hospital for patients diagnosed at the earlier stages of CKD

Distance in minutes to the hospital for patients at the earlier stages of CKD	
Mean	28.41
Std. Error of Mean	3.54
Std. Deviation	33.25

Appendix I: the average distance to the hospital for patients diagnosed at the late stage of CKD

Distance in minutes to the hospital for patients at the late stage of CKD	
Mean	29.04
Std. Error of Mean	1.847
Std. Deviation	34.758

Appendix J: the average travel time to the hospital for the population within Edo state

Travel in minutes to the hospital for CKD patients	
Mean	89.76
Std. Error of Mean	0.03
Std. Deviation	52.24

Appendix K: the location-allocation model using travel time (in minutes) as impedance to UBTH with 26 minutes as the threshold value

Hospital	Demand count (number of wards)	total demand (total population)	total distance (in minutes)	total weighted distance (in minutes)
UBTH	36	1072243.87	564.77	15736612.77

Appendix L: A location-allocation model using travel time (in minutes) as impedance to UBTH and the proposed 18 CKD healthcare locations

Name	Type of facility	Demand Count (number of wards)	Demand Weight (population in the wards)	Total time travelled (in Minutes)	Total Weighted time (in Minutes)
OVIA SOUTHWEST	Chosen	1	31493	12.08	380423.99
OVIA NORTHEAST	Chosen	2	25586	25.50	315852.54
ESAN WEST	Chosen	3	49870	26.01	400980.26
ETSAKO EAST	Chosen	3	41288	48.58	694684.47
IKPOBA-OKHA	Chosen	3	60962	18.11	447174.68
ORHIONMWON	Chosen	5	63814	79.62	1086144.85
EGOR	Chosen	6	227911	62.27	2459709.08
ESAN SOUTHEAST	Chosen	6	69240	123.46	1393912.32
OWAN EAST	Chosen	6	126176	93.94	1862827.42
AKOKO-EDO	Chosen	7	129647	107.87	1947136.36
UHUNMWONDE	Chosen	7	143881	94.00	1714824.23
OREDO	Chosen	8	234073	124.80	3432244.80
OWAN WEST	Chosen	9	116905	154.13	2000880.40
ESAN NORTHEAST	Chosen	10	113070	168.14	1819774.77
IGUEBEN	Chosen	10	112530	135.84	1650626.74
ETSAKO WEST	Chosen	14	186828	237.46	3218239.94
ESAN CENTRAL	Chosen	16	245660	232.98	3702680.59
ETSAKO CENTRAL	Chosen	16	199814	303.54	3823474.39
UBTH	Required	18	552327	219.51	5852438.64

Appendix M: A location-allocation model using the road junctions as facilities and travel time (in minutes) as impedance to UBTH and the proposed 18 CKD healthcare locations

Location of junction	Type of facility	Demand Count (number of wards)	Demand Weight (population in the wards)	Total time travelled (in Minutes)	Total Weighted time (in Minutes)
OVIA NORTHEAST	Chosen	3	49487	44.42	702928.91
EGOR	Chosen	4	118959	44.21	1336041.66
IGUEBEN	Chosen	4	55762	68.81	960331.63
OWAN EAST	Chosen	5	110111	74.74	1819070.77
ETSAKO EAST	Chosen	5	72755	100.24	1529089.78
ORHIONMWON	Chosen	5	63814	71.15	937361.34
ESAN SOUTHEAST	Chosen	5	50881	83.36	824409.54
UHUNMWONDE	Chosen	6	115541	73.13	1336189.64
OVIA SOUTHWEST	Chosen	6	98935	99.76	1850518.93
ESAN CENTRAL	Chosen	7	81279	61.34	687750.48
IKPOBA-OKHA	Chosen	8	256467	96.31	3107275.95
UBTH	Required	9	225740	93.72	1968361.49
ESAN WEST	Chosen	9	192314	110.86	2126980.39
AKOKO-EDO	Chosen	9	172256	128.92	2574672.86
OWAN WEST	Chosen	12	174460	172.90	2609331.35
OREDO	Chosen	13	469727	173.77	5506705.63
ETSAKO WEST	Chosen	13	167831	175.98	2276060.92
ETSAKO CENTRAL	Chosen	15	183292	288.87	3563812.60
ESAN NORTHEAST	Chosen	21	219365	353.49	3481730.18

Appendix N: A location-allocation model using travel time (in minutes) as impedance to identify the optimal location for another CKD health service that would cater for patients at the last stage of CKD

Name	Type of facility	Demand Weight (population in the wards)	Demand Count (number of wards)
UBTH	Required	527253.2456	35
Irrua Specialist Teaching Hospital	Chosen	207013.3801	35
Uromi central hospital	Candidate	0	0
Igbenedion university teaching hospital	Candidate	0	0
Auchi central hospital	Candidate	0	0