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Title: Pre-Hospital Trauma Assessment and Management of Older Patients and their Association with Patient Outcomes: Challenges and Barriers

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Abstract

BACKGROUND: Saudi Arabia faces an increasing prehospital healthcare burden from older people with injuries, but little is known about their characteristics and current treatment.

METHODS: This was a sequential explanatory mixed-methods design, preceded by a scoping review on the prehospital geriatric trauma care. A retrospective quantitative study was conducted using registry data from older patients (≥55 years) admitted by ambulances from 01/08/2017 to 31/10/2021 at a major trauma centre in Saudi Arabia. A qualitative study was conducted using a purposive sample of Saudi paramedics and ambulance technicians from Riyadh and Makkah using online semi-structured interviews and analysed using the framework method. The quantitative and qualitative findings were integrated.

RESULTS: The quantitative study recruited 452 eligible cases and found most of them were admitted with low falls (53.7%), normal physiology, and extremities injuries (53.1%). The study identified no significant predictors of in-hospital death ($p>0.05$ for all predictors), although statistical power was limited. The qualitative study recruited twenty participants and identified that they reported age-related challenges including physiological changes, polypharmacy, and communication difficulties. They all wanted training and guidelines to improve their knowledge. They reported struggling with communication difficulties, inaccurate adverse outcomes predictions, difficult intravenous cannulations, and cultural restrictions affecting care provision for female patients. I identified organisational barriers (e.g. lack of shared patient records and lack of guidelines) and cultural barriers (e.g. barriers to assessing women, attitudes towards older people, and attitudes towards paramedics) that influenced implementation of knowledge. This study also found that the participants' perceptions aligned with the retrospective study's cohort, and they acknowledged the difficulty of predicting death in older trauma patients.

CONCLUSION: Ambulance clinicians in Saudi Arabia want guidelines and training in managing older trauma patients but these need to take into account the characteristics of older trauma patients and the cultural barriers that I identified.

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l) Keywords:

Prehospital care; ageing; geriatric; injuries

II) Abbreviations:

ABC: Airway, Breathing and Circulation Acronym

ACLS: Advance Cardiac Life Support

ACS: The American College of Surgeons

AIS: Abbreviated Injury Score

AVPU: Alert, Verbal, Painful and Unresponsive Scale

BLS: Basic Life Support

DM: Diabetes Mellitus

EBP: Evidence-based Practice

ED: Emergency Department

EOI: Expression of Interest

EMS: Emergency Medical Services

EMT: Emergency Medical Technicians

GCS: Glasgow Coma Scale

GEMS: Geriatric Education for Emergency Medical Services Course

IO: Intraosseous Access

IRB: Institutional Review Board

ISS: Injury Severity Score

ITLS: International Trauma Life Support

IV: Intravenous Access

KAIMRC: the King Abdullah International Medical Research Center

KAMC's MTC: King Abdulaziz Medical City's Major Trauma Centre in Riyadh

KSMC's MTC: King Saud Medical City's Major Trauma Centre in Riyadh

MTC: Major Trauma Centre

MVC: Motor Vehicle Collision

PHTLS: Prehospital Trauma Life Support

PRISMA-ScR: PRISMA Extension for Scoping Reviews

SASEM: The Saudi Association Society of Emergency Medicine

SBP: Systolic Blood Pressure

ScHARR: School of Health & Related Research

SECF: The Sheffield Emergency Care Forum

SRCA: The Saudi Red Crescent Authority

TARN: The Trauma Audit and Research Network Database in UK

UK: United Kingdom

US: United States of America

III) List of tables:

IV) List of figures:

V) List of oral and poster participations in peer-reviewed conferences:

1. Harthi N, Goodacre S, Sampson F, Alharbi R. Research priorities for prehospital care of older patients with injuries: scoping review the annual ScHARR PGR conference, Sheffield, June 2021 (online) (**see Appendix 18**)

2. Harthi N, Goodacre S, Sampson F, Alharbi R. Research priorities for prehospital care of older patients with injuries: scoping review the Royal College of Emergency Medicine RCEM conference, London, October 2021 (online)

3. Harthi N, Goodacre S, Sampson F, Alharbi R. Research priorities for prehospital care of older patients with injuries: scoping review the British Geriatric Society BGS conference, November 2021 (online)

4. Harthi N, Goodacre S, Sampson F, Alharbi R. Research priorities for prehospital care of older patients with injuries: scoping review the 999 EMS Research Forum, the Yorkshire Ambulance Service NHS Trust, Yorkshire Ambulance Service Charity, and the National Ambulance Research Steering Group, March 2022

5. Harthi N, Goodacre S, Sampson F, Alharbi R. Paramedics and EMTs' perceptions of Geriatric Trauma Care the British Geriatric Society BGS, Wales, March 2023 (**see Appendix 19**)

6. Harthi N, Goodacre S, Sampson F, Alharbi R. Paramedics and EMTs' perceptions of Geriatric Trauma Care the 999 EMS Research Forum, Manchester, June 2023

VI) List of peer-reviewed publications and supplements:

1. Naif Harthi, Steve Goodacre, Fiona Sampson, and Rayan Alharbi, "755 Research priorities for prehospital care of older patients with injuries: scoping review," Emergency medicine journal: EMJ, vol. 39, no. 3, pp. 253–253, 2022, doi: 10.1136/emermed-2022-RCEM.22.

2. N Harthi, S Goodacre, F Sampson, R Alharbi, 707 RESEARCH PRIORITIES FOR PREHOSPITAL CARE OF OLDER PATIENTS WITH INJURIES: SCOPING REVIEW, *Age and Ageing*, Volume 51, Issue Supplement_1, March 2022, afac036.707, https://doi.org/10.1093/ageing/afac036.707

3. Naif Harthi, Steve Goodacre, Fiona Sampson, Rayan Alharbi, Research priorities for prehospital care of older patients with injuries: scoping review, *Age and Ageing*, Volume 51, Issue 5, May 2022, afac108, https://doi.org/10.1093/ageing/afac108

VII) List of contributions:

1. Became a reviewer in the Age and Ageing journal, United Kingdom from 22nd April 2022 after publishing my scoping review in the journal that has a high impact factor = 12.782

VIII) Other presentations:

1. Attended the annual ScHARR PGR conference (held on 3rd June 2020 via online), Sheffield, UK, and presented my proposed research as a Gone in 60 Seconds presenter (online)

2. Attended the Sheffield Emergency Care Forum (SECF) (held on 23rd April 2020 via online), Sheffield, UK, and presented a presentation for my proposed project (online)

Chapter 1

The Background to Research Topic

(Chapter title: Prehospital Trauma Care for Older People in Saudi Arabia: Ageing-related Challenges & Barriers)

Chapter overview:

"This chapter outlines the background to the research topic, presenting impacts of ageing changes on healthcare and patient outcomes, and clarifying ageing implications for injured older patients, clinicians and ambulance services. Further, it explains the roles of ambulance workers in caring for older patients with injuries, along with the ageing impacts on prehospital trauma care from scene until patient delivery. Lastly, it describes the current status of the trauma system and prehospital system in Saudi Arabia".

1.1 Introduction:

In recent decades, prehospital calls and resource requirements for older patients have increased (Shah *et al.*, 2007; Goldstein, Andrew and Travers, 2016). Ambulance workers strive to provide effective assessment and management for injured older patients (Goldstein, Andrew and Travers, 2016). However, offering this necessary care creates challenges to ambulance staff (Moore *et al.*, 2012; Dalton, NPM and Monroe, 2015; Platts-Mills, Evans and Brice, 2016). The common causes of injuries in older patients requiring ambulance care are falls < 2m, as the commonest mechanism of injury, followed by falls > 2m, road traffics collisions, and so on (Banerjee *et al.*, 2017). In such situations, ambulance workers can encounter issues relating to the impacts of ageing and challenges that can lead to negative outcomes such as disabilities or deaths (Sullivan, Mirbahai and Lord, 2018). Unfortunately, current prehospital care education provides limited knowledge in geriatric healthcare, despite unique needs of older population (Shah *et al.*, 2008, 2012; Peterson *et al.*, 2009). We need to understand the characteristics of the older population to improve prehospital geriatric care. This includes the frequency of older cases, their characteristics, special management guidelines as well as their outcomes (Duong *et al.*, 2018).

From this personal interest, I believe that paramedics should strive to provide effective trauma care for the most rapidly growing segment of society. This could be achieved in this PhD project by conducting further research and exploring current research gaps within the field of "prehospital trauma care for older patients". Goldstein, Andrew and Travers (2016) state that little evidence focuses on paramedical care for older patients with injuries. Therefore, based on my professional practice, undertaking this project will help to increase awareness of Saudi ambulance workers regarding the ageing impacts on prehospital care and patient outcomes. There is less attention paid regarding the impacts of ageing changes on the prehospital trauma care for older patients and patient outcomes in Saudi Arabia. This chapter clarifies the global trend of ageing, anatomical and physiological ageing changes, the impacts of ageing changes on healthcare and patient outcomes, along with implications of these ageing changes for clinicians, care services and resources. Further, I will describe the current status of the trauma system in Saudi Arabia.

1.2 The global ageing and population:

Globally, the population is ageing rapidly, and the proportion of older people is increasing. This phenomenon has arisen due to more advanced care for chronic illnesses, improved lifestyles, social and public health developments such as housing and nutrition leading to greater health and life expectancy and contributing to increased injuries among older people (Jacob, 2003; Lunenfeld and Stratton, 2013; Dalton, NPM and Monroe, 2015; Hildebrand *et al.*, 2016). Bala *et al.* (2013) estimate that the older population's global rate is predicted to reach two billion in 2050 based on the World Health Organisation statistics. Studies of population demographics worldwide suggest that 20% of the United States US population will be aged over 65 by 2030 and 23% of the United Kingdom UK population will be aged over 65 by 2035, with 30% aged over 65 in Europe by 2050 and 21% in Australia by 2054 (Office for National Statistics, 2012; United Nations, 2014; Australian Institute of Health and Welfare, 2015; Dalton, NPM and Monroe, 2015). Further research indicates that ageing growth is a primary reason for increased injures in the older population (Scheetz, 2010; Ichwan *et al.*, 2015). These increases in injuries can increase the volume of ambulance services and attendances to hospitals (Snooks *et al.*, 2006). This suggests that ambulance workers face a challenge of increased calls for managing older patients with injuries (Shah *et al.*, 2012). According to Bonne and Schuerer (2013), injured older patients admitted to hospitals represent 25% of all injured cases in the US. This suggests there are increased burdens on healthcare services and resources. As a result, healthcare costs will be increased on the pre-hospital and in-hospital services due to significant complication rates and prolonged hospitalisations (Newell *et al.*, 2009; Bonne and Schuerer, 2013; Staudenmayer *et al.*, 2013).

1.3 Age cut-off for defining older patients:

As injuries in older patients are increasing and trauma centres are suffering from higher numbers of older patients, treatment protocols and guidelines are being developed to meet the needs of this population (Caterino, Valasek and Werman, 2010). However, definitions of older patients vary, and this causes confusion as to which patients should be managed by geriatric-specific protocols (Fakhry *et al.*, 2021). Many studies use arbitrary cut-off ages to investigate mortality and outcomes in injured older patients that leads to a variety of results (Fakhry *et al.*, 2021). This suggests that there is no clear

a uniform age for older patients that may then influence which patients should be managed by geriatric-specific guidelines (Hildebrand *et al.*, 2016). This causes difficulty in comparing relevant studies, hampers the process of creating or improving trauma triage protocols, and confuses clinicians in determining which specific population groups are exposed to the mortality risk (Caterino, Valasek and Werman, 2010; Fakhry *et al.*, 2021).

The majority of relevant papers define the older people as 65 years and older. However, the clinical and research implications of this consideration still are variable, and it seems to be arbitrary (Fakhry *et al.*, 2021). Therefore, Fakhry *et al.* (2021) decided to determine the most appropriate age cut-off for defining older patients by investigating which group of older cases had a higher risk of deaths and morbidities. This step was taken with a goal of creating evidence-based trauma care guidelines for geriatric patients (Richmond *et al.*, 2011). Fakhry *et al.* (2021) then conducted a multicentre retrospective study in Tennessee State-US, included more than 255,000 injured patients. This large study reported that in comparison with trauma patients younger than 55 years old, mortality increased significantly at 55 years old, again at 77 years old, and again at 82 years old (Fakhry *et al.*, 2021). Considering the initial high mortality rate at age 55, Fakhry *et al.* (2021) then decided that it is most appropriate to define older patients with injuries at this age in future studies.

This is important because there is no unified age cutoff considered in Saudi Arabia (Jastaniah *et al.*, 2018). Most research in Saudi Arabia considers ≥60 years old as a cut-off age to define older individuals (Jastaniah *et al.*, 2018; Alawad *et al.*, 2020; Moafa *et al.*, 2021), while the Ministry of Health and the General Authority of Statistics as well as some research, use ≥65 years as an age cut-off (Abolfotouh *et al.*, 2018; Alsuwaidan *et al.*, 2019; MOH, 2021). This may reflect the arbitrary consideration of age cut-off to define older patients in the country.

1.4 The anatomical and physiological changes associated with ageing:

Ageing is defined as "progressive changes in body systems leading to physiological impairments in functions and deaths" (Balcombe and Sinclair, 2001; Sullivan, Mirbahai and Lord, 2018). This definition involves anatomical and physiological changes that influence nervous, cardiovascular, respiratory, musculoskeletal, and renal systems within progressive ageing changes:

1.4.1 The nervous system:

Ageing changes may include central and peripheral nervous systems that can then lead to the possibility of injuries or poor communication between clinicians and older patients (Zimmerman and Anderson, 2016). These changes can include vision and hearing deficiencies, gait dysfunction, cognitive impairments, and alterations in the brain (Scheetz, 2012; Dalton, NPM and Monroe, 2015). These can then predispose to the risk of having falls and motor vehicle collisions MVC, resulting in severe injuries (Dalton, NPM and Monroe, 2015; Hildebrand *et al.*, 2016). For example, ageing changes can include brain changes that can lead to risks of brain shrinkage and development of bridging vessels between the brain and cranium, leading then to ruptured vessels and haemorrhage (Gąsecki *et al.*, 2013). These progressive changes also can limit communications between caregivers and older patients, limiting the necessary information of medical history, polypharmacy and older patient needs (Scheetz, 2010; Beck *et al.*, 2018).

1.4.2 The cardiovascular system:

Older people can suffer from a decreased cardiac output, increased dependence on stroke volume, reduced cardiac reserve, inefficient compensatory mechanism and cardiac diseases that can then predispose to injuries (Scheetz, 2010; Carpenter and Rosen, 2016). Older patients can also suffer from decreased vascular elasticity, atherosclerosis and increased resistance of peripheral vessels, early developments of cardiac shock, conductive defects and diminished hemodynamic response to hypovolemia that may hide major internal bleeding (Ferrera, Bartfield and D'andrea, 2000; Dalton, NPM and Monroe, 2015). In terms of polypharmacy, older people use long-term prescribed medications, including anticoagulants, antiplatelets, angiotensin-converting enzyme inhibitors and beta-blockers that the clinicians should consider. Two papers suggest that anticoagulants or antiplatelets might increase the risks of bleeding in older patients (Williams *et al.*, 2008; Howard *et al.*, 2009). Further, three papers suggest that angiotensin-converting enzyme inhibitors and beta-blockers may mask the hypovolemic shock in older patients or decrease the tachycardiac and hypotensive responses to injuries (Demetriades *et al.*, 2001; Neideen, Lam and Brasel, 2008; Benjamin *et al.*, 2018).

1.4.3 The respiratory system:

The ageing process can limit the pulmonary system's ability to respond to trauma optimally (Joseph and Hassan, 2016). Ageing changes in this system can involve thoracic wall stiffness, decreased alveoli elasticity, increased airflow resistance, weak respiratory muscles, and diminished compliance of thoracic wall that can then cause reduced oxygen exchanges and reduced ratios of ventilation or perfusion (Brashers, 2010; Carpenter *et al.*, 2017). Older patients may also deteriorate with minimal injuries (Hildebrand *et al.*, 2016). Research shows that minimal thoracic injuries can lead to risks in older people such as impaired mechanical ventilations, diminished air exchanges, reduced ventilation-perfusion ratios and early respiratory failures (Brashers, 2010; Benjamin *et al.*, 2018). The geriatric population tends to suffer deeper and larger thermal injuries than younger adults due to the age-related changes (Joseph and Hassan, 2016). Older burn victims are also more susceptible to severe inhalation injuries due to diminished respiratory reserve (Joseph and Hassan, 2016). Therefore, it will be important to improve the clinician's familiarity regarding these changes to avoid underestimating respiratory injuries in older people (Amelia *et al.*, 2012).

1.4.4 The musculoskeletal system:

Musculoskeletal changes can begin after the age of 30 (Joseph and Hassan, 2016). Muscle mass decreases by 4 percent for every decade after the age of 25 and by 10 percent after the age of 50 (Joseph and Hassan, 2016). The reasons for this are decreased anabolic hormones, vitamin deficiency, malnutrition, and decreased activity levels (Kacey and Perez-Tamayo, 2012). The ageing-related musculoskeletal changes can also include fragile bones, weak tendons, ligaments and cartilages (Dawson and Dennison, 2016; Zimmerman and Anderson, 2016). These musculoskeletal-related changes in older patients can worsen outcomes from injuries (Dalton, NPM and Monroe, 2015). Joint stability can be decreased and spontaneous rupture risks can be increased because of these changes (Joseph and Hassan, 2016). Among older patients with osteoporosis, there is an increased incidence of minor trauma and fractures due to the loss of more than 60% of trabecular bone and 35% of cortical bone (Kacey and Perez-Tamayo, 2012). Fractures need to be stabilised early and older patients must be

mobilised to avoid devastating complications (Joseph and Hassan, 2016). Research confirmed that older people with osteoporosis, frailty, sarcopenic muscles, and osteoarthritis could suffer rapid injuries and decreased physiological recovery, leading to prolonged disability and organ dysfunction (Bonne and Livingston, 2017).

1.4.5 The renal system:

Renal function can decline rapidly due to decreased glomerular filtration rates, reduced tubular function, and loss of kidney mass due to the decreased numbers and sizes of glomeruli (Nyengaard and Bendtsen, 1992; AlZahrani, Sinnert and Gernsheimer, 2013; Zimmerman and Anderson, 2016). Clinicians should be aware of the following ageing impact that is related to these declined renal functions: decreased systematic blood flow in older patients with an aged renal system can lead to a declined renal perfusion that may occur due to low blood pressure, bleeding, shock and reduced cardiac output (Zimmerman and Anderson, 2016). This impact suggests that older patients might tolerate the effects of injuries less than younger counterparts (Sammy *et al.*, 2016). Furthermore, there is evidence that older adults who have urgency, frequency, nocturia, or urinary incontinence are more likely to fall (Tromp *et al.*, 2001; De Rekeneire *et al.*, 2003). These symptoms may force abrupt, unexpected changes in daily physical routines, leading to potential senior citizens engaging in potentially hazardous activities. Incontinence or urinary frequency were more common among fallers than non-fallers (Huang, 2004). A higher risk of falls has also been associated with stress urinary incontinence and nocturnal or daytime urination frequency in addition to urgency and urgency incontinence (Foley *et al.*, 2012). Physical activity and medical conditions can be improved, medications can be reviewed, and adverse environmental factors can be changed to prevent falls (Soliman, Meyer and Baum, 2016).

1.5 The low energy trauma impacts and pre-existing medical complaints associated with ageing:

Older people suffer different injuries, not just because of their anatomical limitations and physiological responses, but also because they have an increased risk of serious injury following low energy trauma (Dalton, NPM and Monroe, 2015). The frailty increases the likelihood of falls, which

increases the chances of significant injury as a result, while physiological reserve and the ability to recover decline with age (Bruijns *et al.*, 2013). In the UK, major trauma is no longer primarily a disease of young men, but rather a disease of older adults over 50 years old (Kehoe *et al.*, 2015). Furthermore, older patients are more likely to have significant comorbidities (Kehoe *et al.*, 2015). Co-morbidity and pre-existing conditions have been found to increase mortality and morbidity following trauma (Wardle, 1999). According to a study in the US, patients with fall-related head injury have a higher rate of comorbid conditions than those injured in MVCs (Coronado *et al.*, 2005). In both injury mechanisms, co-morbid conditions (such as hypertension, diabetes, cardiac arrhythmias, fluid and electrolyte disorders) were similar (Thompson, McCormick and Kagan, 2006). However, patients with fall-related head injury were more likely to suffer from dementia, depression, and Parkinson's disease (Thompson, McCormick and Kagan, 2006). Another study found that comorbid cardiac conditions or coagulopathies significantly increased mortality in older patients with isolated closed head injuries (Pasquale *et al.*, 2005). A third study found that fall-related head injuries are more likely to occur when there is comorbid dementia, whether from Alzheimer's disease or another cause (Starkstein and Jorge, 2005). In older patients with head injuries, it can be difficult to separate pre-existing dementia from head injury-related cognitive impairment (Thompson, McCormick and Kagan, 2006). The diagnosis of head injury after trauma can be complicated by pre-existing cognitive impairment (Thompson, McCormick and Kagan, 2006). These highlight that comorbidities and frailty increase the risk of falls and worsen the injuries sustained.

1.6 The process of triage and whether specialist trauma care benefits older people with major trauma:

Trauma triage tools are used by ambulance personnel on scene to identify people with major injuries (Fuller *et al.*, 2021). Prehospital triage tools are typically used to determine transport decisions for trauma patients based on their injury severity (Sasser *et al.*, 2009). An effective trauma triage tool should be sensitive enough to identify patients with major trauma so they can be referred to a Major Trauma Centre MTC of level I/II (equivalent to the UK's MTCs or an Australian Major Trauma Service), while being specific enough to identify patients who have injuries that aren't classified as major

trauma, so they can be treated at a lower or non-MTC facility (Rehn *et al.*, 2009). High-quality care and a reduction in mortality rates begin with the effective triage of injured patients (Sartorius *et al.*, 2010). The United States Field Triage Decision Scheme and the UK Major Trauma Triage Tool are two of the most common examples of prehospital triage tools (McCoy, Chakravarthy and Lotfpour, 2013; Freshwater and Crouch, 2015). The trauma triage tools vary from country to country, and even within the same nation there are different tools, so it is difficult to estimate the number of these tools (Alshibani, Alharbi and Conroy, 2021).

Currently, trauma triage tools are not accurate enough to identify major trauma in older adults (Ichwan *et al.*, 2015). It is important to keep in mind that factors such as physiological criteria (Lehmann *et al.*, 2009; Garwe *et al.*, 2017), comorbidities (Garwe *et al.*, 2019), injury pattern and mechanism (Brown *et al.*, 2019) can adversely affect the ability to meet some criteria of the triage tool for older trauma patients (Alshibani, Alharbi and Conroy, 2021). Triage tools also consider the distance between the patient and the MTC when determining whether to transport the patient to a MTC (Garwe *et al.*, 2017, 2019). Geriatric-specific trauma triage tools could be developed taking into account these factors. Researchers are working to develop trauma triage guidelines specifically designed for older trauma patients (Alshibani, Alharbi and Conroy, 2021), to address recommendations that all trauma centres and systems should have geriatric-specific guidelines (Lehmann *et al.*, 2009).

Previous studies have modified the current triage tools or developed specific triage criteria for older patients with injuries (Alshibani, Alharbi and Conroy, 2021). For example, by applying age (age boundary of > 55 years) as a mandatory triage criterion in a trauma triage tool, one additional patient with severe injuries (Injury Severity Score ISS > 15) was identified for every 60–65 patients with less severe injuries transported to MTCs (Nakamura et al., 2012). However, using the Systolic Blood Pressure SBP < 110 mm Hg instead of the SBP < 90 mm Hg to determine the appropriate prehospital care level for older trauma patients reduced the rate of under-triage by 4% and increased the rate of over-triage by 4% (Brown et al., 2015). For older trauma patients with a SBP < 110 mm Hg, the risk of death is similar to that of those with a SBP > 90 mm Hg, so this criterion should be applied for direct transportation to MTCs (Brown et al., 2015). Using Glasgow Coma Scale GCS ≤ 14 instead of GCS ≤ 13 in trauma patients aged ≥ 70 years, the sensitivity of the triage tool increased from 50.7 to 59.2%, with a

similar specificity rate to GCS ≤ 13, applied to younger adult patients (Caterino, Raubenolt and Cudnik, 2011).

Some studies have developed separate trauma triage criteria for older adults that are specific to their needs. For instance, an alternative trauma triage tool developed in the US for trauma patients aged 65 and over proved to be more sensitive to major trauma (ISS > 15) (92% vs 76%) than current adult trauma triage guidelines, but significantly less specificity (42% vs 78%) (Newgard *et al.*, 2016). Further, Newgard and colleagues developed a clinical decision rule for triaging older patients with injuries that takes geriatric physiology and comorbidity criteria into account (Newgard *et al.*, 2019). This decision rule had an overall sensitivity of 90%, but a low specificity (17%) for identifying older trauma adults with ISS higher than 15 (Newgard *et al.*, 2019). Anticoagulant use in this decision rule has not been shown to be a good predictor of high-risk patients, when compared with triage criteria, geriatric-specific physiologic measures, and comorbidities (Newgard *et al.*, 2019). However, the Trauma Committee of the Ohio Emergency Medical Services Board developed geriatric-specific trauma triage guidelines which increased sensitivity for patients ≥ 70 years (93% vs 61%) and reduced specificity (49% vs 61%) compared to current adult trauma triage criteria (Ichwan *et al.*, 2015). Further, this developed triage tool performed similarly in geriatric trauma patients as current triage tools in younger trauma patients (sensitivity: 93% vs 87%, and specificity: 49% vs 44%) (Ichwan *et al.*, 2015).

It is also important to consider how often trauma triage tools are used and how they are used. The concept of 'destination compliance' refers to ensuring that trauma patients who meet prehospital trauma triage criteria have access to the highest level of trauma care (Alshibani, Alharbi and Conroy, 2021). For instance, if a trauma patient with a GCS 8 meets the triage criteria for MTC transport and has severe injuries, the paramedic will actually transport that patient to a MTC (Alshibani, Alharbi and Conroy, 2021). The rate of destination compliance decreased with increasing age for injured patients meeting current triage criteria according to research (Cox *et al.*, 2014; Meyers *et al.*, 2019). A study in Australia reported that the percentage of older confirmed major trauma patients transported to MTCs in Australia is 67%, compared to 88% of younger patients (Cox *et al.*, 2014). A US study found that the number of older trauma patients transported to designated MTCs was half that of younger adults, when they met the triage criteria (Chang *et al.*, 2008). Using the current triage tools, these findings

were identified before they were adjusted or developed specifically for the geriatric patients. According to Caterino *et al.* (2016), developing geriatric-specific triage criteria increased the accuracy of identifying trauma, but the initial transportation rate only increased by 1%, whereas the initial transportation and interhospital transfers rate increased by 2%; thus, patients meeting the triage criteria are not complying with their destination. In the US, only 47% of older patients who met geriatric-specific trauma triage criteria were initially transported to level I/II trauma centres and 59% of those patients were ultimately transported to these facilities (Amoako *et al.*, 2019). Poor sensitivity of triage guidelines, ageism, patient or relative choice, or other factors relevant to signs of severe trauma in this population may have contributed to destination non-compliance that led to under-triage in older trauma patients (Nakamura *et al.*, 2012; Newgard *et al.*, 2016). The subjective judgments of paramedics could also affect decisions made during triage of older trauma patients (Cox *et al.*, 2014). There is also a possibility of bias associated with ethnicity, age, and gender (towards female sex) based on the assessment of socio-economic factors, which needs to be further examined (Garwe *et al.*, 2019; Uribe-Leitz *et al.*, 2020). Also, surveys of paramedics indicated that inadequate training, unfamiliarity with protocols, possible ageism, and feelings of unwelcomeness could affect appropriate triage decisions for older trauma patients (Chang *et al.*, 2008).

It is important to take into consideration the outcomes of triage tools use and the benefits of trauma centre access (Horst *et al.*, 2019). It could be time-consuming, expensive and resource-consuming to bypass and pre-alert patients who cannot benefit from MTC care (over-triage) (Fuller *et al.*, 2021). Taking patients further away from their homes may also inconvenience them and their families (Fuller *et al.*, 2021). By contrast, a failure to recognise injury severity (under-triage) could result in a patient being transported to a non-MTC without trauma team activation or specialist facilities, resulting in less effective care (Fuller *et al.*, 2021). Serious injuries in the older people have become more common in developed countries due to demographic changes (Kehoe *et al.*, 2015). Despite this, older patients with major trauma are undertriaged, face increased mortality and suffer a poorer recovery with current prehospital triage systems (Newgard *et al.*, 2014). Several factors contribute to inaccurate prehospital major trauma triage for the older victims. Firstly, geriatric victims are frequently injured after falling at ground level or due to acute medical conditions (Fisher, Bates and Banerjee, 2017). Thus, triage tools

may not be applied if injuries do not appear after low energy mechanisms or when nontrauma presentations are considered (Fisher, Bates and Banerjee, 2017). Secondly, several factors, such as frailty, ageing, comorbidities, polypharmacy, and differing responses to injury, may affect the accuracy of triage tools themselves in older cases (Fuller *et al.*, 2021). The GCS score may not be able to be assessed due to physical or cognitive disabilities (Lindner *et al.*, 2015). Lastly, a physiological triage variable, such as blood pressure, may be suboptimal as physiological ranges change with age (Evans *et al.*, 2011). Moreover, the response to injury may also be altered by ageing, such as higher GCS following expanding intracranial haemorrhages due to increases in intracranial volume and brain involution (Kehoe *et al.*, 2016).

Conflicting evidence exists regarding the survival and mortality rates of older trauma patients after trauma access (Alshibani, Alharbi and Conroy, 2021). Some studies have found that under-triaging older trauma patients is associated with a high rate of death, disability, and complications (Lehmann *et al.*, 2009; Brown *et al.*, 2019). Trauma centres had significantly higher costs and longer in-hospital stays than non-trauma centres (Alshibani, Alharbi and Conroy, 2021). Furthermore, major trauma is often defined by an ISS greater than 15 (Fuller *et al.*, 2021). Patients with unsurvivable injuries or very severe comorbidities may not benefit from specialist care, which makes bypassing family support unnecessary (Fuller *et al.*, 2021). Patients and relatives may also prefer to receive healthcare closer to home in a local hospital and may be willing to trade a better outcome for a closer location (Fuller *et al.*, 2021). There is little evidence that older people with intracranial injuries benefit from neurosurgical treatment, so they would not benefit from transfers to MTCs (Whitehouse *et al.*, 2016; Lecky *et al.*, 2017). Those who suffer serious head injuries that are not suitable for neurosurgery may be better taken to the nearest hospital where they can receive rehabilitation (or end-of-life care) close to their homes (Lecky *et al.*, 2017). According to a recent review, the prevalence of older adults with incident traumatic brain injury is rising, but clinical guidelines for acute and long-term management of this condition are scarce or non-existent (Gardner *et al.*, 2018). The lack of evidence-based guidelines has led some centres to recommend strict age cut-offs for severe head injury treatment for older victims (Petridis *et al.*, 2009). While, others send older adults with any head injury to the neuro-intensive care unit for serial neurological evaluations and head CT scans, a method that may be overly conservative

(Gardner *et al.*, 2018). Geriatric head injury requires prognostic models and evidence-based treatment guidelines that identify patients who would benefit best from aggressive versus conservative interventions (Gardner *et al.*, 2018).

1.7 The implications of ageing changes for older people, healthcare services and clinicians:

This section outlines three categories of implications of ageing changes that can be generated from the older patients' exposure to injuries (**see Figure 1.1**):

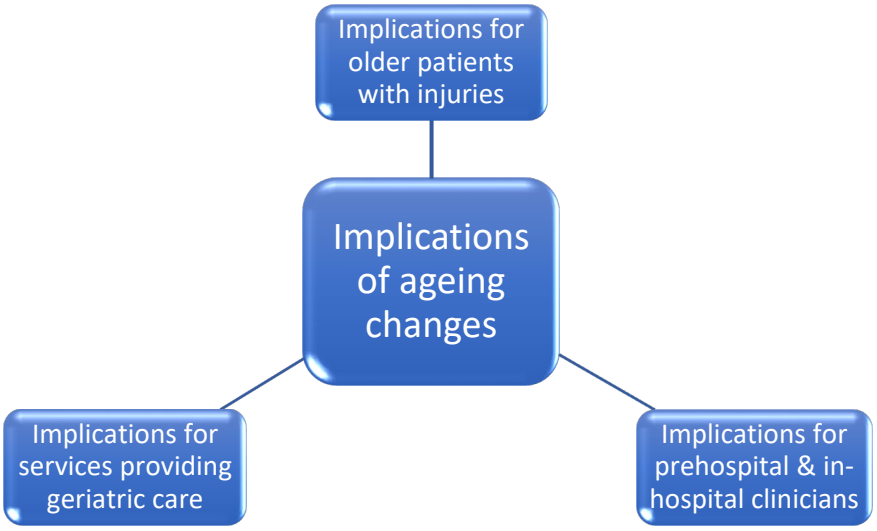


Figure 1.1: Implications of ageing changes

1.7.1 The implications of ageing changes for injured older patients

Assessing and managing older patients with injuries is more complex than younger counterparts (Carpenter *et al.*, 2017). Furthermore, two papers show that injured older victims have higher fatality rates due to low-velocity vehicles than younger victims (Sterling, O'connor and Bonadies, 2001; Spaniolas *et al.*, 2010). Similarly, Hashmi *et al.* (2014) claim that it is worth considering older people are more susceptible to injuries than younger people despite similar injury mechanisms. As I have previously clarified, older patients can deteriorate rapidly following injuries due to their reduced

response to injuries by the diminished cardiac reserve, increased comorbidities, decreased compensatory mechanisms and adverse functional outcomes, leading to poor outcomes.

For instance, there are two major factors that increase the risk of traumatic brain injury among older adults (Thompson, McCormick and Kagan, 2006). Firstly, a person's dura becomes more adherent to the skull as he or she ages (Thompson, McCormick and Kagan, 2006). Second, more older adults are receiving aspirin and anticoagulant therapy as part of their routine management of chronic conditions (Thompson, McCormick and Kagan, 2006). Therefore, older people are more likely to suffer a traumatic brain injury because of the mechanisms of injury that most often occur in them (e.g. falls or MVCs) (Thompson, McCormick and Kagan, 2006). Atherosclerosis of the cerebrovascular system and a decrease in free radical clearance are also examples of normal aging changes (Timiras, 2003). As a result of the former, injury or secondary insult may occur, while the latter increases the rate of oxidative damage after traumatic brain injury (Timiras, 2003). In some older adults with moderate brain atrophy, head computed tomography (CT) may reveal occult findings despite an intact neurological examination (Timiras, 2003).

1.7.2 The implications for services providing care for injured people:

The implications for services caring for injured older patients are divided into: a) implications of geriatric care for healthcare services and b) implications of injury preventions for healthcare services:

1.7.2.1 The implications of geriatric care for healthcare services:

Older patients with injuries are transported by ambulance services into trauma units or MTCs to benefit from prolonged social or healthcare services until stages of rehabilitation or early discharge (Fisher, Bates and Banerjee, 2017). Research indicates that rates of comorbidities and mortalities among injured older patients are higher than in younger counterparts and these outcomes create challenges for healthcare services (Hildebrand *et al.*, 2016; Fisher, Bates and Banerjee, 2017). There is also a greater demand on resources when caring for older patients with trauma injuries as compared to younger patients with similar injuries (Adams *et al.*, 2012). Several factors contribute to this difference, including comorbid medical conditions, medications, and frailty, all of which can affect the

physiologic response to injury and complicate recovery and treatment (Kozar *et al.*, 2015). Also, admissions of older patients with injuries can generate specific implications for health services such as prolonged hospitalisations, costly care and diminished care system efficiency (Taylor *et al.*, 2002; Newell *et al.*, 2009; Aitken *et al.*, 2010; Hashmi *et al.*, 2014). Consequently, economic burdens influence governments and health sectors due to increased healthcare costs (Durham *et al.*, 2006).

The costs associated with providing geriatric trauma care are a complex challenge facing trauma systems (Dela'O *et al.*, 2014). For instance, approximately 30% of trauma expenditure in the US is attributed to geriatric trauma (Dela'O *et al.*, 2014). In 2009, there was an estimated 9 billion US dollars expenditure for geriatric trauma, and this percentage is expected to continue to rise (Weir *et al.*, 2010). The majority of older patients' injuries are caused by falls, MVCs, and pedestrian-related collisions, which are associated with increased injury severity, undertriage, and a higher case fatality rate than among younger people (Dela'O *et al.*, 2014). As a result of these facts, trauma-related medical costs are increasing among this group of patients (Dela'O *et al.*, 2014). All of these findings suggest that prevention strategies could contribute to cost savings if they are applied appropriately through well-structured and well-planned clinical pathways (Dela'O *et al.*, 2014).

1.7.2.2 The implications of injury prevention for healthcare services:

Preventive programmes used proactively by care services to minimise injuries among older people can have other implications (Karlsson *et al.*, 2013). Intrinsic and extrinsic factors that increase injuries in older people should be identified to guide preventive solutions (Ambrose, Cruz and Paul, 2015). The intrinsic factors include age, multiple illnesses, musculoskeletal disorders, fall history, cognitive impairments, visual impairments, depression, fear of falls, frailty, balance disorders and polypharmacy, whilst the extrinsic risk factors involve environmental risks such as slippery floors, poor lighting, electric wires, slippery handrails and unsuitable footwear (Reed-Jones *et al.*, 2013). Many of these factors impair a person's ability to regulate movement and compensate for slips or disturbances of balance during everyday life (Nowak and Hubbard, 2009). Karlsson *et al.* (2013) recommend using a multifactorial preventive strategy focusing on these intrinsic and extrinsic risk factors rather than a strategy focusing on limited factors to reduce geriatric injuries. These programmes often consist of

exercising, planning of care, medical and/or diagnostic approaches, changes to the physical environment, educational programmes, calcium and vitamin D supplements, medication reviews, and the removal of physical restraints (for instance, bedside rails) (Cameron *et al.*, 2010; Gillespie *et al.*, 2012).

However, Irvine *et al.* (2010) argue that applying these multifaceted strategies can cost more than healthcare costs due to injury. Romli *et al.* (2017) also indicate that some organisations encounter shortages of resources in applying effective strategies. It is difficult in developing countries to deliver effective management of falls because of the high costs associated with fall prevention and healthcare services compared to developed countries (Tangcharoensathien *et al.*, 2011). These findings suggest that there are financial implications for services for injury preventive programmes that require effective and cost-effective strategies. Elley *et al.* (2008) suggested that older individuals who are at high risk for falls should be evaluated in a structured manner for risk factors, then referred to individually tailored falls prevention programmes based on their specific risks. This multifactorial intervention individualised to each participant reduced the rate of falls in older people living in the community by 25 % (Gillespie *et al.*, 2012). The rate of falls in hospital settings was reduced by 31 % and the risk of falling by 27 % by similar interventions (Gillespie *et al.*, 2012). This individualised multifactorial intervention is cost-effective because it focuses only on specific risk factors specific to older individuals (Church *et al.*, 2012). Therefore, further research is needed to determine their effectiveness.

1.7.3 The implications of the ageing changes for clinicians:

The Emergency Department ED visits by older patients are on the rise, and clinicians are less confident in managing older cases due to inadequate training and complexity of these cases (Deasey, Kable and Jeong, 2014; Conroy *et al.*, 2016; Ringer *et al.*, 2018). A qualitative study identified several challenges in managing older patients with dementia (Laparidou *et al.*, 2019). They were difficulties in diagnosing and caring for dementia patients, a lack of in-depth understanding of dementia, and inadequate geriatric education (Laparidou *et al.*, 2019). Despite the efforts of geriatric specialists from different disciplines in developing geriatric-specific care guidelines, there is insufficient evidence

focusing on the effectiveness of these guidelines with older patients (Mezey *et al.*, 2004). One paper has investigated the ageing-related challenges with nurses and found that nurses receive inadequate geriatric care education, leading to suboptimal geriatric care and reduced satisfaction among older patients (Barba, Hu and Efird, 2012). Another study indicates that nurses do not receive adequate continuing education regarding the ageing-physiologic changes (Gillis, MacDonald and Macisaac, 2008). These suggest improving clinician's knowledge can contribute to increased satisfaction in older patients.

Ambulance workers face ageing-related challenges while caring for injured older patients, leading to permanent disabilities or deaths (Dalton, NPM and Monroe, 2015). Papers argue that despite evidence showing ageing impacts on geriatric care, ambulance workers are still less likely to transport those high-risk older patients to definitive healthcare facilities (Huei-Ming *et al.*, 1999; Nakamura *et al.*, 2012). Firstly, geriatric-specific training is limited for ambulance workers and some of them have modest knowledge about geriatric emergencies (Scheetz, 2011; Shah *et al.*, 2012). Second, there is a lack of knowledge among ambulance workers about the long-term impacts of injuries in older patients (Beck *et al.*, 2018). Regarding the outcomes of older patients with injuries, one qualitative study explored that some paramedics do not apply holistic care due to repeated calls to low-mechanisms of injuries (Simpson *et al.*, 2017). They clarified that they did not receive sufficient training and education in dealing with geriatric patients (Simpson *et al.*, 2017). This indicates that paramedics need to improve their knowledge and attitudes towards older injured patients.

1.8 Impacts of ageing changes on prehospital trauma care for older patients:

1.8.1 Upon arrival to the scene:

Ambulance workers follow guidelines for triaging trauma cases in the field to determine the transport decision (Fuller *et al.*, 2021). The mechanism of injury can be determined upon arrival at the scene and can influence transport destination and healthcare decisions (Dalton, NPM and Monroe, 2015). According to North American statistics, injured older patients are five times more likely to die than younger patients with similar injury mechanisms (CDC, 2013). Ambulance workers can also determine prescribed medications, any clues for elder abuse at the scene, and information on the pre-event

status and injury event (Dalton, NPM and Monroe, 2015; Khoujah and Cimino-Fiallos, 2020). Cervical and pelvic stabilisation should be considered to prevent secondary spinal injuries and pelvic blood loss (Dalton, NPM and Monroe, 2015). However, it is important to consider the impacts of osteoporosis and kyphosis that may create difficulties in positioning older patients during maintaining airway and immobilising the cervical spine (Dalton, NPM and Monroe, 2015). Further, ambulance workers should consider the impacts of the full-body immobilisation that may cause respiratory restrictions among older patients (Dalton, NPM and Monroe, 2015).

1.8.2 During primary survey:

Ambulance workers assess and manage trauma patients using (<C>ABCDE) acronym to prevent any life-threatening conditions: (Catastrophic haemorrhage, Airway/C-Spine, Breathing, Circulation, Disability and Exposure), or transport them rapidly to definitive care facilities (Fadden and Prior, 2017). During managing haemorrhage, ageing changes would be considered by ambulance workers (Dalton, NPM and Monroe, 2015). As these changes can influence compensatory mechanisms of respiratory and cardiovascular responses to injuries during bleeding (Hashmi *et al.*, 2014), along with difficulties in detecting signs of these hidden injuries due to using beta blockers (Neideen, Lam and Brasel, 2008; Scheetz, 2012; Dalton, NPM and Monroe, 2015). Further, prescribed antithrombotic agents can create challenges to ambulance workers to manage bleedings in older people (Scheetz, 2010; Wong *et al.*, 2017). These challenges are important to be considered proactively by ambulance workers.

For airway and breathing, ambulance workers can face difficulties in opening airways in older people due to impacts of edentulous and arthritis of temporomandibular joints such as a reduced mouth opening and ineffective bag-valve-mask ventilations (Dalton, NPM and Monroe, 2015; Carpenter *et al.*, 2017). Further, the reduced respiratory reserve can occur due to weak respiratory muscles and reduced compliance of the thoracic wall (Dalton, NPM and Monroe, 2015; Carpenter *et al.*, 2017). In terms of circulation, increased resistance of peripheral vessels, increased dependence on stroke volume for rising in cardiac output and blunted tachycardic response to hypovolemia can delay recognition of hypovolemia (Dalton, NPM and Monroe, 2015; Carpenter *et al.*, 2017). Moreover, blood pressure and heart rate can be unreliable parameters in evaluating older patients, so occult

hypovolemia can become unrecognised, which may result in inaccurate transport decisions to trauma units rather than MTCs (Bala *et al.*, 2013; Salottolo *et al.*, 2013). Geriatric patients might not tolerate large volumes of fluids, so paramedics are recommended to provide smaller amounts (e.g. 200-300 mL) while monitoring patient condition between these amounts (Dalton, NPM and Monroe, 2015). In this way, the physiological adjustment of the heart can be given time based on the given amount and fluid overload can be avoided (Dalton, NPM and Monroe, 2015).

Regarding the disability, there are arguments regarding applying the GCS with injured older patients. Firstly, Kehoe, Rennie and Smith, (2015) reported that GCS score could be unreliable with head-injury older patients. Secondly, Scheetz (2012) and Carpenter et al. (2017) indicated that many older patients with head injury present in the ED with normal GCS scores or near to normal scores with intracranial bleeding. Thirdly, Norwood et al. (2002) advised that older patient with a GCS score (14 or less) is a reliable indicator for transport to MTCs. Lastly, Wasserman et al. (2014) argued that geriatric patients with GCS score 13 to 15 might have poor outcomes compared to younger patients. Therefore, GCS reliability in older patients with injuries still needs further investigations (Scheetz, 2012). Emergency Medical Services EMS challenges can also include facing older patients with diminished hearing or environmental noises in the scene that might influence determining the exact GCS score (e.g. 14 vs 15) (Scheetz, 2012). In terms of the exposure component, having assessed and managed the haemorrhage, airway, breathing, circulation, and disability, prehospital clinicians should then package and transfer patients to definitive care (Fadden and Prior, 2017). In terms of ageing impacts, older patients have increased risks of infections and hypothermia due to premorbid malnutrition and immunosenescence (Carpenter et al., 2017).

1.8.3 During secondary survey:

At this stage, ambulance workers take a history, undertake physical examination and monitor vital signs (Fadden and Prior, 2017). In taking a history, ambulance workers will obtain information of signs & symptoms, allergies, medications, pertinent medical history, last oral intake, and injury event (Jayaprakash *et al.*, 2016). In terms of ageing impacts, ambulance clinicians can encounter the issue of diminished hearing that can limit obtaining important information of chronic diseases, prescribed

medications, injury events and injury symptoms (Scheetz, 2012; Kwan and Straus, 2014). Further, ageing impacts can include reduced pain perception and quality that can prevent identifying hidden injuries when applying physical examination (Dalton, NPM and Monroe, 2015). For vital signs, pulse rate and blood pressure in older patients can be unreliable parameters (Bala *et al.*, 2013), as they can be deceptive and falsely reassuring due to using some medications such as antihypertensives and pacemakers that might confuse these vital signs (Bala *et al.*, 2013). This reflects the importance of obtaining comprehensive information on polypharmacy (Dalton, NPM and Monroe, 2015).

1.8.4 During transport to hospital:

Ideally, major trauma patients should be transported to MTCs, and those who have less severe injuries are transported to trauma units. Ambulance workers should consider the following ageing impacts while transporting older patients: a) older patients are vulnerable to high-risk injuries with lower mechanisms of injuries (Scheetz, 2012; Kehoe, Rennie and Smith, 2015). b) Older patients can experience fragility fractures, occult hypoperfusion and hidden life-threatening injuries such as intracerebral bleeding and oedema due to increased cerebral atrophy (Scheetz, 2012; Dalton, NPM and Monroe, 2015; Kehoe, Rennie and Smith, 2015). Ambulance workers may undertriage by transporting older patients to trauma units or nearest hospital rather than MTCs (Scheetz, 2012; Kehoe, Rennie and Smith, 2015). This can be caused due to inadequate training or knowledge in considering ageing impacts when caring for injured older patients (Huei-Ming *et al.*, 1999; Chang *et al.*, 2008; Scheetz, 2012; Khoujah and Cimino-Fiallos, 2020). The older patient then can deteriorate in the scene or enroute to the trauma unit, and mortality risk can then increase (Scheetz, 2012). Hildebrand *et al.* (2016) and Carpenter *et al.* (2017) recommended the following proactive procedures for ambulance workers: early intensive monitoring, careful physical examination, aggressive resuscitation, early injury management and early achievement of hemostasis to help reduction of mortality risks. These procedures to be applied with considering the impacts of ageing when caring for injured older patients.

1.9 The role of paramedics and ambulance services in providing care for injured people:

It is a challenge for in-hospital clinicians to find the time and resources to identify frailty accurately (Goldstein, Andrew and Travers, 2016). This requires in-depth information not available in the hospital, and this information might be missed if relatives or ambulance workers are not present (Goldstein, Andrew and Travers, 2016). Ambulance workers are present in the patients' living environment and can obtain in-depth details that can suggest whether the patient is at risk or properly treated in the home (Goldstein, Andrew and Travers, 2016). The contact time between ambulance workers and older patients can allow a more detailed assessment for older patients, such as gathering information for environmental clues, family and social situations (Goldstein, Andrew and Travers, 2012; Goldstein *et al.*, 2015). Information gathered in the patients' homes can inform decisions made in the emergency departments (EDs) regarding the treatment goals, diagnostic tests, social care, and patient discharge (Goldstein, Andrew and Travers, 2016). This reflects the importance of ambulance workers' roles in starting care for older patients. This reflection led to establishing the key focus of this PhD research, showing the relationships between the impacts of ageing changes, prehospital geriatric care and patient outcomes (**see Figure 1.2**):

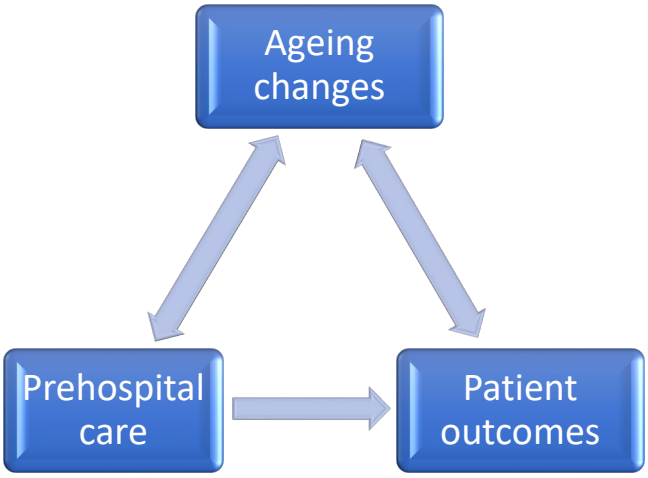


Figure 1.2: The research's key focus

1.10 Recent estimates of injuries/deaths among the older cases admitted to the Saudi hospitals:

Saudi Arabia is the largest country in the Middle East with around 2,150,000 km^2 in its size which is two times bigger than the UK, France and Germany together (Kennedy and Bishop, 2011). Population in Saudi Arabia has increased rapidly (average growth per annum = 2.38%), with a total population of 34,110,821 living in 13 regions (MOH, 2021) (**see Figure 1.3**):

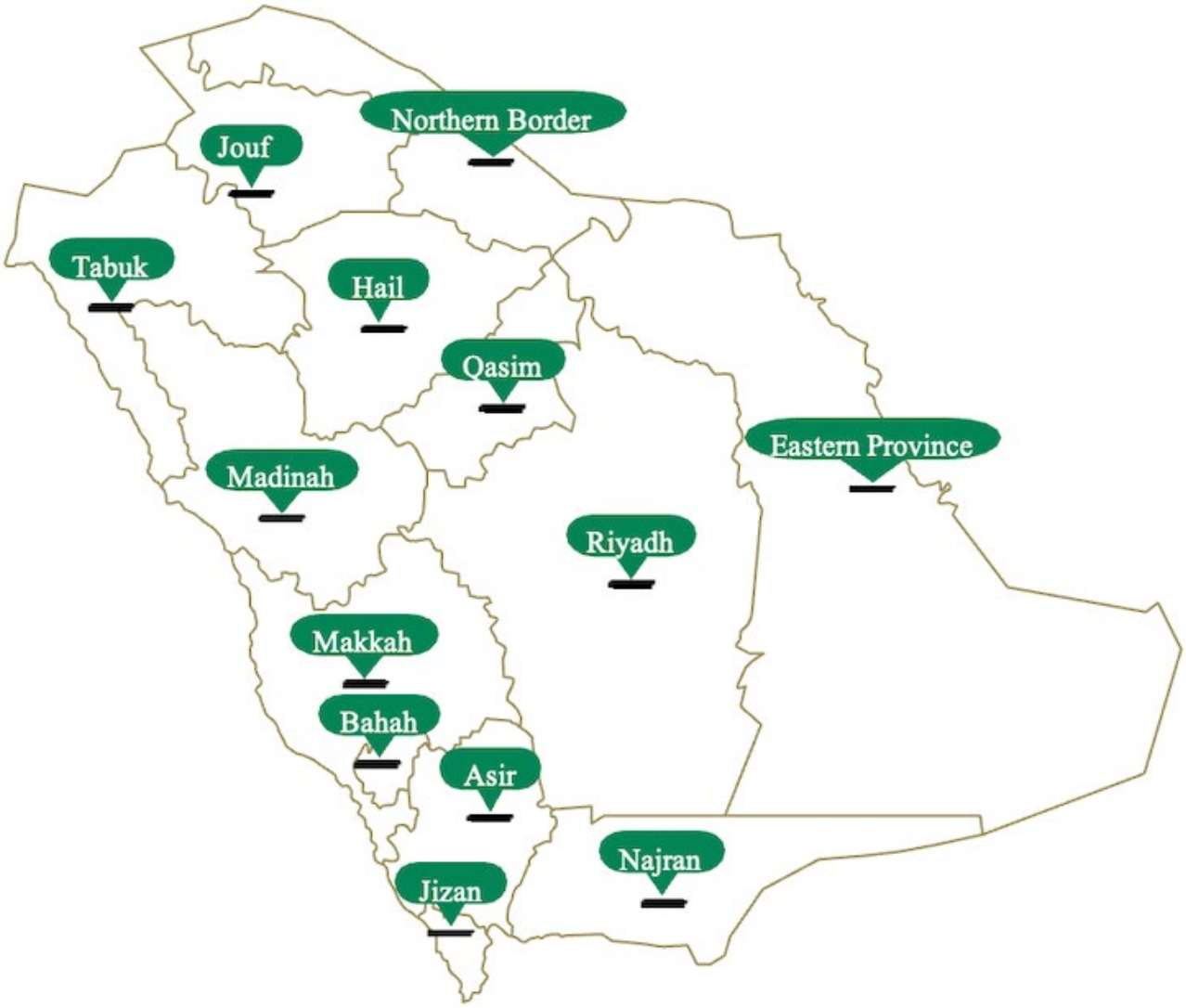


Figure 1.3: The map of Saudi Arabia-the thirteen Saudi regions (MOH, 2021)

In Saudi Arabia, 72% of the population are aged 15-64 years, 24.5% aged under 15 years, and only 3.5% are aged over 63 years (MOH, 2021). Estimates that report and compare injury/death proportions

with population size, such as those applied in countries such as the UK and the US, can be useful. However, in reviewing the Saudi Ministry of Health's estimates, I discovered that they present only raw numbers rather than percentages or rates that that are meaningful to readers. Only MVCs were identified in these estimates and not other mechanisms of injury, because the MVC as a mechanism of injury remains a leading cause of mortality and disability among trauma patients in Saudi Arabia based on the WHO statistics (Alharbi *et al.*, 2020). Absence of a national trauma database in Saudi Arabia creates difficulties in identifying all trauma cases and estimating their mortality rates (Alharbi *et al.*, 2020). According to Alferdaus and Shaher (2021), some Saudi hospitals do not provide comprehensive data on injuries, and there is no mechanism for injury surveillance or injury registry, nor are there any efforts towards quality assurance. They also stated that trauma research in Saudi Arabia is sparse, mainly due to the lack of a trauma registry (Alferdaus and Shaher, 2021).

The majority of recent trauma-related research in Saudi Arabia has reflected the burden of the MVCs among younger and older patients. Abolfotouh et al. (2018) concluded that 52 % of 3786 injured patients admitted to the King Abdulaziz Medical City (KAMC) trauma centre, including younger and older patients, were MVC cases, followed by 25% who were fallers. Moreover, another study has concluded that 81.2% of 335 recruited trauma patients from the KAMC trauma centre were MVC victims, followed by pedestrian collisions (9.6%), and 3.9% of all patients were fallers (Aldelaijan et al., 2020). These might be a reason for the Saudi Ministry of Health showing only data on MVC injuries and deaths so as to reduce Saudi economic expenditures on MVCs, which totaled 4.7% of the gross financial product and more than 5.85 billion US dollars per year based on the government’s statistics (Alharbi et al., 2020; Alghnam et al., 2021).

1.11 The current trauma system status in Saudi Arabia:

A trauma system is a regional or national injury response network that is planned, systematic, and coordinated, involving all facilities with a capacity to manage injured patients and combined with the local public health system (Al-Naami, Arafah and Al-Ibrahim, 2010). This system consists of four components: injury prevention, prehospital care, acute care units and post-hospital care (Peterson and Vaca, 2003). Injury prevention is the first component of the trauma system to reduce disability and

mortality rates (Rivara, 1999). It focuses on contributory factors of increased mortality rates and identifies high-risk age groups (Potenza *et al.*, 2004). The Saudi government exerts huge efforts to implement and improve public safety and high-quality healthcare to reduce injury events (Alshamrani *et al.*, 2020). Despite these efforts, rates of mortality and trauma events still represent burdens on the government and also researchers (Alshamrani *et al.*, 2020). Two Saudi studies indicate that MVCs are still the leading cause of death in trauma patients (Alghnam, Alkelya, *et al.*, 2017; Aljerian *et al.*, 2018). Second, emergency care consists of effective communication, team activation and healthcare actions taken at the scene (Al-Naami, Arafah and Al-Ibrahim, 2010). These actions involve using resources and managing injured patients on the scene and in an ambulance until they are delivered to definitive care facilities (Al-Naami, Arafah and Al-Ibrahim, 2010). These roles can be applied under the "golden hour" concept, which means an approximate time frame emphasising the necessity of urgency for effective trauma management from the scene to arrival to hospitals (Al-Naami, Arafah and Al-Ibrahim, 2010).

Lastly, regarding the acute care units & post-hospital care, these components depend on capabilities to provide injury prevention, training, research programmes, and multidisciplinary medical interventions to manage major trauma patients from the ED until rehabilitation phases (Alshamrani *et al.*, 2020). In Saudi Arabia, the large cities have at least one to two tertiary hospitals treating major trauma patients, and only two MTCs that have trauma registries that (located in the King Saud Medical City KSMC and King Abdulaziz Medical City KAMC in Riyadh), equivalent to a level I trauma centre (Alghnam, AlSayyari, *et al.*, 2017; Alharbi *et al.*, 2020). For post-hospital care, rehabilitation aims to recover normal mental and physical functions, reduce disabilities and enhance patient self-independences (Al-Naami, Arafah and Al-Ibrahim, 2010). In Saudi Arabia, there are three rehabilitation centres under the administration of the Ministry of Health (Alharbi *et al.*, 2020).

Overall, a recent Saudi study argued that currently no organised trauma system in the Saudi Arabia takes into consideration the complexity, range, and time-critical nature of injuries requiring immediate, integrated care by trained professionals (Chowdhury, Mok and Leenen, 2022). The vast distances, harsh climatic conditions, and lack of communication infrastructure contributed to this difficulty (Chowdhury, Mok and Leenen, 2022). The current trauma system in Saudi Arabia has complex gaps and challenges: 1) the trauma system in Saudi Arabia varies according to regions and trauma care expertise

(Alharbi et al., 2022). 2) Only two trauma centres (KAMC and KSMC) in Riyadh met the criteria for level I trauma centres, and other regions lack MTCs (Alferdaus and Shaher, 2021). 3) Saudi Arabia does not have a formal trauma registry for collecting and analysing data to improve trauma care by research (Alferdaus and Shaher, 2021). 4) A lack of guidelines for referral between the hospitals made it unclear what the role of tertiary hospitals is in the treatment of traumatic injury patients (Alharbi et al., 2020). Therefore, it is difficult to gain a comprehensive understanding of patients characteristics and outcomes following injury events due to the absence of robust national trauma system (Alharbi et al., 2022).

Further, 5) there is little effort to link prehospital triage to receiving hospitals or prehospital to in-hospital data (no networking) (Alharbi *et al.*, 2022). 6) There are no clear trauma activation protocols in the Saudi trauma centres based on the American College of Surgeons ACS criteria with no quality assurance programmes and no research investments to design healthcare protocols (Alharbi *et al.*, 2020). 7) Prehospital guidelines such as trauma bypass protocols or field triage guidelines are lacking based on the ACS criteria employed to assess the level of prehospital care (Alharbi *et al.*, 2020). 8) Saudi ambulance workers transport patients to the nearest hospital regardless of the transporting time and level of care provided by that hospital (Alharbi et al., 2020). Therefore, avoidable mortality may arise if patients are initially taken to a hospital that is unable to provide the quality of care available at the MTC. 9) Further, there is little published prehospital care research in Saudi Arabia (AlShammari, Jennings and Williams, 2017), and a shortage of trauma-related research despite the government efforts (Alshamrani *et al.*, 2020).

1.12 The current prehospital care status in Saudi Arabia:

Prehospital care is provided by the Saudi Red Crescent Authority SRCA, established in 1934 and funded by the government (Anon., 2013), which offers free healthcare for public and humanitarian relief abroad (Alharbi et al., 2020). EMS system in Saudi Arabia is based on an Anglo-American model, where ambulances are staffed by trained Emergency Medical Technicians EMTs and Paramedics employed by the SRCA (Al Mutairi *et al.*, 2016). In early 2000, a formal EMS education programme was established, which focused on improving the EMS system as well as reinforcing public trust (Al Mutairi

et al., 2016). The Emergency Medicine Institute in Riyadh was established in 2002 by the Saudi Council for health specialties and is the first and only specialised institute dedicated to the education and training of emergency medical staff (Al Mutairi *et al.*, 2016). In the following years, Saudi universities started offering Bachelor of Science degrees in EMS in response to the noticeable increase in the need for skilled and qualified EMS personnel (Al Mutairi *et al.*, 2016). However, it was found in a recent Saudi Arabian study that most Saudi EMS personnel were unaware of stroke symptoms (Althubaity, Yunus and Al Khathaami, 2013). The study recommendations included addressing educational needs along with screening tools (Althubaity, Yunus and Al Khathaami, 2013). According to AlShammari, Jennings and Williams (2017), this lack of knowledge is indicative of EMS education's lack of development in Saudi Arabia.

The most important aspect of prehospital care is training (Al-Naami, Arafah and Al-Ibrahim, 2010). EMTs provide basic life support with limited airway management skills, cardiopulmonary resuscitation, automated external defibrillator use, haemorrhage control, and rapid transport for patients (Alharbi *et al.*, 2020). Paramedics provide advanced life support (ALS) with advanced skills, use equipment and medications to treat high-risk trauma or medical patients, and deal with major incidents (Alharbi *et al.*, 2020). Therefore, the SRCA currently prefers to hire paramedics who are bachelor's degree holders over EMTs because paramedics were trained in Saudi universities rather than private schools and have advanced care skills. The EMS personnel undergo continuing education and training of Basic Life Support BLS, Prehospital Trauma Life Support PHTLS or International Trauma Life Support ITLS, and Advance Cardiac Life Support ACLS courses as conditions to obtain professional registration accredited by the Saudi Commission for Health Specialities organisation (Alharbi et al., 2020). Although these courses are available in Saudi Arabia, the trained personnel are not at a level that can fulfil the local and national needs (Al-Naami, Arafah and Al-Ibrahim, 2010).

In Saudi Arabia, the EMS education transition has historically been divided into three broad stages. During Stage 1, the first aid provider provided workplace training between 1934 and 2005; a second stage of development is the professional technician diploma, which is awarded from 2005 to 2012; and the third stage: academic transition: bachelor's degree in EMS 2007-present (AlShammari, Jennings and Williams, 2017). In terms of trauma care education, increasing knowledge, skills, attitudes, and

relationships are the goal of trauma education (Carley and Driscoll, 2001). Developing a trauma system requires education and training, but it's unclear whether trauma training courses affect trauma mortality outcomes (Alshamrani *et al.*, 2020). Saudi trauma training and education need to be studied for its impact on healthcare providers (Alshamrani *et al.*, 2020). There is no data on whether trauma training in Saudi Arabia increases healthcare providers' confidence in dealing with trauma patients (Alshamrani *et al.*, 2020). There is no information on the current state of trauma training and education in Saudi Arabia, and further research is needed to determine how training courses are affecting outcomes (Alshamrani *et al.*, 2020).

1.13 The current efforts of the Saudi government towards the trauma system's issues and gaps:

As a part of the Saudi vision 2030, a national clinical advisory group for the trauma care has been developed employing 11 multidisciplinary members from EMS, emergency and disaster management, ED, trauma surgery, nursing, paediatric emergency, trauma research, and rehabilitation (Chowdhury, Mok and Leenen, 2022). This group is under the supervision of the Vision Realisation Office of the Ministry of Health to develop a new Saudi Arabian trauma care system (Chowdhury, Mok and Leenen, 2022). This team has conducted several workshops with participating more than 300 healthcare professionals from the Riyadh to assess the new trauma system that will be firstly implemented in Riyadh (Chowdhury, Mok and Leenen, 2022) (**see Figure 1.4**):

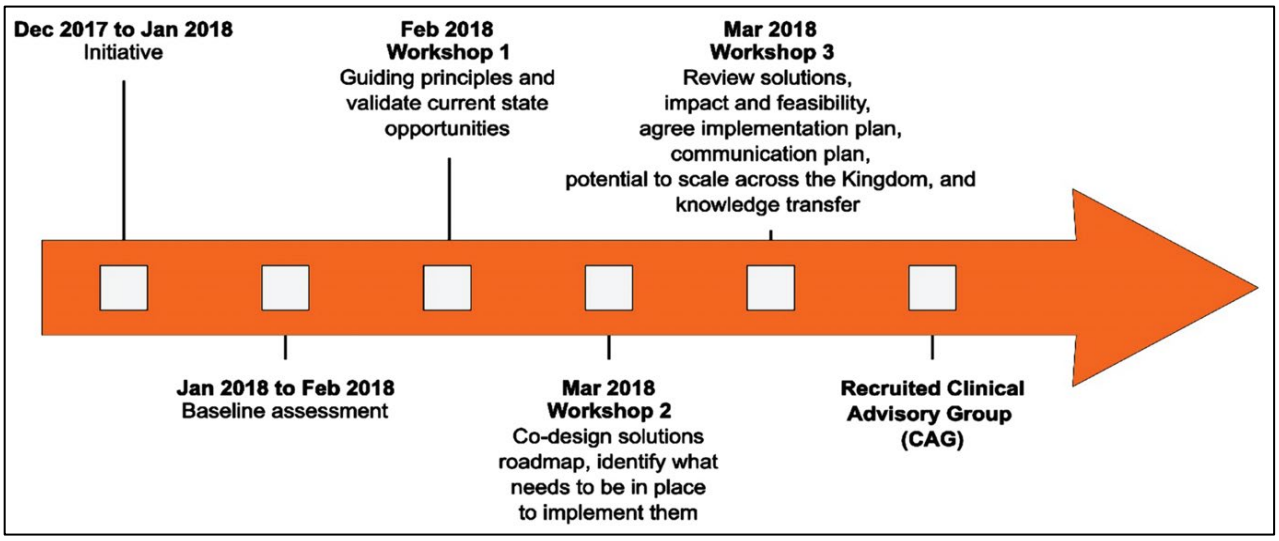


Figure 1.4: Recent CAG workshops to develop a new Saudi trauma care system plan: reproduced with permission from Chowdhury, Mok and Leenen (2022) in accordance with the CC BY 4.0 licence (https://creativecommons.org/licenses/by/4.0/)

These workshops initially identified additional gaps that hinder employing trauma care systems in Saudi Arabia, such as lacked prehospital transport resources and capabilities, no collaborative networks, hospitals' lack of transportation, number of staff and public awareness gap under the rehabilitation and community discharge, limited geographic networks for rural trauma care and shortages of paediatric trauma care centres (Chowdhury, Mok and Leenen, 2022). The team then has proposed an initial standard trauma care pathway to be implemented and then improved in Riyadh until December 2019 because it is challenging in applying it regionally (Chowdhury, Mok and Leenen, 2022) (**see Figure 1.5**):

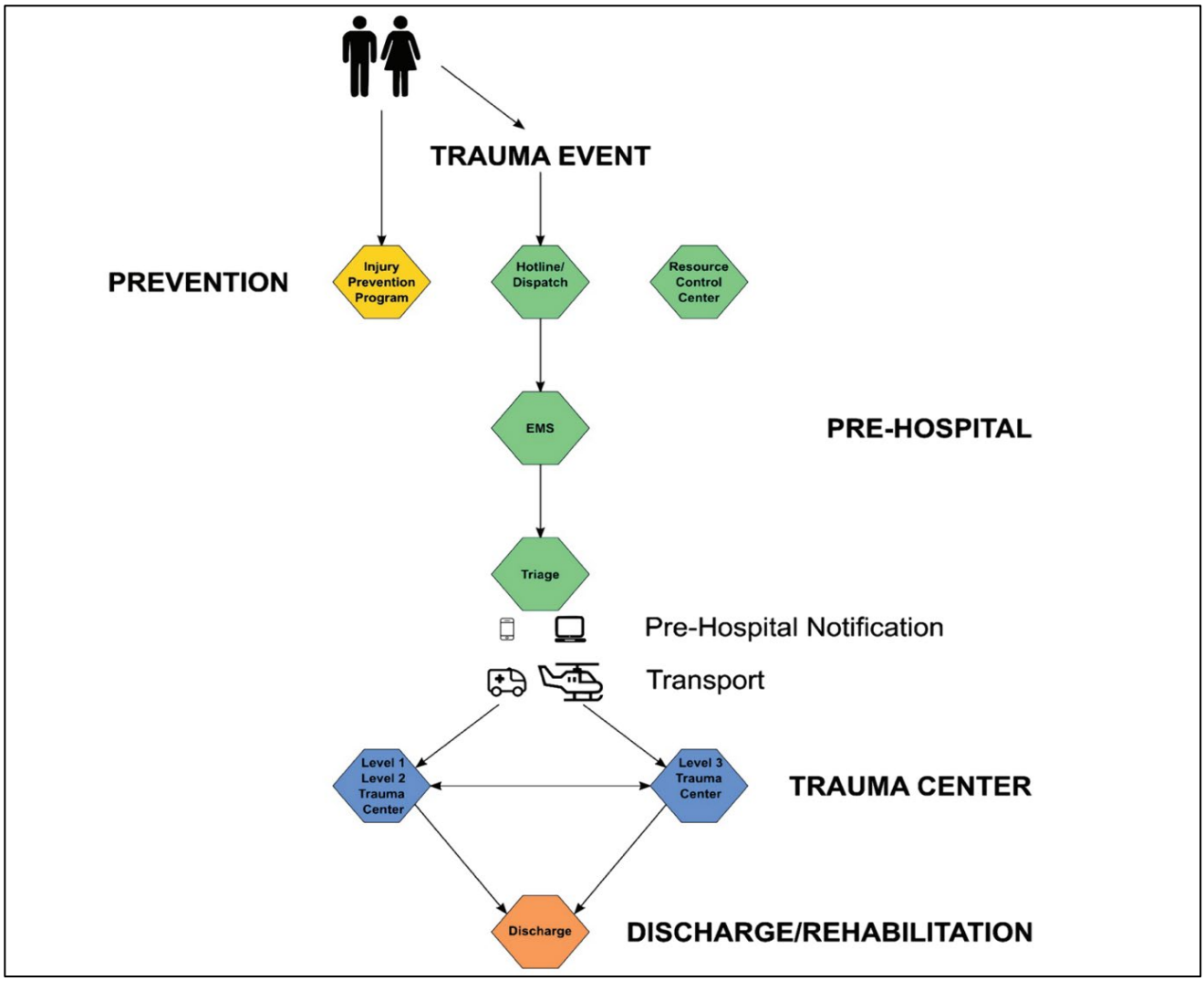


Figure 1.5: Developed standard trauma care pathway plan: reproduced with permission from Chowdhury, Mok and Leenen (2022) in accordance with the CC BY 4.0 licence (https://creativecommons.org/licenses/by/4.0/)

Further, it is worth indicating that trauma-related studies in Saudi Arabia focused on all trauma patients in general. According to a recent Saudi study, high rates of mortality and trauma events still pose burdens for the government because of increased healthcare costs (Alshamrani *et al.*, 2020). Another Saudi paper found increased in-hospital mortality and disability among trauma patients and recommended preventive injury measures (Abolfotouh *et al.*, 2018). Therefore, based on my knowledge, this research will be the first to investigate the impacts of ageing changes on prehospital care for injured older patients and patient outcomes in Saudi Arabia.

1.14 Conclusion:

Ageing changes impact the efficiency of prehospital trauma care for older patients and patient outcomes (Scheetz, 2010, 2012). Further, ambulance workers require additional geriatric-specific education to expand their roles to make high-level decisions for older patients (Goldstein, Andrew and Travers, 2016). Trauma in older people increases the healthcare burden in Saudi Arabia, and the age factor has a substantial impact on trauma care. Research is required to identify the impacts of ageing changes on prehospital care and patient outcomes in Saudi Arabia and explore factors that lead to lack of awareness of ambulance clinicians regarding these impacts. Therefore, the next chapter will determine what themes have been addressed in existing research.

Chapter 2

The Literature Review

(Chapter title: Current Knowledge in Prehospital Trauma Care for Older Patients with Injuries: Scoping Review)

Chapter overview:

"This chapter reports a scoping review undertaken in order to determine current knowledge and identify gaps in current knowledge regarding the prehospital care for older patients with injuries. Major themes and subthemes were identified with research gaps that will then be investigated in the next chapters from the perspective of Saudi Arabia".

2.1 Introduction:

Research and Evidence-based Practice EBP have recently started to increase through prehospital care (Simpson *et al.*, 2012). This reflects the paramedic's professional role in effectively caring for patients, using healthcare guidelines based on paramedic-driven research. However, there is still a shortage of evidence to guide prehospital trauma care for older patients and their outcomes, as highlighted in the first chapter. Therefore, a scoping review is required to identify what evidence is available and where the gaps in the evidence lie. This chapter will enhance the spirit of inquiry by conducting a scoping review identifying current knowledge and gaps in current knowledge with regard to the prehospital care for older patients with injuries.

2.2 Evidence-based practice and its importance in prehospital research:

EBP is "a problem-solving approach to the delivery of health care that integrates the best evidence from studies and patient care data with clinician expertise and patient preferences and values" (Melnyk *et al.*, 2010). By considering the importance of EBP in prehospital research, we can improve patient outcomes and clinician experience. The importance of EBP is focused on: (1) developing policy and practice for paramedic protocols to provide effective services based on existing evidence; (2) improving current paramedical care and changing practices based on emerging research; (3) engaging paramedics in research activities such as developing research questions, synthesising evidence and constructing arguments to improve healthcare and practice (Simpson *et al.*, 2012). As has been explained in the first chapter, my project aims to explore ageing-related challenges and barriers that ambulance staff encounter while caring for older patients with injuries. Therefore, achieving this aim to ensure meeting the needs of older patients and reduce ageing-related challenges and barriers when caring for older patients with injuries.

2.3 Developing the scoping review:

Due to shortages of research into the ageing impacts in prehospital care and patient outcomes, a scoping review was conducted to determine current knowledge and identify knowledge gaps in the prehospital care of older patients with injuries. The scoping review aims to map existing literature on my field of interest (ageing changes-related impacts on prehospital trauma care). This kind of review

aims: (1) to examine the extent, range, and nature of research activities, (2) reflect the value of conducting a full systematic review, (3) summarise and disseminate the research findings and (4) identify research gaps in the existing evidence (Arksey and O'Malley, 2005). Consequently, this review is guided by the Arksey and O'Malley framework for undertaking scoping reviews, the most popular framework employed in conducting scoping reviews (Pham *et al.* 2014). This framework consists of five stages: (1) to establish the review question; (2) to identify the relevant literature; (3) to select and include papers; (4) to chart the data (5) to collate, summarise and report the existing findings. This approach was applied in line with the PRISMA extension for scoping reviews (PRISMA-ScR) checklist (Tricco *et al.*, 2018) (**see Appendix 1**). This tool has been developed by Tricco *et al.* (2018) to 1) help readers gaining an in-depth understanding of relevant terms, primary concepts and essential items for reporting scoping reviews, 2) provide reporting guidance of scoping reviews and 3) reflect a rigorous methodology in conducting scoping reviews (Tricco *et al.*, 2018).

2.3.1 The first stage: development of the research question:

A well-formulated question is needed to identify the appropriate evidence for a literature review. The scoping studies' research questions should be broad and focus on the breadth of evidence (Levac, Colquhoun and O'Brien, 2010). Arksey and O'Malley (2005) indicate that scoping studies need to keep the broad scope of their questions and provide a roadmap of scoping review stages. Thus, it was crucial to use an approach that would integrate a broad question with a clear inquiry scope (Levac, Colquhoun and O'Brien, 2010). This review relied on an approach that has been developed by Levac, Colquhoun, and O'Brien (2010) for formalising the questions of scoping studies, maintaining the scope of review and ensuring an effective search strategy. This approach consists of three components: the concept, target population and health outcomes of interest (**see Table 2.1**):

"What does published research tell us about current knowledge and gaps in current knowledge in the prehospital trauma care for older patients?"

Components	***Descriptions***
The concept	Prehospital care
The target population	Older patients with injuries

Health outcomes of interest	Improvement of prehospital trauma care of older patients and their outcomes

Table 2.1: The formalisation of research question

Additionally, it is advised to clarify the rationale and purpose of this review after developing the question to facilitate making decisions in the next stages of the review, such as inclusion criteria and data extraction (Levac, Colquhoun and O'Brien, 2010). The rationale is to ensure that future research builds on existing research. The purpose is to examine the extent, range, and nature of this research area and identify research gaps in the literature.

2.3.2 The second stage: identification of relevant papers:

After developing the review question, I applied a literature search strategy to identify relevant papers. This strategy was conducted in several steps: starting by using specific online databases to ensure the review question had not been reviewed in the last five years (**see Table 2.2**):

Database	***Descriptions***
Cochrane library	This database contains systematic reviews in healthcare. It has different kinds of high-quality and independent research to guide decision-making in healthcare.
Campbell Library of Systematic Reviews	It is an open-access journal to publish systematic reviews, evidence maps, and research methods related papers.
PROSPERO	A database of systematic reviews in different disciplines such as social and health care, public health, education, crime, justice, and development in the health-related outcome.

Table 2.2: Databases for systematic reviews

These databases were searched by employing broad three terms related to the review question: "elderly", "injury", and "prehospital" (**see Figure 2.1**):

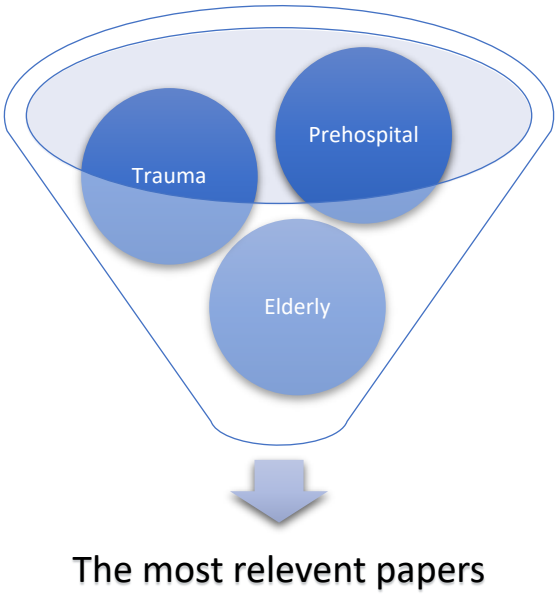


Figure 2.1*:* The essential components of literature search strategy

This action made sure that there were no existing reviews undertaken in the last five years regarding my topic area. Inclusion and exclusion criteria were then developed to help to identify the relevant papers (**see Table 2.3**):

Inclusion criteria	***Exclusion criteria***	***Rationale***
English or Arabic papers	Non-English and non-Arabic papers	There might be useful non-English papers, but practical difficulties of translating papers would make a scoping review unmanageable. Papers written in Arabic may have been very relevant to my research.
Available full-text papers	Unavailable full-text papers	The practical barriers to accessing full-text such as a lack of funding to pay for access fees and some databases or journals do not have access to full-text articles.
Papers focus on prehospital care	Papers focus on other settings	This review focuses on prehospital settings.
All published relevant papers that include method and results sections.	The following papers: editorials, opinion pieces, and narrative reviews.	The review is intended to identify objective evidence rather than subjective opinion or narrative.

Papers published in or after 2001.	Papers published before 2001.	To ensure including the most relevant evidence existed through the last twenty years.
Papers are focusing on paramedical roles for older persons with injuries.	Papers focus on other disciplines such as epidemiology, injury preventions, etc.	To ensure the most useful papers focusing on paramedic's roles for older patients with injuries.

Table 2.3: Inclusion and exclusion criteria

These inclusion and exclusion criteria were agreed as a consensus between NH (Mr Naif Harthi), SG (Prof Steve Goodacre) and FS (Dr Fiona Sampson) through a team discussion. These criteria aimed to refine the initial search records depending on the PRISMA guidelines until it included the most relevant papers.

A full electronic literature search was then carried out between 20th – 25th January 2021. This search strategy ideally aimed to ensure the comprehensiveness and breadth of this review by including relevant papers from: online databases search (for published papers), grey literature search (for unpublished papers) and reference lists of relevant papers (Tricco *et al.*, 2018). However, the grey literature search was not used in this review for two reasons: a) grey literature is inconsistent with one of the inclusion criteria, which indicates that "including all published relevant papers that have method and results suctions" (**as shown in the Table 2.3**). b) the nature of the review question dictated, including only published papers.

The keywords: "elderly", "injury", and "prehospital" were used to explore their synonyms by using two steps: depending on self-suggestion to generate synonyms for each keyword and using then each keyword and suggested synonym in the MeSH search engines of the PubMed and CINAHL databases to allow for high specificity searches and produce potential synonyms as much as possible (**see Table 2.4**):

Keywords	***Synonyms***
Elderly	Old, Elder, Older, Geriatric, ageing and aging.
Injury	Trauma and Wound.
Prehospital	Out of Hospital, Emergency medical services, Ambulance, and Paramedic.

Table 2.4: Keywords and synonyms

I used these keywords and synonyms with applying a truncation style (*), acronyms and phrases (using quotes " ") during searching in these online databases Scopus, CINAHL, MEDLINE, PubMed and Cochrane library (**see Table 2.5**):

Database	***Description***
Scopus	An Elsevier abstract and citation database provides a detailed overview of global, technological, medical and social sciences, and research outputs in arts and humanities.
CINAHL via EBSCO	(Cumulative Index for Nursing and Allied Health Literature). It contains research in different disciplines of healthcare.
MEDLINE	The most common database used in medical sciences, including research from around the globe, dating to 1946.
PubMed	A free source of the biomedical and life sciences literature to improve health globally and personally.
Cochrane library	A database for systematic reviews in healthcare. It contains different kinds of high-quality and independent research to guide decision-making in healthcare.

Table 2.5: The online databases

Therefore, a combination of keywords, synonyms, and phrases was applied in these online databases by using Boolean operators (AND/OR) to refine the literature search further (**see Table 2.6**) and (**see Appendix 2**).

Keywords	***Synonyms***	***Searching words and phrases***
Elderly	Old, Elder, Older, Geriatric, Ageing and Aging.	elder* OR olde* OR geriatric* OR ageing OR aging
		AND
Injury	Trauma and Wound.	injur* OR trauma* OR wound*
		AND
Prehospital	Out of Hospital, Emergency Medical Services, Ambulance and Paramedic.	prehospital OR "out of hospital" OR "emergency medical service*" OR ambulance OR paramedic*

Table 2.6: Use of keywords, synonyms, and phrases in the literature search

2.3.3 The third stage: study selection:

This review did not achieve the registration criteria in the PROSPERO. According to the PROSPERO team, they have decided to accept systematic reviews and refuse scoping reviews despite my explanation that my scoping review would be systematic. The literature search's initial records underwent a refining process using the **PRISMA 2009 Flow Diagram**. This tool describes the flow of papers to include the most relevant articles by classifying the records into identified, included, and excluded papers (Moher *et al.*, 2009). The inclusion and exclusion criteria were employed to limit these records to the most relevant articles. Additionally, this stage was conducted independently by two reviewers NH (Mr Naif Harthi) and RA (Dr Rayan Alharbi).

This literature search process yielded initial 5452 citations: Scopus n=1572; CINAHL via EBSCO n=518; MEDLINE via Ovid n=1303; PubMed n=1154; Cochrane library n=905, that were then refined by using the PRISMA guidelines against the inclusion and exclusion criteria (**see Table 2.7**). These 5452 citations were then refined (electronically) into 2940 that are English papers, published in or after 2001 and available as full-text papers. The two independent reviewers then applied a two-stage screening process to find the eligible papers: 1st stage to scan titles and abstracts & 2nd stage to review full-text papers. The 2940 citations were then scanned, focusing on their titles and abstracts in order to include papers that focused on older patients, injuries and prehospital settings, and reported methods and results sections. This stage led to include 127 articles. These 127 were then exported to **Mendeley Software** to remove duplicates and manage and facilitate reviewing the final included papers. 62 duplicates were then removed to include 65 articles. The 2nd stage was then undertaken to review these 65 articles that led to finally including 25 papers by excluding each paper that: a) does not involve methods & results sections, b) does not focus on pre-hospital settings, and c) conducted under other health disciplines (such as injury prevention, epidemiology...etc.) rather than paramedical care. The reference lists of the 25 included papers were then scanned to help verify the search literature strategy, and no paper in these lists met the inclusion criteria (**see Figure 2.2**). The second reviewer checked the eligibility of the 65 articles and did not find any differences from the first reviewer.

Database	***The initial hits (without applying the inclusion & exclusion criteria)***	***After refining the initial records electronically focusing on: English, in or after 2001 and full-text available papers.***	***The results of the 1st stage of the scanning process***
Scopus	1572	1259	52
CINAHL via EBSCO	518	131	26
MEDLINE via Ovid	1303	267	10
PubMed	1154	475	36
Cochrane library	905	808	3
Total	5452	2940	127
Number of duplicates removed= 62		The results of the 2nd stage of the scanning process= the final 25 papers	

Table 2.7*:* The searching results in online databases before and after application of the inclusion and exclusion criteria

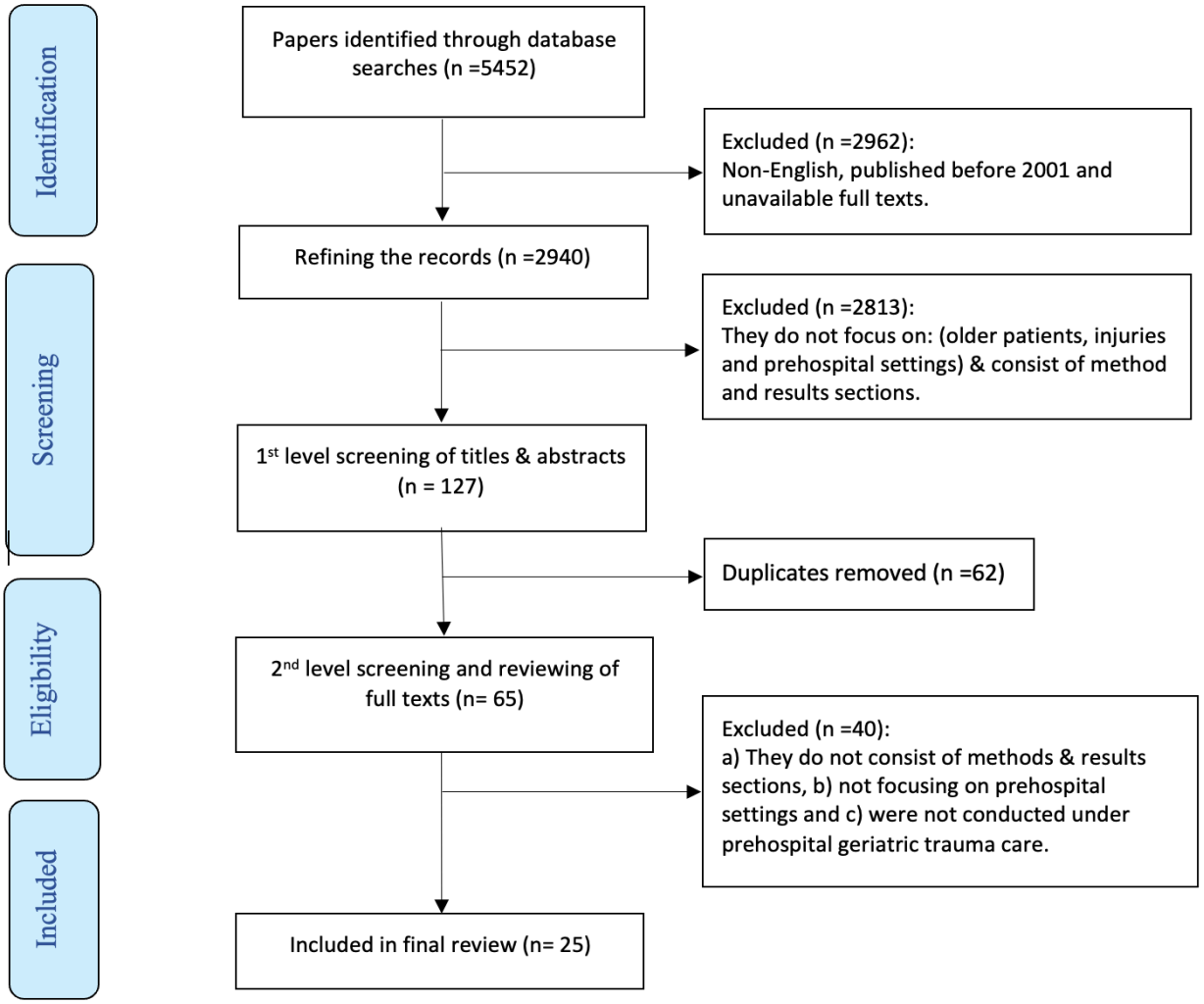


Figure 2.2: The PRISMA flow diagram

2.3.4 The fourth stage: charting data:

At this stage, I decided to undertake the thematic analysis approach as an overall analysis method, presenting a narrative account of existing literature (Arksey and O'Malley, 2005). Levac, Colquhoun and O'Brien (2010) recommended using one of two analysis methods when deciding to use the Arksey and O'Malley approach: 1) 'Descriptive analytical method' that involves summarising process information using a theory or model in a meaningful format, or 2) 'thematic analysis' that determines where sufficient evidence exists for a complete synthesis or where there is insufficient evidence and further research is required. Therefore, I found the thematic analysis method more appropriate to address the purposes of this review.

By reading and reviewing for the 25 included papers, a table of the characteristics of included articles was developed that consisted of the following extracted items: authors, date of publishing, origins, publishers, aims/objectives, research designs, sample and key findings from the included papers (**see Appendix 3**). The extracted information were then extracted onto a **Microsoft Excel spreadsheet** to develop the data-charting form to: a) help identifying themes and subthemes to outline the fifth stage of this review & b) facilitate updating this scoping review in an iterative process. The key information of included papers such as authors, publications years, study settings and research designs were then extracted and charted by using **SPSS 27 software** to show percentages of included papers in terms of publication years, settings, and research designs in order to describe and reflect the characteristics of existing literature to readers. **Figure 2.3** describes the publication years for the included papers from 2001 into 2021. It is worth noting a gradual increase in the number of relevant published papers until 2019:

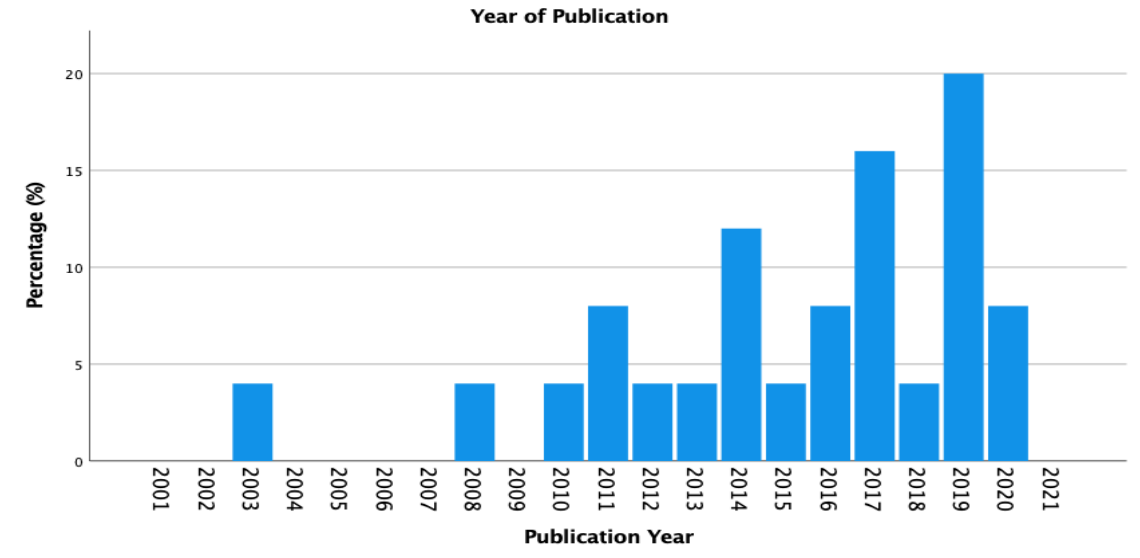


Figure 2.3: Years of publication for the included papers

Interestingly, 80% of the included papers were originated from the US (twenty papers), followed by four papers in Australia and one paper in Germany, in terms of research settings. Also, **Figure 2.4** indicates that this scoping review included 21 quantitative papers (18 retrospective papers and three

prospective papers) that represent the majority of papers, followed by two reviews (systematic and literature reviews), one mixed methods paper (a consensus panel of experts) and one qualitative paper (semi-structured interviews and focus groups), in terms of research designs:

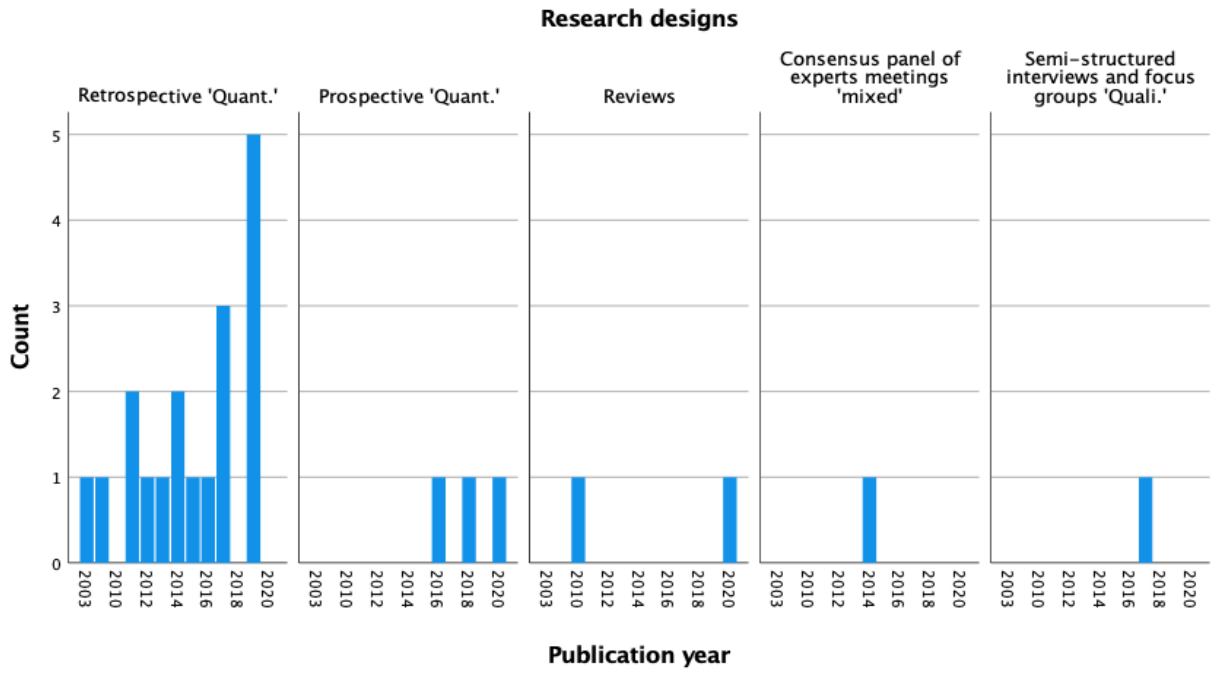


Figure 2.4: The included papers in terms of research designs

Figure 2.5 displays the highest number of studies that originated from the US, were retrospective that represents the most research design used in the included papers:

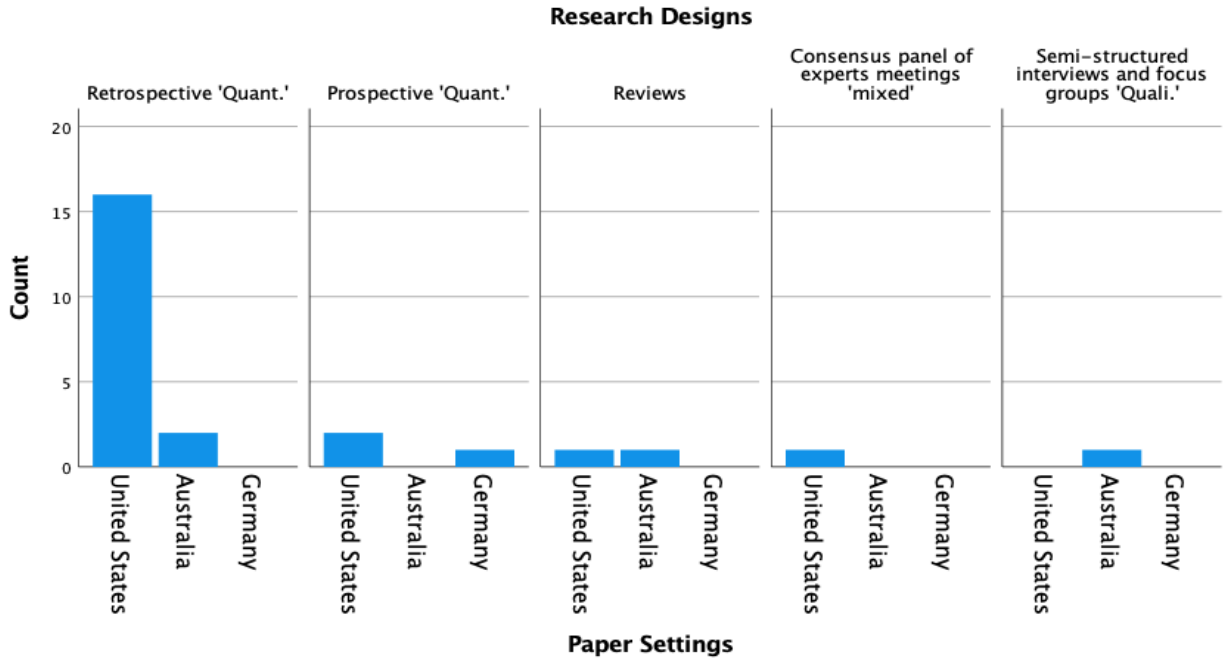


Figure 2.5: Distribution of paper settings within the research designs

After that, the major themes and subthemes were identified by the following steps: firstly, the included papers' findings were reviewed using the **Excel Sheet software** to record information related to the review question. The **Excel Sheet** was used to link each piece of identified information with each paper appropriately. Secondly, the identified information was then collected and considered as subthemes. Thirdly, the subthemes were then collected and classified to generate the following major themes: 'field triage, 'ageing impacts', 'decision-making', 'paramedic' awareness' and 'paramedic's behaviour' (**see Figure 2.6**):

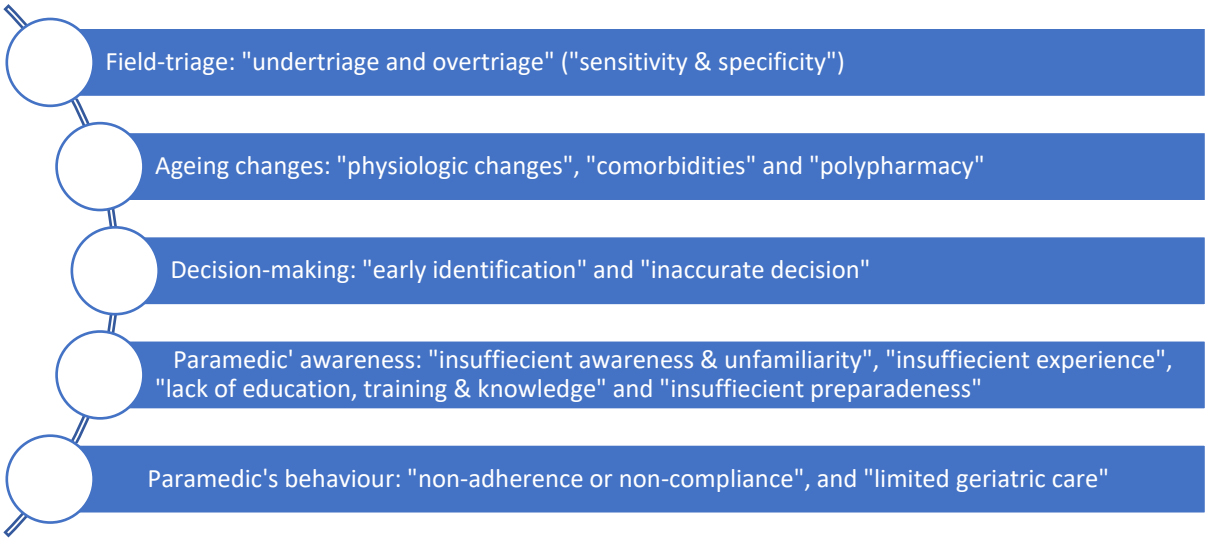


Figure 2.6: The major themes and subthemes

Fourthly, a process to determine whether each major theme was identified in each included paper, was implemented by creating the following table that contains the papers and five themes:

No	*Papers*	*Field-triage*	*Decision-making*	*Ageing changes*	*Paramedic's awareness*	*Paramedic's behaviour*
1	Amoako et al. (2019)	Yes	Yes	No	Yes	No
2	Benjamin et al. (2018)	Yes	Yes	Yes	No	No
3	Brown et al. (2019)	Yes	No	No	No	No
4	Brown et al. (2020)	Yes	Yes	No	Yes	Yes
5	Caterino, Raubenolt and Cudnik (2011)	Yes	No	No	No	No
6	Chang et al. (2008)	Yes	Yes	No	Yes	No
7	Cox et al. (2014)	Yes	Yes	Yes	No	No
8	Cull et al. (2019)	Yes	No	No	Yes	No
9	Garwe et al. (2017)	Yes	No	Yes	Yes	No
10	Hon et al. (2020)	Yes	Yes	No	Yes	No
11	Ichwan et al. (2015)	Yes	No	No	No	No
12	Meyers et al. (2019)	Yes	Yes	No	Yes	Yes
13	Nakamura et al. (2012)	Yes	No	Yes	No	No
14	Newgard et al. (2019)	Yes	Yes	No	No	No

15	Newgard et al. (2016)	Yes	No	No	Yes	No
16	Newgard et al. (2014)	Yes	No	No	Yes	No
17	Oberkircher et al. (2016)	No	No	Yes	Yes	No
18	Simpson et al. (2017)	No	Yes	No	Yes	Yes
19	Staudenmayer et al. (2013)	Yes	No	Yes	No	No
20	Wasserman et al. (2014)	Yes	No	No	No	No
21	Werman et al. (2011)	Yes	No	No	No	No
22	Nishijima, S. D. Gaona, et al. (2017)	Yes	No	No	Yes	No
23	Nishijima, S. Gaona, et al. (2017)	No	No	No	Yes	No
24	Scheetz (2003)	Yes	No	Yes	Yes	Yes
25	Scheetz (2010)	Yes	Yes	Yes	No	No

Table 2.8: Distribution of the major themes in the included papers

Lastly, using the distributed results of **the Table 2.8** in the **SPSS 27** software showed percentages of each major theme in the included papers. Therefore, it is worth noting that field-triage represented the most common major theme investigated in the existing literature (38 % - 22 times), followed by the paramedic's awareness (24% - 14 times), decision-making (17% - 10 times), ageing changes (14% - 8 times), and paramedic's behaviour (7% - 4 times). This suggests the major themes that may require more investigations in future research.

2.3.5 The fifth stage: collating, summarising and reporting the existing results:

At this stage, the process of collating, summarising and reporting the existing findings was conducted in a narrative format using the following major themes:

2.3.5.1 Field-triage:

This is the most common theme covered by the existing literature. The following field-triage subthemes were generated: undertriage & overtriage issues and triage sensitivity & specificity. Field-triage aims to: a) distinguish between major and minor patients with injuries and determine the proper level of care and b) reduce the impacts of mortality, disability and healthcare costs (Scheetz, 2003).

Regarding the issues of undertriage and overtriage, older patients with major injuries can be undertriaged by transporting them to a suboptimal level of care (Staudenmayer *et al.*, 2013; Amoako

et al., 2019; Brown *et al.*, 2019, 2020), while overtriage can occur when older patients with minor injuries are taken to the MTCs (Wasserman *et al.*, 2014). The existing literature showed that the undertriage issue is higher with older patients with injuries than the overtriage issue (Scheetz, 2010; Nakamura *et al.*, 2012; Staudenmayer *et al.*, 2013; Garwe *et al.*, 2017; Brown *et al.*, 2020). Undertriage is a multifactorial issue (Amoako *et al.*, 2019). The reasons are: inadequate training in geriatric care, some paramedics believe it is not worth spending expensive healthcare for older patients, unfamiliarity in triaging older patients, perceived negative attitudes at MTCs towards paramedics during delivering older patients, poorer EMS prognosis, the proximity to trauma units, ineffective or inapplicable triage tools, patient preference, no MTCs in the residence area, increased comorbidities, failure to identify major injuries during minor mechanisms of injury, resistance to improve, non-adherence by paramedics (Scheetz, 2003; Chang *et al.*, 2008; Garwe *et al.*, 2017; Amoako *et al.*, 2019; Cull *et al.*, 2019; Meyers *et al.*, 2019; Brown *et al.*, 2020). This considerable focus on the undertriage in the literature reflects its importance, but Newgard *et al.* (2016) reported that improving any triage tool by reducing the undertriage in injured geriatric patients can increase the overtriage issue.

Most research suggested focussing on reducing both undertriage and overtriage, but Wasserman *et al.* (2014) described this as a challenge. Nakamura *et al.* (2012) and Newgard *et al.* (2016) showed that the causes of undertriage and implications of overtriage are poorly understood. Furthermore, Wasserman *et al.* (2014) and Newgard *et al.* (2016) recommended that overtriage also should be considered while reducing the undertriage. Regarding the implications of overtriage and undertriage, Benjamin *et al.* (2018) and Brown *et al.* (2019) reported that undertriage led to reduced transports to MTCs and then increased in-hospital mortality among geriatric patients. While Newgard *et al.* (2014) and Wasserman *et al.* (2014) reported that overtriage resulted in increasing ambulance transports, ED attendances, healthcare costs, decreasing trauma system efficiency and disruption in healthcare continuity.

In terms of triage sensitivity and specificity, the sensitivity means the field-triage tool's probability of identifying older patients with major injuries when the condition is present, whilst the specificity means the probability that the field-triage tool will determine patients who do not suffer from major injuries when the condition is absent (Scheetz, 2003). Ideally, field-triage tools should aim to increase its sensitivity to prevent undertriage and increase its specificity to reduce overtriage (Scheetz, 2003).

Adding geriatric criteria to adult field-triage tools can increase the sensitivity and specificity for identifying older patients who need transport to MTC (Ichwan *et al.*, 2015). Using adult field-triage with older patients can lead to decreased sensitivity, while using geriatric field-triage with younger patients can lead to increased sensitivity and decreased specificity (Ichwan *et al.*, 2015; Hon *et al.*, 2020). Further, four retrospective studies were conducted to determine the field-triage sensitivity and specificity after adding the geriatric criteria such as GCS, vital signs, comorbidities and anticoagulants & antiplatelet use (Caterino, Raubenolt and Cudnik, 2011; Nishijima, S. D. Gaona, *et al.*, 2017; Cull *et al.*, 2019; Newgard *et al.*, 2019). Cull *et al.* (2019) found that adding prehospital scores of GCS and vital signs helped improve undertriage 'sensitivity' and overtriage 'specificity'. While Caterino, Raubenolt and Cudnik (2011) and Newgard *et al.* (2019) reported that changing the GCS cutoff from 13 to 14, or adding vital signs and comorbidities improved the field-triage sensitivity to identify elderly patients who need transporting to MTCs at the expense of specificity. Regarding the anticoagulant and antiplatelet use criterion, Nishijima, S. D. Gaona, *et al.* (2017) showed that this criterion has improved triage tool sensitivity, while Newgard *et al.* (2019) found that adding anticoagulant use criterion did not help to identify high-risk older patients.

2.3.5.2 The ageing changes:

The emerging literature focused on the following aspects of ageing changes that can influence older patient outcomes: physiologic changes, comorbidities and polypharmacy as "combined factors"(Scheetz, 2003; Staudenmayer *et al.*, 2013). Older patients with injuries might suffer from physiologic changes such as they cannot tolerate severe pain & blood loss, rapid fluid shifts, inefficient respiratory mechanisms, reduced hypotensive and tachycardiac responses to injuries (Scheetz, 2010; Oberkircher *et al.*, 2016; Garwe *et al.*, 2017; Benjamin *et al.*, 2018). Regarding the comorbidities and polypharmacy impacts, three quantitative studies showed that multiple diseases (cardiac heart failure and cerebrovascular accidents) and polypharmacy use (beta-blockers, anticoagulants and antiplatelets) can blunt the compensatory physiologic responses to injuries (Scheetz, 2003; Garwe *et al.*, 2017; Benjamin *et al.*, 2018). Consequently, these ageing-related issues can lead to undertriage or delayed aggressive care, resulting in avoidable mortality at non-trauma hospitals (Staudenmayer *et al.*, 2013;

Benjamin *et al.*, 2018). Therefore, it is essential to increase paramedic knowledge regarding the ageing impacts that can influence patient outcomes.

2.3.5.3 Decision-making:

Two relevant subthemes were generated: early identification of high-risk older patients and inaccurate decision-making. The first subtheme is an important part of paramedics' decision making during caring for injured older patients. Three papers indicated that early identification of high-risk older patients is the first EMS decision-making step in managing their injuries (Newgard *et al.*, 2016, 2019; Benjamin *et al.*, 2018). Cox *et al.* (2014) stated that paramedics play important roles in the field-triage decision making to provide optimal management for injured older patients. The decisions can be taken inaccurately in transporting older patients who need definitive care (Brown *et al.*, 2020). The reasons for this inaccuracy include age bias, decreased level of suspicion, inadequate training and unfamiliarity with triage (Chang *et al.*, 2008; Newgard *et al.*, 2019; Brown *et al.*, 2020; Hon *et al.*, 2020). Further, a qualitative study indicated that some paramedics received inadequate geriatric training and education regarding the EMS decision making (Simpson *et al.*, 2017). However, it is worth noting that there is modest knowledge from the existing literature on the causes of the inadequacy of prehospital decision-making training. Amoako *et al.* (2019) and Meyers *et al.* (2019) recommended that education and training actions are required to improve EMS decision-making accuracy, whilst Scheetz, (2010) advised providing reliable evidence to inform field-triage decision-making at the scene to reduce preventable deaths and disabilities.

2.3.5.4 Paramedic's awareness:

The four relevant subthemes of the paramedic's awareness emerged: a) insufficient awareness or unfamiliarity, b) inexperience, c) inadequate education, training and knowledge, and d) inadequate preparedness. In terms of insufficient awareness or unfamiliarity, two papers advised that the paramedics' awareness regarding the impacts of pre-injury polypharmacy (e.g. antiplatelets and anticoagulants) with head-injured older patients should be increased (Nishijima, S. D. Gaona, *et al.*, 2017; Nishijima, S. Gaona, *et al.*, 2017). This can protect older patients with head injuries from risks of excessive bleeding due to the use of these medications. Also, some paramedics are unfamiliar with the

field triage, which can be a reason for undertriage (Chang *et al.*, 2008; Cull *et al.*, 2019). In terms of the inexperience & inadequate education, training and knowledge, some paramedics have insufficient experience in assessing and diagnosing older patients with injuries (Brown *et al.*, 2020; Hon *et al.*, 2020). This issue can exist due to inadequate EMS training and knowledge regarding geriatric care and ageing impacts that might contribute to undertriage (Scheetz, 2003; Chang *et al.*, 2008; Cull *et al.*, 2019). Insufficient preparedness can occur due to inadequate EMS education & training, lack of confidence and constant work pressure that can inhibit providing effective care (Simpson *et al.*, 2017). Therefore, the following actions should be considered: a) applying training after adding any new geriatric triage criteria, b) educating paramedics about the impacts of polypharmacy on injured older patients, c) enhancing the field-triage and transport criteria for paramedics, d) educating and training paramedics before implementing new field-triage criteria, and e) training paramedics in giving analgesia for injured older patients without waiting for prehospital physicians (Chang *et al.*, 2008; Newgard *et al.*, 2014, 2016; Oberkircher *et al.*, 2016; Garwe *et al.*, 2017; Nishijima, S. Gaona, *et al.*, 2017; Amoako *et al.*, 2019; Meyers *et al.*, 2019). These actions could ensure effective triage, reduced undertriage or underestimation, and improved older patient outcomes (Scheetz, 2003; Newgard *et al.*, 2016; Oberkircher *et al.*, 2016; Garwe *et al.*, 2017).

2.3.5.5 Paramedic's behaviour:

Two relevant subthemes were then generated: 1) non-adherence or non-compliance and 2) limited geriatric care. In terms of non-adherence or non-compliance, Meyers *et al.* (2019) and Brown *et al.* (2020) argue that paramedics have non-adherence or non-compliance to apply field-triage tools for older patients with injuries. This can be a reason for the undertriage that can affect patient outcomes (Meyers *et al.*, 2019; Brown *et al.*, 2020). Therefore, Scheetz, (2003) recommended integrating the compliance aspect into EMS geriatric training to ensure effective triage. Simpson *et al.* (2017) interviewed paramedics who were frustrated by repeated attendances for older patients with low mechanisms of injuries and reported inadequate geriatric training. These led to limited geriatric care, such as insufficient patient assessment, gathering of poor information and suboptimal healthcare decisions (Simpson *et al.*, 2017). Despite these studies, there is still little investigation of paramedics' behaviour in caring for older patients in the existing literature.

2.4 Discussion:

Based on my knowledge, this is the first review to identify current research themes in prehospital trauma care for older patients and explore research gaps. This review has now been published in a peer reviewed journal (Harthi *et al.*, 2022). This review has identified twenty-five studies that included five topic areas with their subthemes to answer the review question. The search strategy covered the period from 2001-2021, the distribution of publication years and countries shows that most studies were carried out in the last ten years and mostly arise in the US, followed by four papers from Australia and one paper from Germany. Most of these published studies were retrospective. They focused on the most common theme "field-triage" area, followed by "paramedic's awareness", "decision-making", "ageing changes", and "paramedic's behaviour" themes.

This review found that most existing studies focused on the undertriage amongst older patients with injuries more than overtriage. This can prioritise the current focus on undertriage rather than overtriage. There was limited examination of overtriage in the existing literature, despite this review found that the overtriage can increase when solving the undertriage. Future studies needed to investigate factors increase undertriage and overtriage issues along with improving triage sensitivity and specificity by reducing impacts of the undertriage and overtriage. Further, increasing the paramedic's knowledge regarding ageing-related physiologic changes, comorbidities and polypharmacy is important to prevent the undertriage, delayed definitive care and avoidable mortalities. Further research is needed to identify factors leading to insufficient knowledge regarding these ageing-related challenges. This review also found that there is a lack of investigations regarding prehospital decision-making and only one paper investigated it. Future research required into the prehospital decision-making process. This review also found that some paramedics are unfamiliar with triage guidelines, inexperienced in geriatric care, or have insufficient preparedness. Further investigations are needed to identify contributory factors to these issues. This review identified the issues of non-adherence or non-compliance, and limited geriatric care but the reasons for these issues have not been examined by the existing literature. Therefore, further studies are needed to understand and investigate these behavioural issues.

Additionally, it appeared that none of the included research was undertaken in Saudi Arabia. Therefore, it is worth to consider whether findings from other countries can be generalised or applied to Saudi Arabia. Since most research is from the US and I am interested in this research topic from the perspective of Saudi Arabia, so it is appropriate to consider the applicability of research in US to Saudi Arabia. In terms of patient demographics, the US population in 2021 reached 331,893,745 people (49.5% male and 50.5% female), according to the US Census Bureau's estimates (2021), whilst the total population of Saudi Arabia in 2021 is estimated at 34,110,821 people (61.2% male and 38.8% female) (MOH, 2021; The General Authority for Statistics, 2021). The Saudi Arabia has a much smaller proportion of older people than the US. In the US, older people (65 years and over) represent 16.9% of the total population, while in Saudi Arabia, they represent 3.5% (MOH, 2021; The US Census Bureau, 2021).

Regarding the trauma accidents, the National Trauma Data Bank reported that 861,888 records with valid trauma diagnoses were included in the 2016 Annual Report on trauma accidents in the US (Stewart *et al.*, 2016). Minor injuries accounted for 45.29 percent of patients and moderate injuries account for 32.69 percent (Stewart *et al.*, 2016). Injury caused by falls was the most common cause of death, followed by injuries caused by motor vehicle traffic and firearms (Stewart *et al.*, 2016). The peak of motor vehicle-related injuries occurs between ages 14 and 29, followed by a peak of falls between 40 and 50 (Stewart *et al.*, 2016). Adults over 65 and children aged 5-9 were most likely to sustain fall-related injuries (Stewart *et al.*, 2016). 44.18 percent of the injuries in the registry were caused by falls; 25.97% were from traffic accidents; 27.12% were by suffocation; 15.30% were by firearm, and 19.20 percent by drowning (Stewart *et al.*, 2016). Whilst in Saudi Arabia, MVC remains a leading cause of mortality and disability in trauma patients based on the WHO statistics (Alharbi *et al.*, 2020). There is, however, a shortage of trauma statistics compared to the US national trauma data bank statistics due to the absence of a nationwide trauma registry in Saudi Arabia, which makes it difficult for relevant US research to be applied or generalised to the Saudi Arabia.

2.5 Strengths and limitations:

Regarding the strengths in this review, this review followed a systematic approach to scoping the existing literature based upon an established framework, ensure that the methods are transparent and

the results reproducible. Further, this is the first scoping review identifying research priorities in prehospital care for older patients with injuries. There are several limitations: a) the included papers were not critically appraised because this is not a common practice with scoping studies. The lack of critical appraisal means that this review may have accepted conclusions not supported by the data. b) This scoping review has focused only on including papers written in the English or Arabic languages based on inclusion criteria due to practical limitations. This can lead to missing important articles written in other languages. c) It is essential to consider that limitations of undertaking a scoping review rather than a full systematic review. It is justified that this scoping review was conducted on a topic that has not been extensively investigated yet. d) Excluding grey literature can be a limitation which could have influenced findings. I anticipated that the grey literature would be include a lot of subjective opinion and narrative, and little objective evidence such as few studies with a methods and results section. e) It is important pointing out that most of the included papers were quantitative observational studies. Therefore, only limited conclusions can be drawn.

2.6 Conclusion:

To conclude, this scoping review has sought to find out what the published evidence tells us about the research themes of the prehospital trauma care for older patients by examining the extent, range, and nature of this research area and determining research gaps in the literature. This review has highlighted the currently relevant topics (field-triage, ageing changes, decision-making, paramedic's awareness, and paramedic's behaviour) under the umbrella of prehospital trauma care for older patients with identified research gaps. Future research is required to investigate the undertriage, overtriage, triage sensitivity and specificity that will help identify high-risk older patients. Further studies are also needed to determine paramedics' awareness regarding the ageing impacts, explore the EMS decision-making process, and understand paramedics' behaviour in dealing with older patients. In relevance to clinical practice, further educational actions are required to identify and manage high-risk older patients. This chapter has identified research themes and substantial uncertainties that can be explored by quantitative and qualitative methods. It is uncertain how findings of this literature review relate to Saudi Arabia. Therefore, a study in Saudi Arabia is needed.

Chapter 3

The Research Methodology

(Chapter title: The PhD Research Methodology)

Chapter overview:

"This chapter shows my plans to undertake a mixed-methods study in the next chapters. It explains the research questions, aim & objectives, research philosophy, methodology, design, data collections, analysis, integration phase, and ethical considerations".

3.1 Introduction:

In the first chapter, I described the impacts of ageing changes on healthcare (focusing on both in-hospital and prehospital settings) when caring for injured older patients and ageing impacts on patient outcomes, establishing this as the project's focus. In the second chapter, I undertook a scoping review to identify existing research in prehospital trauma care for older patients. The review identified five major themes and research gaps to be further investigated from the perspective of Saudi Arabia. This third chapter describes my plan to undertake a mixed-methods study in order to investigate the identified research gaps while considering the limitations and issues of the current status of the trauma system in Saudi Arabia (as indicated in the first chapter). This chapter outlines the project methodology showing the research questions, aim and objectives, research philosophy, methodology, design, data collections, analysis, integration phase, ethical considerations, and potential strengths and limitations.

3.2 Research questions, aims and objectives:

The research's key focus (**as shown in the Figure 1.2**) and identified research gaps of the scoping review were considered to develop the main question and research aim, followed by subsidiary questions and research objectives (**see Table 3.1**). These research questions were then sorted into quantitative and qualitative questions based on ageing impacts on the prehospital care (qualitative strand) and patient outcomes (quantitative strand). In the quantitative strand, I decided to describe major trauma in older patients and predictors of in-hospital mortality among them in Saudi Arabia. Describing the patient population can help to determine the needs of the relevant population in Saudi Arabia, determine whether research from other settings can be generalised to Saudi Arabia, and to describe the context for the qualitative study. This study is the first quantitative study focusing on major trauma older patients in Saudi Arabia. Understanding older people's characteristics is an important first step toward improving EMS care and practice (Duong *et al.*, 2018). The findings of this research will assist prehospital clinicians and managers responsible for delivering prehospital trauma care in Saudi Arabia and will contribute to the worldwide literature to improving healthcare for geriatric patients.

The main question	What is the potential to improve prehospital trauma care for older people in Saudi Arabia?

The main aim	To improve our understanding of prehospital geriatric trauma care in Saudi Arabia	
The subsidiary questions	1. What are the characteristics of older patients with major trauma presenting to prehospital care in Saudi Arabia? 2. What are predictors of in-hospital mortality among major trauma older patients?	How do Saudi paramedics and EMTs understand the impacts of ageing changes on geriatric trauma care and how they acquire and apply their knowledge? What are the facilitators and barriers to providing improved care? Do their perceptions of older trauma victims align with the characteristics of the cohort in the retrospective study?
The research designs	Quantitative: a retrospective cohort study	Qualitative: semi-structured interviews
The research objectives	a. Describe the prevalence of major injuries among older people (≥55 years old) and common causes of these injuries. b. Compare the differences in sub-groups of those patients based on age strata. c. Identify predictors of in-hospital mortality among injured older patients.	a. Explore Saudi paramedics and EMTs' understanding of the impacts of ageing changes on the prehospital trauma care. b. Explore how they acquire and apply their knowledge when attending to the scene. c. Explore the barriers to providing improved care for older patients with injuries. d. Explore the facilitators to providing improved care for older patients with injuries. e. Explore whether their perceptions of older trauma victims align with the characteristics of the cohort and whether they recognise the difficulty of predicting death in older trauma victims.

Table 3.1: The research's main question and aim, along with the subsidiary questions and objectives for each strand

3.3 The research philosophy and assumptions:

Initially, philosophy means "a view of the world encompassing the questions and mechanisms for finding answers that inform the view" (Birks, 2014, p 18). Ideally, researchers show their philosophical assumptions and interpretations of the world while conducting their research. Any research has a philosophical foundation, and researchers should consider the assumptions they make before obtaining their knowledge from conducting research (Creswell and Plano Clark, 2017). These

assumptions will then help decide how their research will be identified, articulated and processed to be conducted (Creswell and Plano Clark, 2017).

The paradigm or worldview has been defined as “a basic set of beliefs that guide action” (Guba and Lincoln, 2005, p 91). It involves four components: ethics, epistemology, ontology and methodology (Guba and Lincoln, 2005). Ethics to ask; ‘how will the researcher be a moral person in the world’ (Guba and Lincoln, 2005). Ontology means ‘what is reality’ and how researchers, respondents, and readers understand reality (Scotland, 2012; Creswell, 2013a). Epistemology means how this reality might be known to the researcher (Scotland, 2012). Lastly, the methodology means a process undertaken by the researcher to obtain knowledge (Creswell, 2013a).

It is essential also to consider the most well-known paradigms: (postpositivism, constructivism, transformative and pragmatism worldviews) (Creswell and Plano Clark, 2017). Each worldview can be considered based on the researcher’s assumptions. Creswell (2013b) mentioned the worldviews used in mixed-methods research with their researchers’ assumptions as follows: a) Postpositivism (Empirical measurements, Theory verification, or Determination); b) Constructivism (Understanding, Generating theories, or Social and historical construction); c) Advocacy or Participatory (Change-oriented, Empowerment issues-oriented, or Political issues); and d) Pragmatism (Real-world practice orientation, Consequences of actions, Problem-oriented, or Pluralistic).

I decided to adopt postpositivism (usually associated with answering quantitative questions) and constructivism (associated with answering qualitative questions) in my project based on the assumptions shown above. Postpositivism is associated with determining the major injuries, causes of these injuries, and predictors of in-hospital mortality among older patients with injuries. Whilst constructivism is associated with understanding how Saudi ambulance workers acquire and apply their knowledge to provide improved care for older patients with injuries.

Despite the possibility of associating between two paradigms in mixed-method research, the pragmatism worldview is the most appropriate approach for my research (Creswell and Plano Clark, 2017). Pragmatism represents a set of actions, situations, and consequences rather than using one technique (such as positivism or constructivism) and opens the door to different methods, multiple paradigms, multiple assumptions and different forms of data collected and analysed (Creswell, 2009). Considering this paradigm for the following reasons:

a. Tashakkori and Teddlie (2003) found that most researchers embraced the pragmatism as an optimal paradigm and foundation for their mixed-methods studies.
b. In pragmatism, researchers can mix between deductive and inductive thinking by integrating both quantitative and qualitative investigations in a single research rather than using different paradigms (Creswell and Plano Clark, 2017)
c. This paradigm provides "an umbrella worldview" for mixed-method designs and the best paradigm to integrate results of two approaches into a comprehensive understanding of a problem (according to Creswell and Plano Clark's arguments, 2017, p 69).
d. Pragmatism has more flexibility because it depends on the research question as primary importance rather than either the method or paradigm that underlies this method (according to Tashakkori and Teddlie's arguments, 2003).

3.4 The research methodology and design:

Research requires appropriate methodology, appropriate time and properly chosen methods to be robust (Morse and Field, 1995). The methodology is a research design that shapes selecting and using specific data and analysing these data to answer research questions (Crotty, 1998). Regarding the research design, according to Creswell (2009, p 5), "research designs are plans and the procedures for research that span the decisions from broad assumptions to detailed methods of data collection and analysis". Based on the developed questions of this project, a mixed-methods approach was planned to obtain an in-depth understanding of a research question, integrating "quantitative and qualitative approaches in a study" (Tashakkori and Teddlie, 1998, p. ix). The reasons for undertaking a mixed-methods approach were:

a. Mixed-methods research approach can help to overcome the weaknesses of both quantitative and qualitative research methods (Creswell and Plano Clark, 2017).
b. Mixed methods research provides more evidence than conducting a qualitative study or a quantitative study alone (Creswell and Plano Clark, 2017).
c. Research using mixed methods can provide new insights that go beyond the results of separate quantitative and qualitative studies (Creswell and Plano Clark, 2017).

d. Research using mixed methods provides an opportunity to bridge the often adversarial divide between qualitative and quantitative investigators (Creswell and Plano Clark, 2017).
e. Researchers who employ mixed methods are encouraged to employ multiple paradigms rather than limiting themselves to one or the other (Creswell and Plano Clark, 2017).
f. Using mixed methods is practical because the researcher has the freedom to apply all methods to investigate a research problem (Creswell and Plano Clark, 2017).

Regarding the type of mixed-methods approach, I decided to use the sequential explanatory mixed methods design after comprehensive reading in the core mixed-methods designs recommended by (Creswell and Plano Clark, 2017). I considered this design after determining the philosophical worldview and strategies of inquiry, along with comparing between each design regarding the data collection (timing and purposes of each strand) (Creswell and Plano Clark, 2017). This design was considered due to the following reasons rather than sequential exploratory or convergent mixed-methods designs:

a. This design allows the researcher to obtain a comprehensive understanding of research topic because quantitative data can help identify patterns and trends, while qualitative data can delve deeper into the underlying reasons and explore participant perspectives (Creswell and Plano Clark, 2017).
b. Explanatory designs are two-stage designs which sees quantitative data being used as the basis on which to build and explain qualitative data (Almalki, 2016; Creswell and Plano Clark, 2017). This sequence of methods in this design can be more useful than other designs because starting with the quantitative strand collection may generate further questions for the qualitative study (Almalki, 2016; Creswell and Plano Clark, 2017), although my research address different but related questions.
c. This design uses qualitative analysis to explain quantitative results that include unexpected findings more thoroughly (Terrell, 2012). I planned this sequential design but adopted a pragmatic approach that allowed the analysis to develop in response to the emerging data.

d. My research dictated conducting the quantitative strand first (which adopts the positivism paradigm) followed by the qualitative strand (which adopts the constructivism paradigm). This shifting from the positivism to the constructivism applied only in the sequential explanatory designs (Creswell and Plano Clark, 2017).
e. In this design, data integration occurs in two ways: a) by linking quantitative findings with qualitative data, and b) by combining two sets of results following the qualitative phase according to Creswell and Plano Clark (2017). The second way applied in my research. This was considered due to practical limitations: 1) undertaking two strands using two different sources of data. 2) Starting with the quantitative strand collection might generate further questions to be explored in the qualitative study as happened in my research.
f. Qualitative data can validate or challenge quantitative results, making conclusions more robust when quantitative and qualitative data are combined in this design (Creswell and Plano Clark, 2017).
g. This design is easy to implement and the focus of the research can be maintained by building upon one set of data until addressing the primary question of this research (Almalki, 2016).

Additionally, mixed-methods researchers need to show the notation and diagram of their mixed-methods research (Creswell and Plano Clark, 2017). The notation of this project was: **quan → QUAL** = sequential results with higher emphasis on the qualitative part (**QUAL**) and lower emphasis on the quantitative part (**quan**) due to the inductive nature of the project and lack of research on my topic area (Creswell and Plano Clark, 2017) (**see Figure 3.1**). The qualitative element more strongly aligns with the research question. Hence, this research employed the sequential explanatory mixed methods design with a primary qualitative drive (Creswell and Plano Clark, 2011). This means that the emphasis or primary drive of my research, is placed on the second qualitative strand (Creswell and Plano Clark, 2017), although I conducted the quantitative component first to provide context for the qualitative study and identify issues that could be further explored in the qualitative study.

Figure 3.1: The sequential explanatory mixed-methods design (Creswell and Plano Clark, 2017**)**

After that, I considered the Creswell's identification strategy of research design to determine the framework of this research, using three interrelated components: philosophical paradigms, strategies of inquiry and research methods (Creswell, 2009). Considering these components led to determine the research design and generate the framework for this research (**see Figure 3.2**):

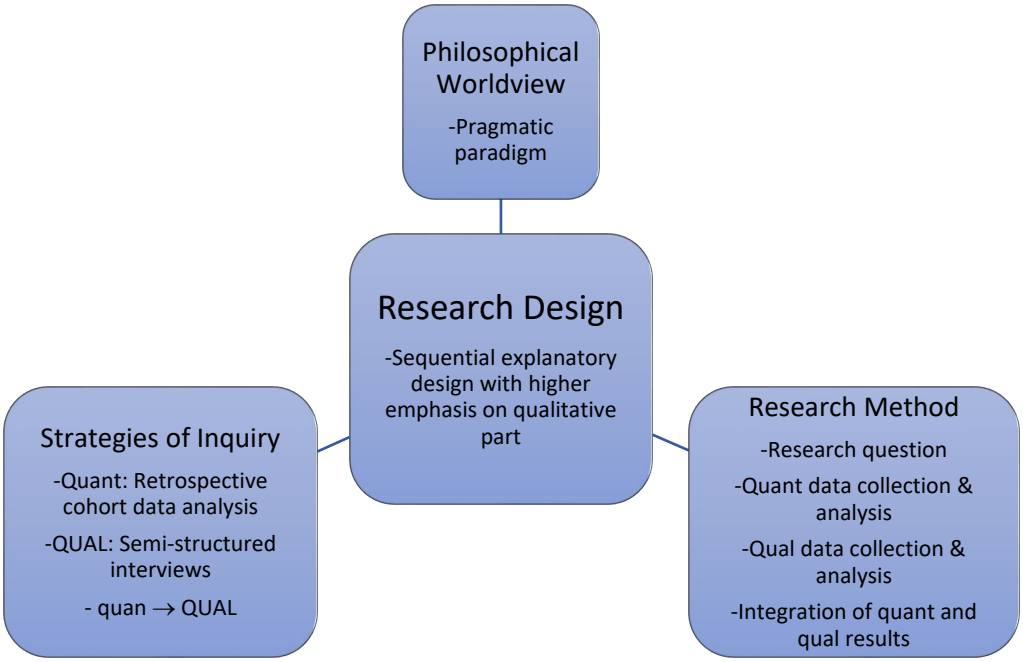


Figure 3.2: The framework of the research (Creswell, 2009): adopted based on my research

3.4.1 First strand: quantitative retrospective study:

There is growing interest in characterising major injuries in older patients and investigating older patient outcomes focusing on hospital settings (Aitken *et al.*, 2010). In the meantime, there is a

shortage of prehospital publications focusing on major injuries in older people and their outcomes. Descriptive quantitative data can represent the first step to improving care and practice in a specific setting. Aitken *et al.* (2010) concluded that research focusing on injury characteristics in older patients and their outcomes might help identify noninjury-related factors that might influence patient outcomes. Retrospective analysis of trauma registry data could provide a relatively efficient way of addressing the research questions within the scope of my PhD project. A prospective study would require a large team, substantial funding, and many years of work. The following sections describes why and how I conducted this quantitative study:

3.4.1.1 The rationale for the quantitative study design:

The retrospective cohort study approach, also known as a medical records review, is a research design in which pre-recorded, patient-transcribed data is reviewed to answer research questions (Vassar and Matthew, 2013). In such reviews, data can be derived from different sources, including electronic databases, diagnostic test results, and clinicians' notes (Vassar and Matthew, 2013). From retrospective studies, real-world evidence could be produced and used to better inform quality improvement, outcomes research, and pharmacovigilance, as well as patient care (Sherman *et al.*, 2016). Such studies that are carried out in clinical settings and use registries and claims data for data collection have broader generalisability because they are conducted in similar settings and patient populations (Sox and Lewis, 2016; Blonde *et al.*, 2018). There are three types of questions that are commonly asked in retrospective studies: descriptive, relational, and comparative (Vassar and Matthew, 2013). The first and second objective of this retrospective cohort study are to describe the prevalence of major injuries among older people (55 years and older) and compare the differences in sub-groups of those patients based on age strata (from descriptive questions). Whilst the third objective is to identify predictors of in-hospital mortality among injured older patients (from a relational question).

Describing injury characteristics can help improve care for older patients through a better understanding of their injuries. Through a better understanding of injuries' distribution and causation, effective strategies have been developed to reduce both injury occurrence and severity and impact (Mackenzie, 2000). Whilst identifying predictors of adverse outcomes helps to translate this knowledge

into care policies and programmes that are acceptable economically, politically, and socially (Mackenzie, 2000). It remains crucial for our understanding of injury mechanisms and patient outcomes to conduct such research describing injuries with using rapidly evolving computerised modelling techniques (Mackenzie, 2000). I hypothesise that the GCS, SBP, pulse rate, and respiratory rate predictor variables can be used as initial field geriatric criteria to reduce undertriage and overtriage and then lead to effectively determine high-risk older patients in Saudi Arabia. This hypothesis is established for two reasons: a) there is no field-triage or bypass tool used by Saudi ambulance workers, as reported by Alharbi *et al.* (2020). Therefore, undertriage and overtriage can then emerge. b) In terms of the basis for this hypothesis, Cull *et al.* (2019) reported that using the GCS, SBP, pulse rate, and respiratory rate measures as geriatric criteria in the prehospital triage led to improve the prediction level in ambulance workers and reduce undertriage and overtriage in older patients with injuries in their state in the US.

3.4.1.2 Quantitative study's setting:

Saudi Arabia has only two level 1 MTCs: the King Abdulaziz Medical City's MTC and the King Saud Medical City's MTC, both located in Riyadh (Alharbi *et al.*, 2020; Alferdaus and Shaher, 2021). This level of care is equipped to care for major injuries, providing comprehensive care for trauma patients 24 hours per day with access to multi-disciplinary staff (Alghnam, Alkelya, *et al.*, 2014). The KSMC has a capacity of 1400 beds and the KAMC has a capacity of 700 beds, making them the largest medical cities in Saudi Arabia and the Middle East (Alquraini, Awad and Hijazi, 2015; Alghnam, Alkelya, *et al.*, 2017; Alharbi *et al.*, 2022). The Riyadh region is the first largest city in Saudi Arabia and the second largest region in its population after the Makkah region (**see Table 3.2**):

Regions	Population(6)	Total area (km2)(25)	Number of MOH* public hospitals (25)	Number of beds in MOH* hospitals (25)	Number of other government hospitals	Number of beds in other government hospitals*(25)	Number of ambulance stations (22)
Riyadh	8,002,100	380,000	47	7937	6	5126	77
Makkah Al-Mokarramah	8,325,304	137,000	41	8457	4	1979	71
Madinah Al-Monawarah	2,080,436	150,000	20	2818	1	205	30
Al-Qassim	1,387,996	73,000	18	2809	0	0	22
Eastern Regions	4,780,619	540,000	35	6161	4	1285	54
Asir	2,164,172	80,000	27	3050	1	609	29
Tabouk	890,922	136,000	11	1220	1	350	21
Hail	684,619	120,000	12	1175	0	0	13
Northern Border	359,235	104,000	9	1310	0	0	12
Jazan	1,533,680	13,000	21	2225	0	0	16
Najran	569,332	130,000	11	1200	1	44	12
Al-Baha	466,384	12,000	10	1165	0	0	14
Al-Jouf	497,509	85,000	12	1770	0	0	13

* (MOH) Ministry of Health; Other government hospitals: include other major health care facilities that are not under the umbrella of MOH such as Universities hospitals, Military and National Guard Medical Cities/hospitals, Security Forces Hospitals, and Royal Commission Hospitals in Jubail and Yanbu.

Table 3.2: The healthcare facilities' characteristics and ambulance stations in Saudi regions (MOH, 2021): The Ministry of Health's Open data can be reproduced without any restrictions

I initially planned to conduct the retrospective study using data from the KAMC registry. I then received data on 259 cases from the KAMC registry that met my inclusion criteria that are clarified later in the subsequent section. Due to this limited sample, I suggested collecting the KSMC registry data so that a multicentre study could be conducted with samples from both registries. I obtained the ethical approval and recruited 452 cases data from the KSMC that met my inclusion criteria in order to add them to the 259 cases data I already had. However, I was unable to use the KAMC data because they refused to allow their data to be used in a multicentre study, so I used the data from the KSMC alone. Alharbi *et al.* (2022) justified that collecting multi-centre data in Saudi Arabia is challenging due to logistical challenges such as comparability, completeness of datasets, some organisations' need for manual data collection and screening. The KSMC registry was originally developed as a prototype for a first national trauma registry in the country (Alsenani *et al.*, 2021).

Table 3.3 outlines the characteristics of the trauma centre I planned to study (KAMC) and the centre I actually studied (KSMC):

Item	***The King Abdulaziz Medical City KAMC's MTC***	***The King Saud Medical City KSMC's MTC***	***References***
Region covered	Riyadh	Riyadh	(Alharbi *et al.*, 2020; Alferdaus and Shaher, 2021)

The Ministry that funds this MTC	The Ministry of National Guard	The Ministry of Health	(Alferdaus and Shaher, 2021)
Capacity of beds and rates of patients admitted annually	A capacity of over 700 beds, including 132 beds in the ED. The ED receives around 32,000 visits annually, of whom 35 % were hospitalised.	A capacity of 1400 beds and this trauma centre receives most of the urgent trauma cases in the Riyadh. It has the busiest ED in Saudi Arabia, exceeding 246000 ED visits annually.	(Alghnam, Alkelya, *et al.*, 2017; Abolfotouh *et al.*, 2018; Alawad *et al.*, 2020; Chowdhury and Leenen, 2021)
The patients who benefit from the healthcare	Provides free healthcare for employees and their families of the Ministry of National Guard, except for patients who are not affiliated with this ministry, unless urgent care is needed.	All trauma patients receive free healthcare regardless of their nationality or occupation.	(Alghnam, Alkelya, *et al.*, 2014; Alawad *et al.*, 2020)
Year of registry establishment and the data collection commencement	The registry was established in 2001, and data collection began in the same year.	The registry was established in 2016, and data collection began in 2017.	(Alghnam, Palta, Hamedani, Alkelya, *et al.*, 2014; Ford *et al.*, 2020; Alferdaus and Shaher, 2021; Alsenani *et al.*, 2021)
The kind of trauma registry database used	-The KAMC'S Department of Surgery considered a standardised data collection sheet to mirror US trauma registries (that use the US National Trauma Data Bank). A research coordinator enters data in the Microsoft® Access 2000 software.	-This trauma centre uses the STAR (Saudi TraumA Registry) database, developed by a partnership with the Alfred Hospital in Melbourne, Australia.	(Alghnam, Palta, Hamedani, Alkelya, *et al.*, 2014; Alsenani *et al.*, 2021)
Registry inclusion criteria	Patients who: a) presented to ED after major injury needing care in a hospital ward or ICU, b) transferred from ED to surgery, c) admitted indirectly (a case asked to return after ED discharge), and d) died after initial assessment in the ED or before arrival.	Patient who are: admitted due to acute physical injuries, died in the ED due to these injuries, admitted for more than two days, admitted to the intensive care unit, or had died in the hospital	(Alghnam, Palta, Hamedani, Remington, *et al.*, 2014; Alghnam, Alkelya, *et al.*, 2017; Ford *et al.*, 2020; Alferdaus and Shaher, 2021; Alsenani *et al.*, 2021)

Table 3.3: The characteristics of the KAMC and KSMC major trauma centres and trauma registries

Abolfotouh *et al.* (2018) reported the characteristics of trauma patients who were received by the KAMC ED focusing on all age groups and identified predictors of hospital mortality among trauma patients (Abolfotouh *et al.*, 2018). In this Saudi research, researchers focused on 3,876 patients

(included 401 older patients who have 65 years and older) admitted to the ED through three years. Most of those trauma patients were exposed to MVCs (52.0 %), followed by the fallers (25.8 %), who represented one-fourth of all injuries. Additionally, 77.5 % of those patients were male compared to female patients. Injuries more frequently involved younger patients (aged 15 to 45 years old = 2104 cases) than older patients (65 years old and over = 401 cases) (Abolfotouh *et al.*, 2018). Age, mechanism of injury and injury severity were predictors of in-hospital mortality (Abolfotouh *et al.*, 2018).

However, it was important to show the implications of these findings for my research. Firstly, it was worth noting that most of the recruited patients were younger patients (from 15-45 years old) who have represented more than half of the included patients compared with older patients. Therefore, my research focused on only older patients, describing their injuries more comprehensively than previous research and identifying predictors of hospital mortality among only geriatric patients. My research is the first study to address these objectives in Saudi Arabia. Secondly, the researchers focused on only patients who were admitted for three years. In terms of older patients, choosing this period led to an insufficient sample size (401 older cases) that may influence the generalisability of older patients' findings in Saudi Arabia. Thus, my research strived to include a sufficient sample size while focusing only on older patients with injuries.

3.4.1.3 Quantitative research population:

I have planned to recruit older patients (aged ≥ 55 years) who were transported to the MTC by ambulance workers from 1 January 2011 to 31 December 2020 in Saudi Arabia. The reason for defining older patients from 55 years and over is that there is no determined age cut-off for defining them in Saudi Arabia. One recent paper also recommended that older trauma patients (55 years and over) be defined as older patients in future investigations and treatment guidelines to enhance patient outcomes (Fakhry *et al.*, 2021). Fakhry *et al.* (2021) have noticed that mortality rates starts to increase at age 55 after conducting their multi-centre research (Fakhry *et al.*, 2021). The sample inclusion and exclusion criteria are presented in **Table 3.4**. All these following inclusion criteria were considered to include older patients in this study:

Inclusion criteria	*Exclusion criteria*
-Including patients aged ≥ 55 years. -Older trauma patients transported from the scene by ambulance, including those who were transferred from non-trauma hospitals to the trauma hospital and were transported by ambulance from the scene to non-trauma hospitals. - Older patients admitted between 1 January 2011 to 31 December 2020 or died after arrival to the ED.	-Patients aged lower than 55 years old (younger and paediatric patients) -All older patients who were not initially transported from the scene by ambulance services. -Deaths occurred before arrivals to the trauma centre.

Table 3.4: The inclusion and exclusion criteria for the retrospective study sample

3.4.1.4 Quantitative data collection:

Table 3.5 below shows where the database is located, who is responsible for the database, who records the data, how the data are recorded, and any checks on data accuracy, how derived data, such as Abbreviated Injury Score AIS and ISS, are calculated, in the two trauma centres:

Item	*The King Abdulaziz Medical City KAMC's MTC*	*The King Saud Medical City KSMC's MTC*	*References*
Where the database is located	The database is located in the KAMC MTC.	The database is located in the KSMC MTC.	After contacting the persons who are responsible for each database.
Who is responsible for the database	The database under the responsibility of Dr Suliman Alghnam who is affiliated in the King Abdullah International Medical Research Center KAIMRC which is located in the KAMC.	The database under the responsibility of Dr. Sharfuddin Chowdhury who is the director of the Research Center which is located in the KSMC.	After contacting the persons who are responsible for each database.
Who records the data	An ED nurse who gathers and records the data using a structured checklist. The completed checklists will then be collected by a trained research coordinator who will then enter the data into the database.	An ED nurse gathers data using an official form. A trained data collector will then come to the ED to screen and collect data from such completed forms and enter the data into the database.	(Alghnam, Palta, Hamedani, Remington, *et al.*, 2014; Ford *et al.*, 2020; Alsenani *et al.*, 2021), and by the persons responsible for the databases.
How the data are recorded	At the end of each day shift, a trained research coordinator will attend the ED and screen the data through and check the completed checklists in order to include cases who meet the registry's eligibility criteria. The	A trained STAR data collector: 1) screens all ED trauma patients in ED; 2) enrolls them according to inclusion & exclusion criteria; 3) fills all STAR Case Report Forms; 4) follows up patients during their	After contacting the persons who are responsible for each database and checking the documents attached with the obtained ethical approvals

	research coordinator will then check the data before entering the database.	stay and after discharge to complete all forms; 5) enters all paper forms to the system; 6) after discharge, codes all injures by the AIS to complete the case.	explaining how data are recorded.
Any checks on data accuracy	The research coordinator is trained at the KAIMRC to ensure that all data is eligible, complete, and validated, and to track missing data before entering it into the registry database.	Once the trained STAR data collector data for each included trauma patient, he/she will verify for missing or incomplete data through the records. The Research Centre trains data collectors on understanding the registry, collecting data, and entering data accurately and efficiently.	(Alghnam, Alkelya, *et al.*, 2014; Ford *et al.*, 2020), after checking the documents attached with the obtained ethical approvals explaining how data are recorded.
How derived data, such as AIS and ISS, are calculated	-The AIS is calculated using AIS codes; (AIS 2005-updated 2008 version) (1 minor/2 moderate/3 serious/4 severe/5 critical/6 maximal). The ISS is derived from the AIS. -The AIS categorises the body into six regions (head and neck, face, chest, abdomen, extremities, and external structure), and assigns a score for each region. The three most severely injured regions then are squared and summed to calculate the ISS. -The ISS range from 0 to 75: (1-8 minor, 9-15 moderate, 16-24 severe, 25-75 very severe).	-After discharge, the AIS is calculated by a trained data collector using AIS codes; (AIS 2005-updated 2008 version) (1 minor/2 moderate/3 serious/4 severe/5 critical/6 maximal). The ISS will then be calculated as the sum of the squares of the three highest AIS severities from the three most severely injured body regions. -The ISS is from 1 to 6: minor, moderate, serious, severe, critical, and maximal. - An ISS > 12 or death from injuries is coded as major trauma on the database.	(Alghnam, Alkelya, *et al.*, 2014; Palmer, Gabbe and Cameron, 2016; Alharbi, Miller and Lewis, 2019; Alsenani *et al.*, 2021; Al Babtain *et al.*, 2022; Alghnam *et al.*, 2022), after checking the documents attached with the obtained ethical approvals showing how the AIS and ISS are calculated.

Table 3.5: The description of the registry data collection and management

Moreover, it is important to describe what data are collected. Alghnam, Palta, Hamedani, Remington, *et al.* (2014) stated that an ED nurse and a trained researcher coordinator in the KAMC's MTC use a structured checklist that includes demographic, anatomic, physiologic, and outcome variables for eligible cases. While the KSMC ED's data collector fills out the STAR Case Report Forms for all eligible cases, including the patients' sociodemographic, injury characteristics, prehospital and in-hospital physiologic variables, and other hospital variables (Alharbi, Miller and Lewis, 2019).

3.4.1.5 Quantitative data management:

The two registries have provided me with two documents showing the variables they gather before applying for their ethical approvals. Consequently, I decided which variables to collect from the included retrospective studies of the scoping review (that was conducted in the second chapter). I then checked whether all variables were available in each of the KAMC and KSMC registry forms. There is a shortage of knowledge regarding the variables that can influence the outcomes of geriatric patients with injuries in research compared with research focusing on younger patients (Giannoudis *et al.*, 2009; Kirkman *et al.*, 2013). In comparison between the KAMC and KSMC registry forms, some variables are collected in one database but not in the other. I identified that the KAMC registry does not gather prehospital data, so they consider the first ED physiological data, whereas the KSMC registry considers prehospital and in-hospital data. **Table 3.6** shows the selected variables I have planned from the KAMC and the variables I have actually studied from the KSMC:

The selected variables from the KAMC		***The selected variables from the KSMC***	
Categories	***Variables***	***Categories***	***Variables***
Demographic variables	Age subgroups: (55-64, 65-74, 75-84 and 85 and older) Sex: (male or female) Admission to the MTC ED: Transport mode: (ground ambulance). Reason for admission: (diverted from another hospital, medical direction, nearest hospital, patient or family request, patient physical request, transfer, trauma protocol or others). Transport time: (30 min or less VS more than 30 min) (Cox *et al.*, 2014). By: (the time between injury date & time VS ED arrival date & time). Admission types: (direct, referred or others). Trauma team activation: (yes or no)	Socio-demographic variables	Age subgroups: (55-64, 65-74, 75-84 and 85 and older) Sex: (male or female) Direct or indirect transport times to MTC: (<60 min VS ≥60 min) (Meyers *et al.*, 2019) By: (measuring the time between red crescent ambulance departure time from scene to the MTC arrival time). (Direct means transport from scene to MTC & indirect means transports from scenes to the non-trauma hospital to MTC). Prior facilities: Number of prior facilities: (No prior facilities, one prior facility, or two prior facilities) Hospital destinations: (Direct to the MTC or indirect to MTC) (Brown *et al.*, 2019).
Anatomic variables	Trauma characteristics: Injury type: (head, neck, chest, abdomen, spine or extremities) Injury date & time	Injury characteristics	Injury cause (mechanism of injury): fall-high (more than 1 metre), fall-low (same level or lower than 1 metre), fire, flames or smoke, cutting or piercing object,

	ED arrival date & time Mechanism of injury: (blunt, penetrating, burn, foreign body, poisoning/intoxication or others). ISS: (0-8 minor, 9-15 moderate, 16 or over) (Newgard *et al.*, 2016).		motor vehicle accidents, motorcycle, pedestrians, struck by or collision with person or object) Affected body parts: (head, neck, thorax, abdomen, lower back, lumbar spine or pelvis, hip or thigh, extremities, burns to external body surfaces or injuries to multiple body areas).
Physiologic variables	SBP: (mmHg) Heart rate: (b/m) Respiratory rate: (b/m) GCS scores: (15, 14, 13 or < 13) (Caterino, Valasek and Werman, 2010; Hon *et al.*, 2020). Comorbidities: (congestive heart failure CHF, smoking, cerebrovascular accident CVA, diabetes mellitus DM, myocardial infarction MI, hypertension, obesity, respiratory disease, others or none) (Benjamin *et al.*, 2018).	Prehospital variables	Ambulance arrival date and time at scene: (DD/MM/YYYY HH:MM) First SBP at scene: (mmHg) First heart rate at scene: (b/m) First respiratory rate at scene: (b/m) Mental status at scene (AVPU acronym): Alert, Verbal (response to voice only), Painful (response to pain), Unresponsive, or Unknown or not collected).
		In-hospital variables	Mode of arrival: (Red Crescent ambulance, government ambulance, private ambulance, or unknown or not documented). Data and time of arrival to ED: (DD/MM/YYYY HH:MM) Trauma team activation: (yes or no) ED- first SBP: (mmHg) ED- first heart rate: (b/m) ED- first respiratory rate: (b/m) ED- first GCS scores (total): (15, 14, 13 or < 13) (Caterino, Valasek and Werman, 2010; Hon *et al.*, 2020). ISS: (0-8 minor, 9-15 moderate, ≥16 serious) (Newgard *et al.*, 2016)
Outcome variables	In-hospital mortality: (yes or no). Hospital length of stay: (weeks). Complications: (acute respiratory distress syndrome, cardiac arrest, coagulopathy or disseminated intravascular coagulation, compartment syndrome, hemothorax or pneumothorax, fat embolism, hypothermia, major arrhythmia, pressure sore, pulmonary edema, pulmonary embolism, renal failure, respiratory arrest, sepsis, shock, stroke CVA, thrombosis, wound infection, others or none).	Outcomes	Disposition from definitive care (in-hospital mortality): (yes or no) Length of stay in hospital: (days)
Note: The lists of domains for each proposed variable in this table were identified from the KAMC and KSMC registry dictionaries, then aligned with papers from the scoping review that studied the same variables.			

Table 3.6: Data variables collected from the KAMC and KSMC trauma registries

When I considered the KSMC registry's variables dictionary, I identified that they were slightly different from the variables of the previous trauma registry (**as shown in the table 3.6**). The KSMC's Research Center provided these data in an Excel spreadsheet along with other documents such as the ethical approval, instructions, variables' dictionary, etc. I received anonymised data, and each case was assigned a unique ID. I then saved all data on my laptop and the university of Sheffield's drive with a password that only I could access.

3.4.1.6 Outcome of interest:

I planned that the primary outcome is the in-hospital mortality, including deaths in the ED (who died after arriving alive in the ED and had baseline vital signs) or during the hospital stay. I also planned to analyse the injury severity score ISS as a secondary outcome, because predicting ISS could identify patients who need MTC care.

3.4.1.7 Quantitative data analysis:

The quantitative data analysis was undertaken after obtaining the ethical approval and data from the KSMC from December 2021 until April 2022. SPSS version 27 (IBM SPSS Statistics for Mac, IBM Corporation) was used as statistical software for this analysis. The KSMC trauma registry data were analysed using descriptive statistical approaches to address the objectives of this quantitative stage (**as shown in the Table 3.1**). While I sent the KSMC my inclusion and exclusion criteria, they sent me data for all cases (55 years and older) admitting to the KSMC ED by any means of arrival, not just ambulances. These received cases were then sorted into two groups based on the study's inclusion and exclusion criteria: a) a group of the eligible cases that met all of my inclusion criteria against b) a group of the excluded cases. I addressed the first objective, which is a descriptive analysis of these eligible and excluded older patients using age, sex, mechanism of injury, in-hospital mortality, ISS, and length of hospital stay variables. At this stage, I calculated 95% confidence intervals for the key descriptive variables. Particularly, I planned to explore major trauma in older patients using different strata of age. I decided to do this to facilitate characterising major injuries in older patients in Saudi Arabia and explore whether characteristics of these injuries become clearer as age strata increases.

Addressing the second objective which is a descriptive analysis of subgroups based on age strata, was also included while addressing the first objective since the age variable in each of the eligible and excluded cases were divided into 10-year age intervals (55 to 64, 65 to 74, 75 to 84 and 85 and older). I compared the subgroups of older patients with injuries by presenting data with (mean, median and mode, maximum, and minimum values) for continuous variables and proportions for categorical variables and used confidence intervals.

Before addressing the third study objective which is the analysis of predictors of outcome, I identified the patterns of missing data and handled the cases that had missing data. Identifying and handling the missing data will be described in detail in a subsequent section. The data analysis was undertaken using descriptive univariate analysis followed by multivariable logistic regression. I planned to undertake a univariate analysis to explore whether there are any associations between the patient characteristics and death followed by exploring any associations between patient characteristics and ISS. Some relevant studies analysed the ISS as a dichotomised outcome ISS≥16. For instance, Hoyle, Biant and Young, (2020) evaluated an in-hospital triage of severely injured patients (ISS ≥16) who were admitted primarily to the MTC in UK, comparing between older and younger trauma patients. They concluded that older patients are more likely to be undertriaged than younger patients, even in MTCs, due to lack of early recognition of severe trauma and lack of appropriate triage (Hoyle, Biant and Young, 2020). After that a binary logistic regression modelling was then undertaken after selecting predictor variables that showed a $p<0.2$ association with death.

I then conducted a secondary analysis to identify whether the predictive association of these continuous prehospital variables such as (SBP, pulse rate, and respiratory rate predictor variables) with the outcome variable differs between the strata by repeating the multivariable analysis in each age strata. This was to examine if I obtained different results in different strata with taking into consideration that I may face insufficient statistical power if there are small numbers of outcomes (in-hospital mortality) in each age strata. This multivariable analysis was undertaken since I hypothesised that these prehospital predictor variables can be used as initial field geriatric criteria to help adopting initial Saudi prehospital triage tools for identifying major trauma older patients in the future. I did not include the GCS in this analysis since the KSMC registry did not gather prehospital GCS scores.

3.4.1.8 Analysis of the continuous variables:

I planned to plot histograms for each continuous variables to check the data distribution. I then planned to explore whether continuous variables that may have a monotonic or complex association with the outcome variable. For example, the age variable can have a simple monotonic association with mortality (mortality increases = age increases). Therefore, I planned that in this situation, the age will be considered as a continuous variable in all analysis. However, some physiological variables can have a complex U-shaped association with the outcome (e.g. tachycardia or bradycardia can be associated with mortality). In these kinds of variables, I also planned that data will be categorised by deciles (D1, D2, D3,…D10) arranged orderly from the lowest decile to the highest decile. Therefore, for a U-shaped association, I planned to create categories reflecting the U-shape and then use a categorical analysis to better predict the outcome of interest.

A descriptive univariate analysis was then be performed on the chosen variables to help to identify variables that should be then included in a multivariable logistic regression model in order to address the third objective. I also planned to identifying predictor variables by the "purposeful selection of covariates" approach recommended by Hosmer and Lemeshow (2013), used when analysts face a lot of variables. The reason for their recommendation is "the more variables in a logistic model, the greater standard errors become, and the more dependent the model becomes the observed data (Hosmer and Lemeshow, 2013, p. 90).

Hosmer and Lemeshow (2013) also advised using 0.20 or 0.25 as a conservative level of significance in the initial screening selection of predictor variables to the multivariable logistic regression, as Mickey and Greenland (1989) also recommended. For my research, I used a level of significance (0.20) to select variables into the model. However, Hosmer and Lemeshow (2013) indicated that after the initial inclusion of important variables, the analyst should review the added variables to the model before the final decision to ensure excluding any disadvantaged variables (Hosmer and Lemeshow, 2013). After that, a multivariable logistic regression was applied to determine the predictors of in-hospital mortality among older patients with injuries (the third objective of this strand). This stage evaluated the association between identified variables and the outcome variable (in-hospital mortality as a dichotomous variable). The results were reported as odds ratio OR with 95 Cl. A p-value <0.05 was considered statistically significant.

3.4.1.9 Handling the missing data:

It is known that any observational study has missing data that can influence data quality. Data can be missed due to three reasons: a) missing completely at random MCAR (when observations are not documented due to an issue in the registry system), b) missing at random MAR (when missing values rely on other observed values in the dataset), and c) data can be missing not at random MNAR (if a missing variable relies only on that variable, and not any other recorded variables) (Shivasabesan, Mitra and O'Reilly, 2018).

It was difficult to determine which mechanism of these three mechanisms might cause missing data in my data collection. Therefore, assumptions must be made regarding the reasons for missing values during identifying missing data and before dealing with any missing data (Shivasabesan, Mitra and O'Reilly, 2018). Dealing with missing data can be done by complete case analysis (excludes observations with missing data), single imputation, or multiple imputations (Haukoos and Newgard, 2007). However, Shivasabesan, Mitra and O'Reilly (2018) conducted a systematic review concerning missing data issues in trauma registries. They found 70.7 % of 331 manuscripts dealt with missing data by the complete case analysis approach (Shivasabesan, Mitra and O'Reilly, 2018). This suggested that considering and prioritising this method in my study rather than other techniques that can also be considered when needed.

Shivasabesan, Mitra and O'Reilly (2018) also have shown the range of missingness in the following variables in 331 manuscripts (**see Table 3.7**):

Variable	Range of missingness (%)
Race/Ethnicity	0.0–44.6
Age	0.0–2.7
Gender/Sex	0.0–2.8
Insurance status	2.4–33.5
ED Glasgow Coma Scale	0.0–57.0
ED Blood Pressure	0.3–42.3
Mechanism/Cause of Injury	0.0–27.8
Injury Severity Score	0.0–27.0
Mortality	0.0–30.0

Table 3.7: The ranges of missing data in variables in 331 manuscripts used trauma registries:

reproduced from Shivasabesan, Mitra and O'Reilly (2018), with permission from Elsevier in accordance with an agreement (license no. 5590510927998) and conditions provided by the Elsevier and Copyright Clearance Center

I planned to evaluate for missing data while conducting the univariate analysis. According to previous research were conducted using the KAMC trauma registry, the variables (such as mode of transportation, GCS, SBP, ISS and respiratory rate) had missing data (Alghnam, Alkelya, *et al.*, 2014; Alghnam, Palta, Hamedani, Alkelya, *et al.*, 2014; Alghnam, Palta, Hamedani, Remington, *et al.*, 2014; Aljerian *et al.*, 2018), (**see Table 3.8**):

The variables with missing data	***Saudi studies***	***Sample size & age of patients***	***Rates of missing data***
Mode of transportation	(Aljerian *et al.*, 2018)	493 patients & all patients ≥16 years old	0.2 %
GCS	(Aljerian *et al.*, 2018)	493 patients included & all patients ≥16 years old	2.6 %
SBP	(Alghnam, Alkelya, *et al.*, 2014)	10 847 patients & all ages	3.2 %
	(Alghnam, Palta, Hamedani, Remington, *et al.*, 2014)	5290 patients & all ages	0.7 %
ISS	(Alghnam, Alkelya, *et al.*, 2014)	10 847 patients & all ages	0.1 %
	(Alghnam, Palta, Hamedani, Remington, *et al.*, 2014)	5290 patients & all ages	0.1 %
	(Alghnam, Palta, Hamedani, Alkelya, *et al.*, 2014)	5352 patients & all ages	N/A in %, (only 6 patients had missing ISS data)
Respiratory rate	(Alghnam, Alkelya, *et al.*, 2014)	10 847 patients & all ages	3.2 %

Table 3.8: The missing data for variables from the previous KAMC research

These low proportions of missing data in the Saudi studies also supported my previous suggestion to use the complete case analysis approach. Therefore, I planned that any cases with a missing predictor

variable or missing outcome variable should be excluded. However, receiving limited data from the KSMC influenced this plan. After gathering 452 eligible cases, I then investigated patterns of missing data and identified 135 cases out of these that had missing data. I then excluded 4 cases with the highest numbers of missing data and imputing the rest to avoid excluding many cases, leaving 448 cases. As I clarified in the first chapter, the Saudi Ministry of Health estimated that about 72 % of Saudi Arabia's population is young (15-64), 3.5 % are older (65 years and older), and 24.5% are people under 15 years old (MOH, 2021). Older people represent a smaller percentage of the population than younger people in Saudi Arabia. This can explain the lack of data that I collected from the KAMC registry and then from the KSMC's registry, lower than I expected.

Further, it can be useful to show the rates of variables' missing data of a trauma registry's publications prior to conducting an observational study as I did in **the Table 3.8**. Shivasabesan, Mitra and O'Reilly (2018) indicated that such reporting can help in determining trauma registry missingness levels, the most appropriate technique to deal with missing data, and the level of data completeness in reporting variables among publications when analysing data of similar registries. However, it is noticed that the missing variable rates from the KAMC were only used because no such data have been published from the KSMC.

3.4.1.10 The relationships between the continuous variables and the outcome variable:

After planning my retrospective cohort study, I clarified what the relationship would be between continuous predictor variables (such as age, SBP, heart rate, respiratory rate and GCS) and outcome variable (in-hospital mortality) for a multivariable regression model. Age has a strong relationship with increased rates of in-hospital mortality. According to Benjamin *et al.* (2018), the age (≥ 60 years old) was identified as a significant independent predictor of in-hospital mortality. Regarding the following variables (SBP, heart rate, respiratory rate, and GCS) for older patients, these variables have a complex relationship with adverse outcomes. One study conducted in North Carolina, US, found that despite implementing new field-triage guidelines for guiding transport decisions and reducing undertriage, older patients still suffer from the undertriage issue (Meyers *et al.*, 2019). As Meyers *et al.* (2019) noted, ambulance workers underestimated injuries in older patients with hypotension, low GCS, abnormal heart rate, and abnormal respiratory rate, leading to adverse outcomes. Also, they

undertriaged injuries of older patients who had injury occurred less than 60 minutes from an MTC and a much more significant problem among those living more than 60 minutes from an MTC (Meyers *et al.*, 2019). This means ambulance workers themselves can cause the undertriage issue. Also, this means that there is a more complex relationship between more than one continuous predictor variable (such as vitals) and the outcome variable.

3.4.1.11 The sample size estimation for the retrospective cohort study:

The sample size was determined by the number of eligible cases in the registry. The sample size should usually be determined by the planned analysis, which would involve balancing the needs to optimise the precision of estimates against the time and resources required to maximise the sample size. The use of registry data limited my control over data collection and thus the sample size. I maximised the sample size by using all the available data but I could not increase the sample size further by doing more data collection. The precision of estimates in the descriptive analysis was determined by the number of cases in each sub-group analysed and the proportion with the adverse outcome. A major limitation of the registry-based design is that I cannot ensure that the sample size has sufficient power to support the planned multivariable analysis.

According to Riley *et al.* (2019), a sample size requirement for the development data set must be considered by researchers when planning a study for the development of a new multivariable prediction model. In case of calculating the required sample size and compare it with actual sample size, I considered the 'rule of thumb' approach. This approach is recommended by Riley *et al.* (2019) to have at least 10 events per candidate predictor (variable) (Peduzzi *et al.*, 1996), where 'candidate' refers to a predictor that is considered before any variable is selected for inclusion in the final model (Riley *et al.*, 2019) as follows: 17 predictor variables that were considered in order to cross-tabulate them with the outcome of interest (in-hospital mortality), multiplied by 10 = 170 (minimum sample size required) (Peduzzi *et al.*, 1996; Riley *et al.*, 2019). The number of events (which refers to the cases in which the outcome occurs) = 26 (Peduzzi *et al.*, 1996), that did not exceed the minimum sample size.

3.4.2 Second strand: qualitative study:

The qualitative methods are increasingly used in healthcare research because they can provide insights into people's beliefs, attitudes, behaviours, and interactions (Kalra, Pathak and Jena, 2013). Health issues can be better understood through qualitative studies when they are combined with quantitative measures (Kalra, Pathak and Jena, 2013). This strand addressed four questions that were formalised before conducting this study, along with a fifth objective emerged from the retrospective cohort study (**as shown in the Table 3.1**). The following sections describes why and how I conducted this qualitative study:

3.4.2.1 The rationale for the qualitative study design:

In the first chapter, it was stated that ageing changes affect the quality of prehospital trauma care and patient outcomes for older patients (Scheetz, 2010, 2012). This chapter presented a narrative review that clarified the importance of identifying how ageing changes impact prehospital care and patient outcomes and exploring ambulance clinicians' awareness. The scoping review identified five research themes, including paramedic awareness of ageing impacts, paramedic decision-making, and paramedic behaviours in response to older trauma patients. Based on the included literature, the scoping review concluded paramedics' awareness of the ageing impacts, the EMS decision-making process, and their behaviours towards older patients needs to be investigated. Therefore, the qualitative study's first objective was created to explore the Saudi paramedics and EMTs' understanding of the impacts of ageing changes on the prehospital trauma care and patient outcomes.

To explore the research issue more thoroughly, I then intended to explore how Saudi paramedics and EMTs acquire and apply their knowledge as a second study objective. According to a US qualitative study included in the scoping review, paramedic decision-making and knowledge application in elderly falls were considered by scholarly investigations (Simpson *et al.*, 2017). Simpson *et al.* (2017) found that paramedics make decisions and apply knowledge based on their perceptions and cultural norms regarding elderly falls as low acuity (not as serious or important), which shape their judgment regarding transportation decisions. This emphasises the significance of exploring paramedics' learning, subjective knowledge and understanding the implementation of their knowledge in a unique local culture.

Identifying barriers and facilitators to providing improved care for older patients with injuries were then considered as third and fourth study objectives. I intended to identify what conditions and needs the Saudi paramedics' and ambulance technicians require to facilitate their application of knowledge and to assist them in providing optimal care for older trauma patients. Research indicated that identifying barriers and facilitators to providing optimal care for older patients can help set minimum care standards and adopt protocol-based care pathways (Rath *et al.*, 2017). It also helps identifying practice gaps by comparing current practice with recognised best practice standards and adopting best practice to develop strategies for implementing evidence-informed protocols (Chaplin, 2008; Proctor, Powell and McMillen, 2013). The fifth and last study objective emerged from the quantitative study, which explores whether the Saudi ambulance clinicians' perceptions of trauma victims align with the cohort's characteristics and whether they recognise the difficulty of predicting death in older trauma victims. This objective came under the impacts of conducting a quantitative study prior to a qualitative study and facilitating integration of the quantitative and qualitative findings.

3.4.2.2 The qualitative study approach:

To conduct a qualitative study, there are numerous different approaches and each approach has a different range of epistemological, theoretical, and disciplinary perspectives (Guest, G., MacQueen, K. & Namey, 2012, p.3). Choosing the best approach should be guided by the objectives and questions of the research (Parkinson *et al.*, 2016). After reading about different qualitative approaches, I identified that the most widely used qualitative approaches appeared to be grounded theory (Strauss and Corbin, 1990), framework method (Gale *et al.*, 2013; Hackett and Strickland, 2019), or thematic analysis (Braun and Clarke, 2006; Braun and Clark, 2013), recognising overlap between specific different qualitative approaches (Holloway and Todres, 2003). **Table 3.9** summarised the purposes, advantages, and disadvantages of these three qualitative approaches and guided me in selecting the suitable approach for this study:

Qualitative approach	***Purpose***	***Advantages***	***Disadvantages***

Grounded theory	- A theory developed from the perspectives of many participants regarding a process, action, or interaction (Strauss and Corbin, 1990).	- Creatively, conceptually, systematically, and richly, it provides depth and richness to data analysis (Hussein *et al.*, 2014).	- Theories are difficult to define or categories are difficult to identify when they are saturated (Creswell, 2018). - Methodological errors are common in grounding theory because it involves multiple approaches (Hussein *et al.*, 2014). - Coding can be challenging to inexperienced researchers, and the process can take a long time and be laborious (Myers, 2009).
Framework method	- Identifying and comparing qualitative data that reveals how they differ and how they are related, followed by drawing conclusions about them (Gale *et al.*, 2013).	- It facilitates the analysis of data for novice researchers in a systematic and flexible manner (Hackett and Strickland, 2019). - It facilitates continuous comparisons, and can be used by non-experts for data analysis (Gale *et al.*, 2013). - Researchers who are novices or experts will benefit from the strengths of this research software, which outweigh the challenges it presents (Hackett and Strickland, 2019).	- The method takes a lot of time and resources, and is not capable of analysing all types of qualitative data (Gale *et al.*, 2013). - It can be difficult to construct a theoretical framework and summarise ambiguous data sets. - Successful application of this approach requires qualitative analysis training and IT skills. - Training in qualitative analysis is recommended for researchers unfamiliar with the technique. - Ensure novice researchers receive the appropriate guidance and support by finding supervisors with framework experience. (Hackett and Strickland, 2019).
Thematic analysis	- Presents the data in depth and organises it minimally by analysing and reporting patterns (themes) (Braun and Clarke, 2006).	- Researchers without previous experience can use this method due to its ease of learning and flexibility and using it may be useful for summing up or describing a large dataset in more detail. - It highlights similarities and differences between data sets, provides unexpected insights, and informs qualitative discussions. (Braun and Clarke, 2006).	- An inadequately defined (limited) and little-recognised analytical method. - The difficulty of developing high-phase analysis guidelines can paralyse researchers. - It's difficult to maintain continuity and consistency across individual accounts, and contradictions can reveal something about the individual. (Braun and Clarke, 2006).

Table 3.9: Comparisons between the most widely used approaches in qualitative research

When these approaches were compared, I first decided to exclude grounded theory approach. Because it was not advised to be conducted by novice researchers as using it by them can lead to more methodological errors, be time-consuming, may have difficulties in achieving the data saturation and generating theories (Myers, 2009; Hussein *et al.*, 2014; Creswell, 2018) (**as shown in the Table 3.9**). Since the framework analysis and thematic analysis were slightly different approaches, I compared between them and found the framework method is more appropriate. The reasons were: 1) it fitted the objectives of this study as it can contribute to improve the health services and develop the healthcare policies if implemented appropriately (Gale *et al.*, 2013). 2) It is pragmatic in applied policy research that fits the pragmatic question of this PhD research (Ritchie J, 1994). 3) Framework method is recommended to be applied when a study includes a well-structured data collection approach and study objectives that were set in advance and shaped by specific information needs as I considered in my study (Pope, Ziebland and Mays, 2000). 4) It provides a clear systematic process for managing and mapping large sets of data by using a matrix form in order to provide intuitively structured summarised data (Gale *et al.*, 2013). 5) It is the most appropriate approach for analysing interview data because it can be employed to produce comparisons within and between the cases (Gale *et al.*, 2013).

I then had to consider the most appropriate data collection method, considering direct elicitation methods (e.g. interviews or focus groups) or indirect elicitation methods (e.g. non-participant observation). **Table 3.10** shows the advantages and disadvantages of each method:

Methods	***Advantages***	***Disadvantages***	***References***
Individual interviews	-Researchers using thematic and framework analysis most commonly used interviews as qualitative methods. -It is applied to a variety of qualitative methodological approaches. -It enables to gain in-depth understanding of perspectives, feelings, beliefs, and motivations. -Interviews can be conducted digitally when the researcher and participant are in different locations.	-During digital interviews, the interviewer and researcher might not see each other via phone, skype, or other means. -Researchers and participants may experience weak internet connections during online interviews. -Participants' perceptions of reality may differ from those witnessed, so researchers can present only reports of practice, not observations of it.	(Gill *et al.*, 2008; Burges Watson *et al.*, 2012; Gussy, Dickson-Swift and Adams, 2013; Oltmann, 2016; Gill and Baillie, 2018; Busetto, Wick and

	-Researchers' ability to conduct a quality interview is dependent on training and preparation -It is easier to recruit paramedics individually since they are under institutional time pressure.		Gumbinger, 2020)
Focus groups	-In thematic and framework analysis research, focus groups are the second most commonly used qualitative method after interviews. -They are used to explore collective perspectives, attitudes, behaviours, and experiences. -Focus groups include opposing opinions and differing viewpoints on a research topic. -The key to a successful focus group is interaction, which means a preexisting group or stranger groups is best. -Groups with shared experiences are easier to recruit and often have a comfort and familiarity that facilitates discussion and challenge. -Paramedic groups can present preliminary results first, and researchers can incorporate feedback in final interpretations.	-The number of participants makes them difficult to organise and manage, and they can be inappropriate for sensitive topics -Having a small group may limit discussion, while having a large group could lead to disorganisation. -Group power imbalances and existing group norms and hierarchies may adversely affect participants' ability to speak freely. -Focus groups need two researchers should participate: a moderator and an observer. -Data storage, informed consent, and appropriate access can be ethical challenges associated with online focus groups. -Good interpersonal skills and management skills are required to moderate a focus group.	(Kevern and Webb, 2001; Gill *et al.*, 2008; Burges Watson *et al.*, 2012; Gussy, Dickson-Swift and Adams, 2013; Gill and Baillie, 2018; Busetto, Wick and Gumbinger, 2020)
Observation of practice	-Anthropological studies have a long history of participant observation. -A researcher observes a situation and records what he or she observes at the same time -It helps in obtaining unique insights into an organisation or social group. -Observation of practice is useful for gaining insight into a certain setting and actual behaviour. -Each observation is, in a sense, unique and unrepeatable. -Gaining deeper insights into the real-world dimensions of a research problem and decreasing the distance between the researcher and the researched.	-One of the less commonly used approaches. -Healthcare research can be hindered by an ambulance paramedic's chaotic, disorganised, and dangerous work environment. -Gaining access and establishing his/her role within the organisation or social environment can be challenging. -A researcher must spend a considerable amount of time in the field and study the phenomenon in its cultural and social context. -Observations in data may inevitably include those who have consented and others who have not consented by chance.	(Grim *et al.*, 1989; Mulhall, 2003; Iacono, Brown and Holtham, 2009; Burges Watson *et al.*, 2012; Gill and Baillie, 2018; Busetto, Wick and Gumbinger, 2020)

Table 3.10: Comparison between individual interviews, focus groups and observation of practice in qualitative research

I decided to use the interview method for this qualitative study, because it can be applied to a variety of qualitative methods, enabling in-depth understanding of issues. It would be more difficult to conduct focus groups among paramedics due to their different shift times and the need for another researcher to moderate them. A chaotic, disorganised, and dangerous work environment can hinder observation of practice in healthcare research, and I must spend a considerable amount of time in the field (**as shown in the table 3.10**).

3.4.2.3 Study setting:

I conducted this qualitative strand in multiple ambulance stations under the SRCA in Riyadh and Makkah regions. This organisation was established in 1934 under the government's funds and administration (Anon., 2013). It serves public and humanitarian relief abroad free of charge (Alharbi *et al.*, 2020). This organisation operates based on the Anglo-American model, which provides rapid transport to EDs by ambulance clinicians (Al-Shaqsi, 2010). It has 384 ambulance stations in the country, 77 stations are located in the Riyadh region and 71 stations in the Makkah region (Anon., 2016) (**as shown in the Table 3.2**).

3.4.2.4 Research population and recruitment:

The participants included Saudi paramedics (bachelor holders) and EMTs (diploma holders) in multiple ambulance stations in Riyadh and Makkah. Because the SRCA has two levels of ambulance members: EMTs and paramedics. EMTs provide basic life support with limited airway management skills, cardiopulmonary resuscitation, automated external defibrillator AED use, haemorrhage control, and rapid transport for patients (Alharbi *et al.*, 2020). Paramedics provide advanced life support (ALS) with advanced skills, use equipment and medications to treat high-risk trauma or medical patients, and deal with major incidents (Alharbi *et al.*, 2020). Additionally, it is worth recruiting trainers and managers along with ambulance workers. However, it is difficult because ambulance managers in Saudi Arabia are paramedics who became managers because they are unable to do physical duties due to

occupational injuries. Also, it was difficult to find trainers who are interested in geriatric care within the SRCA organisation.

Prior to conducting this study, I planned to identify the participants by releasing Expression of Interest EOI forms inviting paramedics and EMTs from multiple ambulance stations. I planned to visit each ambulance station, meet ambulance managers, and ask them to distribute the information sheets to their paramedics and EMTs. Interested paramedics and EMTs would then find my contact details on the information sheet (my phone number and email address) to contact me. Further, the EOI forms contained an information sheet and a consent form. The interested participants would then record their demographic details, years of experience, clinical level, and educational pathway (public or private) in the EOI forms to enable purposive sampling. I used the purposive sampling by including participants from two different clinical levels at multiple ambulance stations in two Saudi cities in order to ensure diversity of location, EMTs/paramedics, and length of service. That was intended to provide valuable insights into challenges when responding to older trauma patients, as well as barriers and facilitators to providing improved care to those patients.

My approach to sampling began with initial selection of interviewees during an Easter vacation when I tried to visit several ambulance stations in Makkah. However, due to the effects of COVID-19, access to ambulance stations was severely restricted during and after the outbreak. I then decided to recruit participants by using social Telegram and WhatsApp groups while I am in UK. These well-known groups represent the EMS communities in Saudi Arabia that gather paramedics and EMTs from various regions. Upon announcing my need for participants and leaving my contact information in these groups, I received a number of interested participants who accepted my invitation to take part. Participants were then contacted via phone numbers and emails to record their information, share the information sheet and consent forms, and collect their signed consents before scheduling a suitable interview date and time. I tried to balance the number of participants from both cities as well as the levels of the profession and achieve maximum variation. However, I only found two EMTs in Makkah and Riyadh, as most of the paramedics who participated in this study used to be EMTs, and many old EMTs have undertaken bridge programmes to become paramedics.

3.4.2.5 Data saturation:

Saturation has been defined as "the point in coding when you find that no new codes occur in the data. There are mounting instances of the same codes, but no new ones" (Urquhart, 2013, p.194). Historically, saturation was originally developed by (Glaser and Strauss, 1967) to apply theoretical saturation in grounded theory research (Saunders *et al.*, 2018). There are four different models of data saturation used in qualitative research, according to Saunders *et al.* (2018) (**see Table 3.11**):

Model	Description	Principal focus
Theoretical saturation	Relates to the development of theoretical categories; related to grounded theory methodology	Sampling
Inductive thematic saturation	Relates to the emergence of new codes or themes	Analysis
A priori thematic saturation	Relates to the degree to which identified codes or themes are exemplified in the data	Sampling
Data saturation	Relates to the degree to which new data repeat what was expressed in previous data	Data collection

Table 3.11: Models of saturation and their principal focus in the research process: reproduced with permission from Saunders *et al.* (2018) in accordance with the CC BY 4.0 licence (https://creativecommons.org/licenses/by/4.0/)

My study applied the data saturation model by focusing on the amount of repetition of previous data in the new data without referring to theoretical categories (Saunders *et al.*, 2018).

Data saturation has been defined as "the number of interviews required to obtain a reliable sense of thematic exhaustion and variability within the dataset" (Guest, Bunce and Johnson, 2006, p. 65). However, there are many arguments regarding determining the sample size in qualitative research. Bradshaw, Atkinson and Doody (2017) stated that typically, qualitative samples are small due to an emphasis on intensive contact with participants, and findings are not likely to be generalisable. Ironside (2006) argued that qualitative researchers cannot achieve true saturation of data. Similarly, Fusch and Ness (2015) indicated that researchers or students cannot estimate proactively the required number of interviews for this study since it depends on the research method used. LoBiondo-Wood and Haber (2014) suggested that the most appropriate sample size in qualitative research cannot be

determined by a fixed rule, rather a variety of factors must be considered, including the research design, sampling procedures, and the frequency of the phenomena under study.

The arguments from Guest, Bunce and Johnson (2006) can be seen as reflections of arguments from related qualitative data saturation literature, when they concluded that 12 interviews are sufficient to ensure data saturation, give relatively homogeneous subjects, and put a narrow scope on the study. Another paper indicated that interviews lower than 20 participants are sufficient to produce fine-grained findings and provide better involvement with interviewees (Crouch and McKenzie, 2006). Bradshaw, Atkinson and Doody (2017) advised that whenever a qualitative description approach is proposed, tentative sample sizes should be considered. I therefore considered conducting between 20 and 30 interviews, although data saturation of the findings was my first priority. Data saturation has been understood in terms of the richness and thickness of the data, rather than the size of the sample (Dibley, 2011; Burmeister and Aitken, 2012). The best way to differentiate rich and thick data is to think of them as "rich as quality and thick as quantity" (Fusch and Ness, 2015, p.1409).

3.4.2.6 The use of Arabic language in qualitative data collection and analysis:

Undertaking interviews in Arabic enabled me to ask follow-up questions and gain in-depth answers regarding the participants' perspectives and experiences regarding their prehospital geriatric trauma care. In countries that do not speak English or in nations where foreign respondents speak English, qualitative researchers should collect data in languages other than English when interviewing respondents (Liamputtong, 2010; Aloudah, 2022). Each interview was conducted and then transcribed in Arabic. The transcripts were then coded in English, themes and subthemes were created in English, and interesting quotations were translated from Arabic to English and then sorted under each theme or subtheme.

The translation from Arabic to English might take place before analysing data (when interviews are conducted in Arabic and then translated to English) or after analysing data (when interviews are conducted, analysed in Arabic, and then results translated to English) (Aloudah, 2022). It is usually recommended to translate the results after the qualitative data analysis than before it (Aloudah, 2022). Van Nes et al. (2010) argued that analysing translated data instead of the original data can affect the accuracy of the analysis since different languages may involve different epistemological assumptions

and positions. Moreover, the process of translating the results after data analysis allows us to be closer to the meaning that respondents share and experience (Chen and Boore, 2010; Santos, Black and Sandelowski, 2015; Al-Amer *et al.*, 2016). The process of translating data before qualitative analysis is both time-consuming and costly (Chen and Boore, 2010). Researchers who work with large quantities of text might be deterred from conducting cross-language studies due to the uncertainty associated with translation costs (Hendrickson *et al.*, 2013). In terms of time consumption, Hendrickson *et al.* (2013) used data from 32 interviews to examine the turnaround time from Spanish audio to Spanish text. They found that it took an average of 12 days for Spanish audio to be converted into Spanish text (Hendrickson *et al.*, 2013). They also reported that 436.95 hours were spent auditing and correcting the transcriptions from audio to text for 32 interviews, for an average of 6.42 hours per interview (Hendrickson *et al.*, 2013).

To ensure accurate translation and robust findings, I translated the codes, themes, and quotes from Arabic to English using the forward-translation technique, followed by a back-translation technique by the local supervisor (Dr. Meshary bin Hotan) who acted as a bilingual checker. He was a Saudi assistant professor in the EMS programme and an expert in qualitative research working in the King Saud bin Abdulaziz University for Health Sciences in Riyadh. The process of translation was divided into two steps: forward translation and back translation. The forward-translation has been described as a process of conveying the meaning of ideas from one language to another (Regmi, Naidoo and Pilkington, 2010). Whilst, back translation is the process of translating ideas from the target language (e.g. English) back into the source language (e.g. Arabic) to ensure accuracy in translations (Chen and Boore, 2010; van Nes et al., 2010).

I used the model of translation suggested by Brislin (1970), who recommended considering two bilingual translators for the translation process. Also, it was recommended that the forward-translator and back-translator should be truly bilingual, familiar with the concepts and ideas that emerge from the study, fluent in the source and target languages and knowledgeable about both cultures (Chen and Boore, 2010). All of these applied on myself as a forward-translator and my local supervisor who acted as a back-translator. This is necessary as if forward-translation and back-translation techniques have not been applied well, this could report not true results (Chen and Boore, 2010).

Additionally, the meaning can be conveyed by interpreting texts, and word-by-word translation may alter the meaning, resulting in misinterpretation of data; thus, meaning must be considered during translation (Chen and Boore, 2010). The greatest challenge I faced during my translation process was trying to use a literal translation for some words. Thus, I use transliteration technique which is employed to replace a word or meaning in one language with another word with keeping the exact meaning. Also, the participants can answer my questions that contain some English words. Therefore, these words can be identified in transcripts and quotations using *italics* writing style.

3.4.2.7 Qualitative data collection:

Semi-structured interviews and open-ended questions were used to address the research questions. These interviews lasted between 45 and 60 minutes and data collection took place over five months. Compared to unstructured or structured interviews, qualitative studies with unstructured interviews generally begin with a general question about a broad topic area and include an agenda or list of topics (Holloway and Wheeler, 2013a). Structured interviews include a list of pre-planned questions or topics that will be asked to each interviewee in the same order (Holloway and Wheeler, 2013a). In semi-structured interviews, participants can be asked the same questions within a flexible framework, giving them the opportunity to describe their experiences and beliefs more freely than with structured interviews (Dearnley, 2005). By conducting semi-structured interviews, participants will cover all topics and the order of further questions will be determined by the answers they provide (Dearnley, 2005). Due to COVID-19 restrictions in ambulance stations and difficulties conducting face-to-face interviews, all interviews were conducted online. The interviews were undertaken during the participants' off-days to allow me to spend as much time with them as possible without interruptions by emergency calls or other factors. I offered them the opportunity to find a suitable location with a good internet connection.

In my preparation for the interviews, the interview guide, study information sheet, and consent form documents were developed based on the School of Health & Related Research ScHARR guidance and templates, benefiting from my supervisors' comments. I initially conducted three recorded pilot interviews before the real interviews to improve my interviewing techniques and determine whether the questions work. The first pilot interview was conducted in the English language on a random topic.

After my supervisors' guidance, I decided to conduct my Arabic interviews to help achieve improved interviewing techniques. Two pilot interviews were then conducted in Arabic and following my supervisors' feedbacks. These interviews improved my techniques by identifying my mistakes and improving my performance under my supervisors' instructions. The three documents (the interview schedule, information sheet, and consent form) were used (**see Appendix 4 showing these documents including the interview schedule's first version**). These documents were developed in English (forward-translation) then translated back into Arabic (back-translation) to ensure accurate translations. Aloudah (2022) recommended that the interview schedules' questions require both translation and cultural adaptation to make sure they are appropriate for the Arabic-speaking respondents and do not have explicit details that can weaken the interview schedules' qualities.

The interview schedule's initial questions were developed depending on what I have seen and felt when I have practised professionally with other ambulance workers providing care for older patients with injuries. Further steps were then taken to involve stakeholders (academics in paramedic science programmes in Saudi Arabia and the participants after each interview) to improve the schedule regularly to ensure it addressed the research objectives and yielded useful data. I used the Arabic language in the interviews, transcription, analysis, and interpretation stages. The point that I translated from Arabic to English occurred when I translated the emerged themes and interesting participants' quotes to reporting my analysis into the English language. Each interview was followed by a reflective notes report to determine what questions worked well and what did not, and whether any unexpected findings were discovered. Reflective notes also helped determine whether data saturation had been achieved.

I used three versions of the interview schedule. The first version was used on the 1st-9th interviews and led to identifying many themes from the participants and these themes became listed and replicated in these interviews (**See the first version in Appendix 5**). Since these themes were repeatedly reported as challenges when responding to older trauma cases, barriers and facilitators to improving care, I created a second interview schedule version that asked the next participants what themes were more important and less important if they listed similar themes (**See the second version in Appendix 6**). I used this version until I reached the 16th interview and found that the questions that were no longer yielding additional data, so I created a third version that included a figure highlighting a

number of factors that contributed to suboptimal care reported by the previous participants (**See the third version in Appendix 7**). I included this figure to use at the end of the next interviews to explore whether interviewees think (a) the elements are all important to improving care, (b) whether some are more important than others, and (c) if any other important elements exist, in order to providing some respondent validation of the figure. The third version was then used with the 17th participant until saturation with the findings was reached after the 20th interview.

3.4.2.8 Qualitative data analysis and use of the framework analysis approach:

The essential aim of any qualitative data analysis is to explore patterns, insights, and understandings (Patton, 2002). Initially, it was my plan to conduct face-to-face interviews and use an appropriate recording equipment that used encryption in order to digitally record and then transcribe the interviews. I planned to use the Olympus DM-450 digital recorder, which has been recommended by several qualitative researchers to record face-to-face interviews. However, due to the difficulty of conducting face-to-face interviews, I conducted online interviews using the University of Sheffield's Google Meet platform. This facilitated saving recordings of the interviews onto the university's drive, which was secure and safe. The code names assigned to the participants before and after their interviews were kept confidential in this drive with access for only the researcher. The data were then analysed applying the framework analysis approach. As each interview was conducted, saved, and then coded, I accessed it, listened to it, wrote its transcript, then generated its codes, which I then sorted into themes. I planned to use NVivo software (version 12) to help maintain codes and generate themes. I subsequently considered MAXQDA software that supports the Arabic language (Aloudah, 2022) because the NVIVO software was not compatible with the Arabic (Aloudah *et al.*, 2018).

The framework analysis method has been developed by Jane Ritchie and Liz Spencer, from the Qualitative Research Unit at the National Centre for Social Research in the UK in the late 1980s and mainly used in policy research (Ritchie and Lewis, 2003). This method was mainly established to achieve the following aims and outputs from the applied policy research: *"defining concepts: understanding internal structures; mapping the range, nature and dynamics of phenomena… categorising different types of attitudes, behaviours, motivations… finding associations between experiences and attitudes, between attitudes and behaviours, between circumstances and motivations*

and seeking explanations…" (Ritchie J, 1994, p.195). This approach has five stages applied in my study as follows: familiarisation; identifying a thematic framework; indexing; charting; mapping and interpretation (Ritchie J, 1994), which aimed to produce a cohesive and logical structure for displaying the descriptive elements (Ritchie and Lewis, 2003).

Before starting this approach, I conducted a brief unstructured literature review to identify any previous qualitative studies that used interviews or focus groups to elicit the views of practitioners on how their understanding or knowledge could be improved and determine what framework was developed or used for analysis in order to be applied in my study. No relevant framework was identified. This action led to decide using the first initial interviews to construct an initial framework (a priori themes) that address each study objective. The initial framework should be then further developed by new themes and subthemes emerged from the subsequent interviews. The following framework analysis' five stages describe how I used the framework analysis approach to address the qualitative study's objectives:

The 1st stage: familiarisation phase:

At this stage, I familiarised and immersed myself with contents of the interviews by transcribing interviews, reading, and rereading each transcript and reflective notes that could be considered in the interpretation phase as advised by relevant literature (Ritchie J, 1994; Gale *et al.*, 2013). These interviews' materials help researchers to re-listen to all or part of the recorded audios of interviews when needed (Gale *et al.*, 2013).

The 2nd stage: identifying a thematic framework:

At this stage, researchers should begin abstracting and conceptualising the data by reviewing the interviews' materials, taking notes, and writing recurrent themes and what was important to participants themselves, as I also applied (Ritchie J, 1994). Reviewing the interviews' materials gave me an ability to return back to notes made in order to identify the key themes and issues based on which the data examined and referenced as advised by Ritchie J (1994). This action helped me in constructing an initial thematic framework by sifting and sorting identified key themes and issues. When conducting the subsequent interviews, I continuously refined the constructed thematic framework that was based

on both logical and intuitive reasoning to ensure that I addressed the research questions by determining the meanings, relevance, importance, and underlying links between ideas (Ritchie J, 1994). While applying the constructed thematic framework, I needed to consider range of views, attitudes, and experiences under each theme or issue in order to use these data into building up a whole picture of the data. This whole picture of the data should be built up by being thematic (using each theme across all interviewees) or by case (using each interviewee across all themes) (Ritchie J, 1994).

The 3rd stage: indexing (coding) phase:

This phase has been clarified as "the process whereby the thematic framework or index is systematically applied to the data in its textual form" (Ritchie J, 1994, p.200). Indexing references (codes) should be recorded on the right-hand margins of each transcript using a numerical system to link back to the framework or index or by using a descriptive textual system based on the framework or index's themes and subthemes (Ritchie J, 1994). As I used the first way that uses the numerical system. Application of indexing should include making numerous or descriptive judgements based on the meaning and importance of the data (Ritchie J, 1994). Along with using the numerical coding system, I then made descriptive judgements to remind myself of the meaning and importance of each issue identified.

The 4th stage: charting phase:

At this stage, the ability to manage and summarise (reduce) the data is an important step in the framework analysis process as I considered (Gale et al., 2013). As I produced and used a matrix under each study objective that included references to quotations (interesting ideas and issues) as advised by Gale et al. (2013). This step was facilitated by using the MAXQDA software which managed the contents of the framework matrices (charts) (Gale et al., 2013), and I used these matrices when analysed each interview. Each study objective had a separate thematic matrix or chart which has its themes, subthemes, and identified important responses or quotations according to the Ritchie and Spencer's thematic framework analysis guidelines. They recommended drawing a table for each theme with adding additional two columns or rows in each table: one for (others or unspecified ideas) to be

used in case of obtaining new ideas as progressing with further interviews and another for (comments) to record any information if needed (Ritchie and Lewis, 2003). Making a thematic matrix or chart for each study objective facilitated the process of charting and synthesising the data later and showed addressing all study objectives to readers clearly.

The 5th stage: mapping and interpretation:

Once all the data have been charted under each study objective, I applied the process of pulling together key characteristics of the data, then mapping and interpreting these data set as a whole (Ritchie J, 1994). As I constructed the data charts or matrices, I was mapping the emerging data, classifying new ideas into themes and subthemes, and then placing appropriate quotations under each theme and subtheme while conducting additional interviews. These actions contributed to ensuring visibility of the thematic charts, a transparent audit trail, use of reflexivity, and clarity of interpretation of the data to ensure results' rigor and trustworthiness (Hackett and Strickland, 2019).

3.4.2.9 Rigour and trustworthiness of qualitative research:

Lincoln and Guba's trustworthiness criteria (Lincoln and Guba, 1986), were considered during data collection to ensure the quality and rigor of the qualitative study's findings. These four criteria were defined as follows (**see Table 3.12**):

Criteria	***Briefed definitions***	***Actions to be achieved***
Credibility	A belief in the validity of the results of the study.	Maintaining observation, extending engagement, triangulating data collection, assessing researcher performance, peer debriefing, analysing and comparing negative cases, and using adequate reference materials.
Dependability	Results are applicable to other contexts.	Critical description
Confirmability	Maintaining consistency and reproducibility of results.	Audit of inquiry
Transferability	Researchers' backgrounds and characteristics are not used in generating results, but rather respondents' responses.	Reflexivity, audit trial, and confirmability audits.

Table 3.12: The rigour and trustworthiness of evaluative criteria adopted by (Lincoln and Guba, 1986)

Regarding the credibility criteria, I used valid methods to enhance the credibility of the study. Online interviews are recognised as being credible as face to face method and well-widely used during pandemics. The data credibility was enhanced by using well-established methodologies and methods. The interview schedule was developed based on my professional experience working with other ambulance clinicians providing care for older trauma patients and involving stakeholders, as well as piloting with three participants. Interviewing a range of participants from different job levels and different cities can provide a more comprehensive understanding of the research topic that will enable the researcher to capture an expanded range of opinions, attitudes, and experiences pertaining to the phenomenon being studied (Shenton, 2004). Research approaches that are well-established should increase the credibility of the data and, therefore, make them more trustworthy (Shenton, 2004).

Dependability refers to the likelihood that the same results will be obtained when the work is repeated under similar circumstances by another person (Shenton, 2004). Methods and findings should be described thoroughly so they can be replicated by others. Therefore, I provided a detailed description of the methods used and the findings. This allows other researchers to apply the methods in a similar way. There is, however, the possibility of slightly different findings since researchers interpret data differently. Recordkeeping for research activities, such as data collection, analysis, and coding decisions, can also be part of these efforts (Shenton, 2004). This facilitates transparency and enables replication and reliability reviews of the research process (Shenton, 2004). For instance, I used a reflective notes document that contained accurate details on how and why I continually improved the interview schedule until its third version. The transcriptions of all interviewees were also coded as I kept detailed records of how and why they were code. While conducting my research, I also ensured that any changes were explained and justified.

The confirmability criterion also contributes to the assessment of qualitative research quality as it ensures that the research findings are not influenced by the researcher's bias and personal perspectives (Anney, 2014). This criterion was also taken into account, since my supervisors reviewed my results regularly while I analysed my data and produced my findings. However, there were some limitations to the confirmability since the original scripts were Arabic, and my supervisors were unable to read Arabic, and had to rely on my translation and reflections. To make sure that my results can be

easily examined, I outlined my research methodology in a detailed manner. In this research, I have shown the impacts of limitations on each conclusion after identifying the limitations for each study.

Transferability refers to the ability to apply findings in different contexts (Lincoln and Guba, 1986). Researchers who use qualitative methods are not concerned with generalisability to other contexts. Instead, they seek to learn about ordinary experiences of everyday life in depth. Thus, qualitative research doesn't necessarily require a large number of participants (Bryman and Burgess, 1994). Qualitative research does not always aim to generate replicable findings, but there is a reasonable expectation that findings can be generalised so they can be applied elsewhere. The transferability has been considered for the current qualitative findings of this research that represent ambulance clinicians' experiences and responses in two different cities. Prehospital geriatric trauma care challenges and gaps in Makkah and Riyadh can also be generalised and applied to other cities since the participants from both cities reported similar issues.

3.4.2.10 Reflexivity in qualitative research:

In addition to the Lincoln and Guba's trustworthiness criteria, I considered the role of reflexivity in the research process and its relation to data collection and analysis. This reflected the importance of clarifying my background and characteristics in this study (Mays and Pope, 2000). The background and characteristics (e.g., age, gender, professional status, belief, feeling, or experience) can positively or negatively influence data collection (Mays and Pope, 2000). On the other hand, this can have an opposite impact that interviewees might not share their experiences due to the background and characteristics of the researcher. Green and Thorogood (2018) suggested that qualitative research can be influenced by two perspectives: a) those who have an emic perspective are members of the culture or group they are studying and are conversant with their culture. b) In contrast, when a researcher is unfamiliar with the culture being studied or is not a member, he or she uses an etic perspective (Green and Thorogood, 2018). Researchers who are members of the culture being studied may be able to contribute additional knowledge because they understand the expressions, sentiments, modes of communication, and relationship development (Green and Thorogood, 2018). A researcher may, however, be able to view the respondents' experiences objectively as an outsider without prior assumptions (Green and Thorogood, 2018).

In addition to the emic and etic perspectives, Creswell and Plano Clark (2017) advised to include three aspects in a written reflexivity discussion: the researcher's background, how that background might affect data analysis, and what participants and readers in the general literature are supposed to think of the study findings. My research interests me because I am a paramedic, an academic and a researcher at a Saudi Arabian university, where I acquired experience working in hospitals and ambulance stations during my faculty training, and where I am passionate about improving prehospital care for older patients with injuries. Although that I have my views and biases that can be brought to the data collection and analysis processes, I endeavoured to reflect on how my perspectives may impact the interviews and data interpretation. My centrality as a qualitative research tool made it imperative to check my subjective assumptions about ambulance clinicians whose prehospital care for older people with injuries frequently differs. Moreover, the interviewees were encouraged to share their feelings, experiences, and attitudes in negative or positive manners without barriers (Bowling, 2014).

Researchers' bias may be exacerbated when they enter the field with preconceived notions and prior expertise (Silverman, 2015). This may lead me to focus exclusively on points that support my pre-existing ideas (Silverman, 2015). I attempted to conduct this research as a neutral researcher to reduce the potential for my background and characteristics to affect interviews or interviewees' responses. I have worked in similar settings and have a similar professional background as the participants. As a Saudi individual, I am familiar with Saudi society's various norms and characteristics, as well as with some of the challenges ambulance clinicians may encounter when providing care for older patients, particularly female patients. In this sense, my ability to synthesise emic and etic perspectives was useful in adding personal and professional viewpoints as well as describing the Saudi ambulance clinicians' experiences.

Based on the following points, speculation could have been made as to how this account might have affected participants, paramedic-related research readers, and EMS policymakers: first, I may have been perceived as a paramedic and academic concerned with developing prehospital geriatric trauma care, which may have led to more candid views and experiences by the participants. Since I share the ambulance clinicians' experiences, I may be able to understand their perspectives and then evaluate the findings. My own viewpoint, however, will invariably impact their interactions and the data existed,

as well as how they see me. There was a strong interest among many interviewees in reading the final report and learning about the study's findings. The findings of the study should also be considered in light of how ordinary paramedic care research readers and EMS policymakers react to them. They may be able to use this study to create future recommendations by better understanding what issues can be considered and which cannot for improving geriatric care and education, as well as additional recommendations that can be tested based on the interview data.

3.5 Integration of quantitative and qualitative data:

Integration is the point in a mixed methods research project where the quantitative component interfaces with the qualitative component and it reflects the richness of the mixed methods approach (Creswell and Plano Clark, 2017). It involves interacting or conversing between qualitative and quantitative strands to give better or in-depth understanding of a phenomenon (Creswell, Fetters and Ivankova, 2004). Creswell and Plano Clark (2017) indicated that researchers in sequential explanatory designs should undertake the quantitative strand before the qualitative strand to address the primary research question. In terms of data analysis, since the quantitative and qualitative studies in my research address different objectives, mixed methods analysis may not be appropriate, but planning in advance to integrate the qualitative and quantitative data is appropriate, since it is uncertain what the data will show and whether both quantitative and qualitative data will address the same issue.

There are popular integration techniques that can be utilised during data collection and analysis such as data connecting, data building, data matching, data drafting, data hypothesis generation, data embedding, and data merging (Fetters, Curry and Creswell, 2013). Other techniques can be used when interpreting and reporting the results such as triangulation protocol, linking technique, following a thread, joint display, data transformation, correlations, and consolidation (O'Cathain, Murphy and Nicholl, 2010; Bazeley, 2012; Fetters, Curry and Creswell, 2013). However, these methods of data integration were not appropriate since the quantitative and qualitative studies addressed related but separate research questions, and the data collected provided limited potential for integration. Other than to note that the perceptions of paramedics in the qualitative study aligned with the findings of the quantitative study that low falls were the most common injuries and presenting features did not reliably predict severe injury. It could be argued that my research is not a mixed methods study, which

would use different methods to address the same question, although this third chapter states that it was planned as a mixed methods study.

Regardless of the approach chosen, Bryman (2007, p.21) argued that in true integrated studies, quantitative and qualitative results should "talk to each other, much like a conversation or debate, and the idea is then to construct a negotiated account of what they mean together". Moreover, Creswell and Plano Clark (2017) suggested undertaking a discussion of conclusions or inferences drawn from the combined results, no matter what integration strategies were used to merge the two databases. Therefore, I decided to conduct a complementary narrative discussion using both retrospective and qualitative findings rather than using a specific integration approach. Consequently, I decided to follow the advice of Creswell and Plano Clark (2017) by writing a side-by-side narrative discussion as an alternative data integration process. This could describe the results for specific topics using the quantitative results first and the qualitative results second or vice versa, followed by statements interpreting the integrated findings (Creswell and Plano Clark, 2017).

3.6 Ethical considerations for the quantitative and qualitative strands:

Today's healthcare research ethics are more concerned about protecting subjects when they are enrolled as research subjects than ever before (Artal and Rubenfeld, 2017). It is now easier for research participants to understand their rights and options, especially their right to refuse (Artal and Rubenfeld, 2017). Below are sections that show the ethical considerations I have taken into account in the quantitative and qualitative strands:

3.6.1 Patient consent, confidentiality, data protection and ethical risks for the quantitative study:

In this study, patient consent was not required for collecting a trauma registry data as that were de-identified data. In terms of confidentiality and data protection, I did not collect identifiable or personal data, and the relevant data were handled and saved on a secure, password-protected and encrypted drive at the University of Sheffield. The relevant data was managed and kept secure with a data management plan developed before this study was conducted. Regarding the expected ethical risks in this strand, the information of these patients was anonymised as I ensured the datasheet agreement be followed to avoid any breach of ethics. I have attempted to minimise any ethical risks emerged in

this strand. However, it is worth indicating that I was aware that I could encounter a small number of cases with unusual characteristics (e.g. cells with less than 5 cases) that could allow identification. Therefore, I planned that I will not include details of individual patients and cells of less than five patients to be merged with other cells or reported with minimal detail to avoid de-anonymisation. Data were not shared with any third party based on data sharing agreements. In addition, data will be destroyed after the end of my PhD study.

3.6.2 Patient consent, confidentiality, data protection and ethical risks for the qualitative study:

Each participant was asked to sign a consent form after reading and understanding the information sheet. Participant confidentiality was ensured by allocating code names to the participants before participating. These codes were kept and protected with access for only the researcher. Any identifiers were removed from the data before transfer to Sheffield. The information of interviewees and their ambulance stations were anonymous. All interview recordings were encrypted, secured and password-protected in the University of Sheffield's drive. Data deletion will be compatible with my student status and access to my shared drive. These actions were considered as part of the data management plan for this qualitative study, which also helped manage the data securely.

Regarding the ethical risks, it was possible that participants could reveal evidence of poor knowledge or poor care during the interview, which I was obliged to report to an appropriate authority. I ensured that if I identified this ethical risk that might threaten patient safety, they and their managers would be informed about that issue. Therefore, I made them aware of this potential risk in the participant information sheet. Additionally, it was expected that participants can be interviewed during their duty. However, I planned to interview the participants outside their shifts or duties in order to mitigate any stresses or anxiety that come due to their work pressure circumstances. Also, any participants may refuse to commence their interview after obtaining their acceptance to participate due to some uncontrolled circumstances. In this situation, I ensured that the participant will not be obliged, and I will recruit another participant instead.

To minimise ethical issues, I took proactive actions by focusing on the following ethical principles: autonomy, beneficence, and justice, which can alleviate these ethical risks (Orb, Eisenhauer and Wynaden, 2001). Firstly, autonomy means that participants have their rights as autonomous people to

accept or refuse to take part (Orb, Eisenhauer and Wynaden, 2001). For beneficence, it means "doing good for others and preventing harm" (Orb, Eisenhauer and Wynaden, 2001, p. 95). In my research, the participants' well-being was considered. Lastly, I dealt fairly with the participants (Orb, Eisenhauer and Wynaden, 2001). They were not obliged to participate. Therefore, I was reminding them regularly to feel that they were not obliged or inclined to participate in the study.

Furthermore, I expected that threats to the professional reputation of the participant can occur if controversial quotes are attributed to them in any report of research. This risk can be minimised by ensuring they are not identified in any report of research. In terms of benefits for participants, I offered participants the opportunity to join an online presentation and discuss my results at the end of the project. This would allow them to increase their understanding and knowledge regarding the ageing impacts on prehospital trauma care for older patients and patient outcomes and improve their professional practice. I expected that these benefits can outweigh the ethical risks identified, and the participants will only take part after considering the risks and providing consent.

3.7 Ethical approvals for the quantitative and qualitative studies:

Regarding the quantitative strand, firstly, I obtained a conditional letter from the KAMC's the KAIMRC director Dr Suliman Alghnam (**see Appendix 8**). This letter was obtained based on my first supervisor's request for PhD admissions purposes and ensuring that I can collect data from a Saudi trauma registry. Before collecting data, I obtained the ethical approval from the KAIMRC (**see Appendix 9**). This ethical approval letter was then sent via online ethics application to the ScHARR's University Research Ethics Committee to obtain the approved self-declaration letter (**see Appendix 10**). I then decided to consider the KSMC trauma registry through the registry director Dr. Sharfuddin Chowdhury and the KSMC's Research Center provided me with their ethical approval (**see Appendix 11**). Because this organisation was approved by the ScHARR's University Research Ethics Committee, I did not need to send them this approval letter to obtain the approved self-declaration letter, but I updated them on it.

Regarding the qualitative strand, a conditional letter was obtained from the General Directorate of Training of the SRCA, Riyadh city, Saudi Arabia, for PhD admissions purposes and ensuring that I can collect data from the SRCA ambulance stations (**see Appendix 12**). After that, the ethical approval was

obtained from the Ministry of Health, Riyadh, Saudi Arabia, after filling in and sending an Institutional Review Board IRB application form, along with other documents (**see Appendix 13**). The Saudi Ministry of Health also was recognised by the Research Ethics Committee of the University of Sheffield as having sufficiently robust ethics review procedures. Therefore, the qualitative study did not require further review in Sheffield.

3.8 Patient and public involvement:

It was helpful to involve members of the public in presenting my project to improve my project plan. I presented my plans to the Sheffield Emergency Care Forum SECF while developing my project proposal. This forum is a group of patient and public involvement located in Sheffield and collaborating with the ScHARR, providing patient and public involvements in emergency and urgent care-related research. This meeting was held on Friday, 23rd April 2021. It was helpful by benefiting from members' comments and suggestions to improve my research plans. This involved discussing the research design, timing to conduct my project, types of participants and coordination between the quantitative and qualitative components. By participating in the involvement work, I was able to improve the research design, identify which strand should be undertaken first before another, how my research plans can be applied to Saudi Arabia's unique culture, and why involving female paramedics could be challenging in my country, as well as help identify potential limitations and challenges, I may face as a result of the COVID-19 pandemic. Further, continuous engagement was considered with patient and public involvement events (e.g. with the SECF annual meetings and other events) to report back findings and discuss interpretation. Additionally, I am on touch with the SRCA, informing them about any research results in order to improve their ambulance workers' clinical practice and knowledge.

3.9 Conclusion:

This chapter has given a general overview of the primary PhD research. It has clarified the research questions, aim & objectives, research philosophy, methodology, design, data collections, analysis, integration phase, and ethical considerations. Based on my knowledge, this is the first project focusing on prehospital care of older patients with injuries in Saudi Arabia and investigating relevant understanding and knowledge among the Saudi ambulance workers. Through this research, major

injuries in older people and their outcomes will be described, as well as the effects of ageing on prehospital trauma care and patient outcomes among ambulance workers, which will become the basis for future research.

Chapter 4

The Retrospective Quantitative Study: Data Collection & Analysis

(Chapter title: The Injury Characteristics and Predictors of In-hospital Mortality among Older Patients in Saudi Arabia: A Retrospective Cohort Study)

Chapter overview:

"This chapter reports a retrospective quantitative study undertaken in order to describe injury characteristics of older trauma patients in Saudi Arabia and identify predictors of in-hospital mortality. The descriptive study was undertaken describe injury characteristics, followed by univariate and multivariable analysis to identify predictors of in-hospital mortality".

4.1 Introduction:

In the third chapter, I showed my retrospective cohort study as a first stage of this PhD research prior to the qualitative study to describe the characteristics of injuries in older people and identify predictors of in-hospital mortality among them in Saudi Arabia. This chapter covers data analysis that I obtained from the KSMC MTC's registry and use of univariate and multivariable analysis to address the study objectives. Conducting this study enriched my research by new relevant insights that were then explored qualitatively through an additional objective emerged from this study. This action was to obtain in-depth understanding of research problems on the topic-area from the perspective of Saudi Arabia.

4.2 The results of the quantitative study:

I initially received data of 1346 older cases (55 years old and over) who were admitted to the KSMC ED by different arrival modes (such as by walking, police, families, helicopter, SRCA ambulances, government and private ambulances, unknown) from 1st/8/2017 to 31st/10/2021. To include the eligible cases, I relied on a two-phase process using two variables to recruit the final 452 eligible cases: 1) "definitive care mode of arrival", and 2) "prehospital ambulance arrival at the scene" variables (**see the flow diagram in Figure 4.1**):

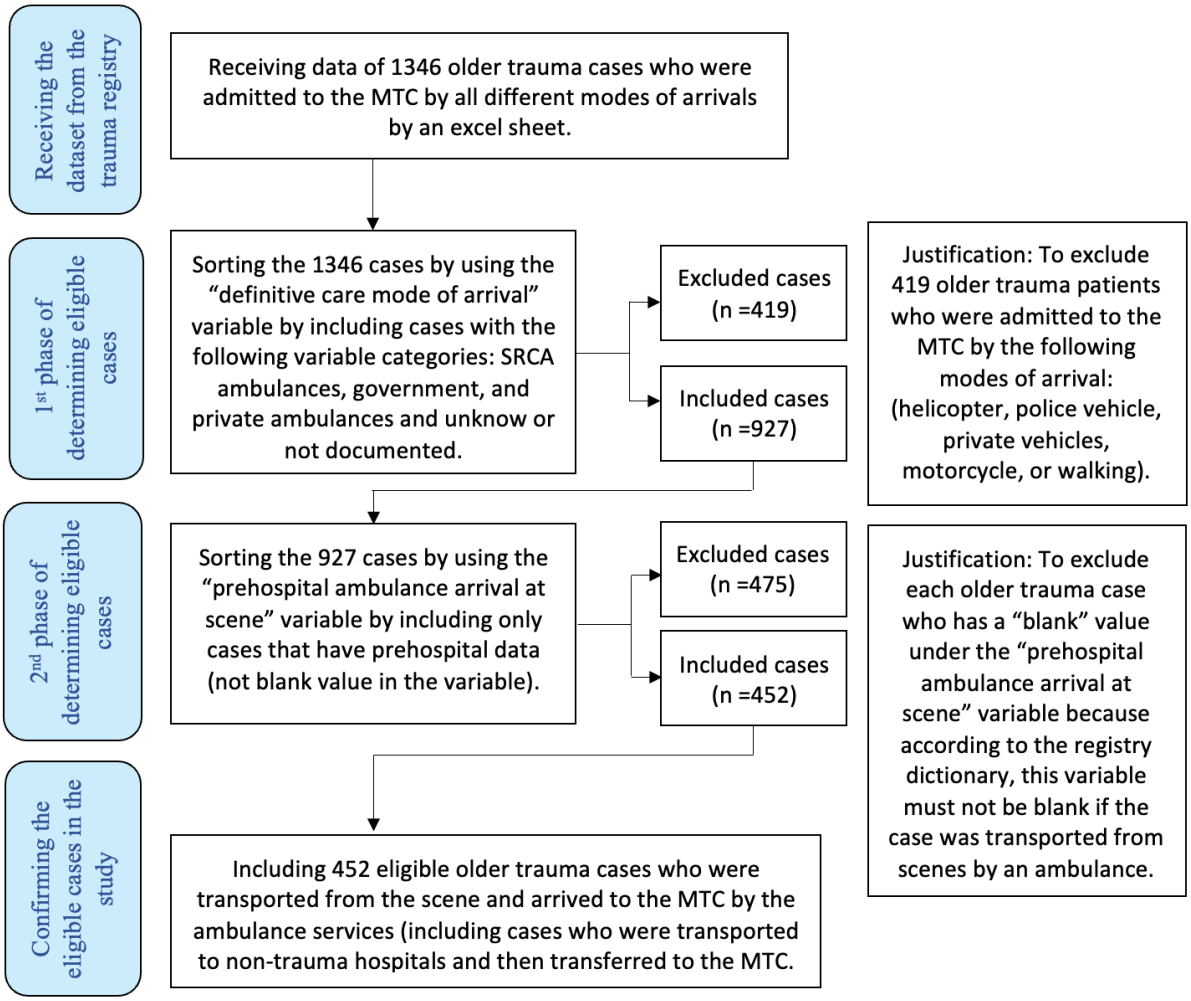


Figure 4.1: The process of recruiting the eligible 452 older cases out of 1346 cases from the trauma registry's excel sheet dataset

In Saudi Arabia, government and private ambulances are used only for transporting trauma patients between hospitals. In contrast, the SRCA ambulances are used to transport trauma patients from the scene to hospitals. **See figure 4.2**, which shows the different types of Saudi ambulance services transportations between scenes and MTC with and without passing through non-trauma hospitals. As I have considered this system (**shown in the Figure 4.2**) in recruiting the trauma older cases from the excel sheets dataset:

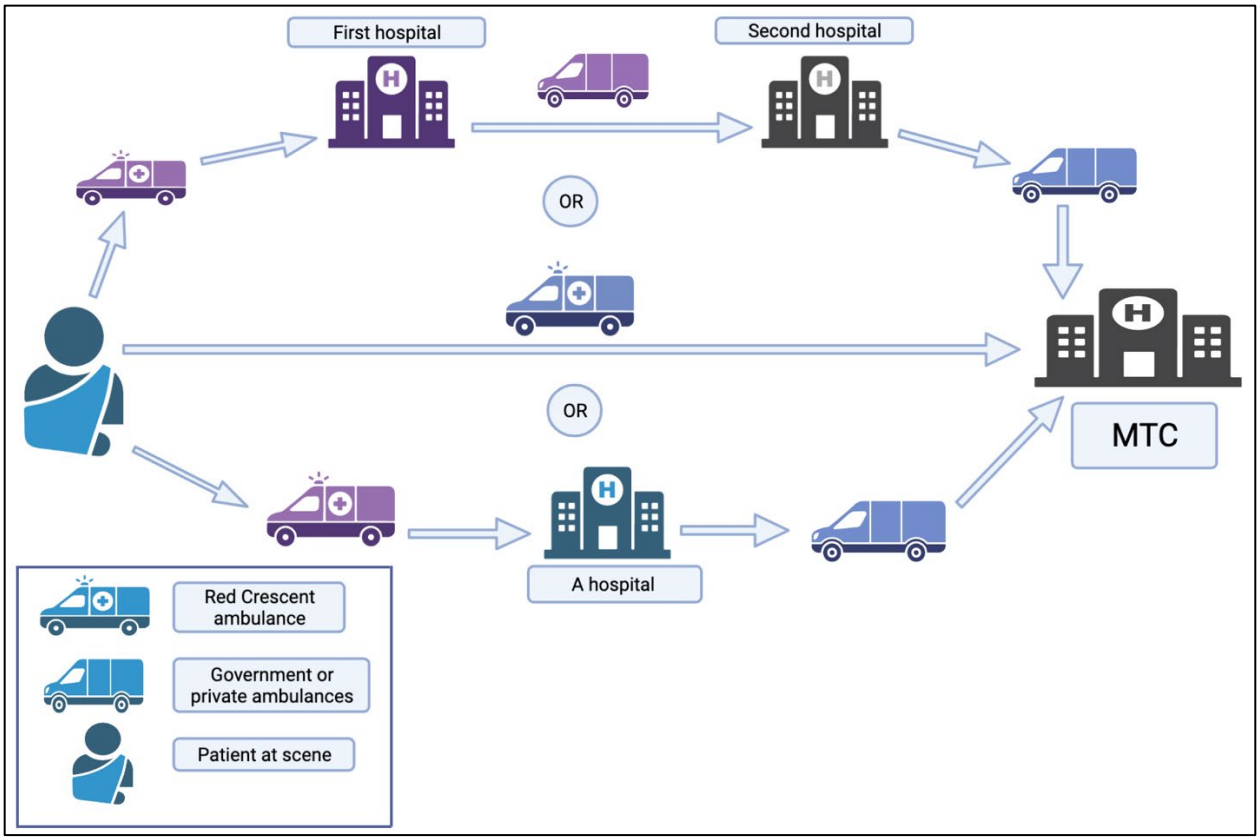


Figure 4.2: The system of ambulance services transportations between scenes and the KSMC trauma centre

After that, the dataset was checked to ensure the availability of the chosen variables based on the suggested study plan, as explained in the third chapter. This stage led to understanding the nature of the KSMC dataset by checking each variable with its domains before importing the data into the SPSS software.

4.2.1 The descriptive summaries of collected data:

At this stage, I started to describe and compare between the 452 included and 894 excluded cases using age, sex, mechanism of injury, in-hospital mortality, ISS, and length of hospital stay variables (**see Table 4.1**). There are no clear differences between the included and excluded cases in terms of the characteristics presented. Almost half were aged 55-64, around half were low falls, and almost 2/3 were male. Most cases (94.2%) were discharged alive compared to low rates of in-hospital mortality.

Approximately 85 % of the ambulances admitted cases with minor to moderate injury severity. Almost half of them spent 1-10 days in the hospital after their injuries.

This comparison of the characteristics between the excluded and included cases was conducted using frequencies and proportions without using specific statistical tests. Statistical comparison between the included and excluded cases does not address the study hypotheses, so is probably not appropriate. Further, comparing descriptive characteristics allows the reader to determine whether any differences suggest a potentially important sampling bias. A significant hypothesis test would not necessarily indicate an important bias, while a nonsignificant hypothesis test would not exclude potentially important bias. Also, the inclusion and exclusion criteria were established in order to ensure the study's internal validity and to ensure that the required population was identified. Moreover, the exclusion criteria were used to exclude cases that might introduce bias or confounding factors, which could also distort the results if they were included in analysis (Motheral *et al.*, 2003).

Variables	***Categories and descriptive items***	***Included cases (No. & %)***	***Excluded cases (No. & %)***
Age (categorical and continuous)	55-64 years old	220 (48.8%)	391 (43.7%)
	65-74 years old	104 (23.1%)	233 (26.1%)
	75-84 years old	80 (17.7%)	194 (21.7%)
	85 and older	47 (10.4%)	76 (8.5%)
	Valid	452	894
	Missing data	0	0
	Mean	68.25	68.56
	Median	65.00	67.00
	Mode	56	56
	Maximum	105	106
	Minimum	55	55
Sex (categorical)	Male	285 (63.2%)	574 (64.2%)
	Female	166 (36.8%)	320 (35.8%)
	Valid	452	894
	Missing data	0	0
	Fall-high (more than 1 metre)	49 (10.9%)	119 (13.3%)

Mechanism of injury (categorical)	Fall-low (same level or lower than 1 metre)	242 (53.7%)	472 (52.8%)
	Fire, flames or smoke	7 (1.6%)	12 (1.3%)
	Cutting or piercing object	2 (0.4%)	13 (1.5%)
	Motor vehicle accidents	81 (18.0%)	200 (22.4%)
	Motorcycle accidents	4 (0.9%)	2 (0.2%)
	Pedestrians	61 (13.5%)	45 (5.0%)
	Struck by or collision with person or object	5 (1.1%)	29 (3.2%)
	External cause	0 (0.0%)	2 (0.2%)
	Valid	452	894
	Missing data	0	0
In-hospital mortality (categorical)	No	426 (94.2%)	833 (93.2%)
	Yes	26 (5.8%)	61 (6.8%)
	Valid	451	894
	Missing data	1	0
Injury severity score ISS (categorical)	0-8 minor	152 (33.7%)	349 (39.0%)
	9-15 moderate	235 (52.1%)	422 (47.2%)
	≥16 serious	64 (14.2%)	123 (13.8%)
	Valid	452	894
	Missing data	0	0
Length of stay (categorical and continuous)	1 to 10 days	229 (50.7%)	425 (47.5%)
	11 to 20 days	150 (33.2%)	282 (31.5%)
	21 to 30 days	41 (9.1%)	101 (11.3%)
	31 to 40 days	13 (2.9%)	34 (3.8%)
	41 to 50 days	7 (1.5%)	16 (1.8%)
	>50 days	12 (2.7%)	36 (4.0%)
	Valid	452	894
	Missing data	0	0
	Mean	14.29	15.73
	Median	10.00	11.00
	Mode	10	8
	Maximum	245	280
	Minimum	0	0

Table 4.1: Descriptive comparisons between the included and excluded cases

After that, two techniques were performed to check the data for completeness and credibility in a variable before conducting detailed analysis: by describing each variable, including the credibility of the range and estimating the proportion missing in each variable (**see Appendix 14**). Estimating missing data was applied by identifying the patterns of missing data to determine whether there are a few cases with a large amount of missing data, or is the missing data spread across a large number of cases (**see Appendix 15**). The variables with missing data were sorted as follows:

a) Prehospital physiological variables with missing data:

Blood pressure at scene (continuous)

Pulse rate at scene (continuous)

Respiratory rate at scene (continuous)

Mental status at scene -AVPU scale (categorical)

b) In-hospital physiological variables with missing data:

Blood pressure at ED (continuous)

Pulse rate at ED (continuous)

Respiratory rate at ED (continuous)

Glasgow coma scale at ED (categorical)

c) Other three categorical variables:

Injured body parts (categorical)

Trauma team activations (categorical)

In-hospital mortality (categorical)

The patterns of missing data were investigated. Initially, this process led to identifying 135 cases with missing data. Each of these cases with missing data was examined to find 1) a few cases with a large amount of missing data, and 2) some missing data that spread across a large number of cases (**see Table 4.2**), which summarises the patterns of missing data:

Sorting of cases based on the number of missing data from the highest to lowest missing data	***Total of cases with missing data***	***Number of missing data in each case***	***The variables that have missing data in each group***
The first group of cases	2 cases	8 missing data	Missing in all four prehospital and four in-hospital physiological data
The second group of cases	2 cases	7 missing data	Missing in prehospital and in-hospital physiological data except the GCS scores
The third group of cases	7 cases	5 missing data	Missing data in all four prehospital data with only one of the in-hospital data
The fourth group of cases	52 cases	4 missing data	51 cases with 4 missing prehospital data and one case with 4 missing in-hospital data
The fifth group of cases	7 cases	3 missing data	Missing data in three prehospital data and some of the in-hospital data (**as shown in the Appendix 15**)
The sixth group of cases	12 cases	2 missing data	Missing data in some prehospital and in-hospital physiological data
Seventh group of cases	55 cases	1 missing data	Only one missing data either in prehospital, in-hospital data, or in one of the other three categorical variables

Table 4.2: The summary of patterns of the missing data

I noticed that the prehospital physiological data collected by the SRCA paramedics and EMTs had higher missing rates than the in-hospital physiological data. While the remaining three categorical variables (Injured body parts, Trauma team activations, and In-hospital mortality variables) had the lowest missing data rates, each with only one missing value.

To deal with cases that have missing data, I decided the following:

1. Excluding the first two groups from the multivariable analysis (the 4 cases with 7-8 missing data items). These cases are missing crucial data with no obvious way of imputing.

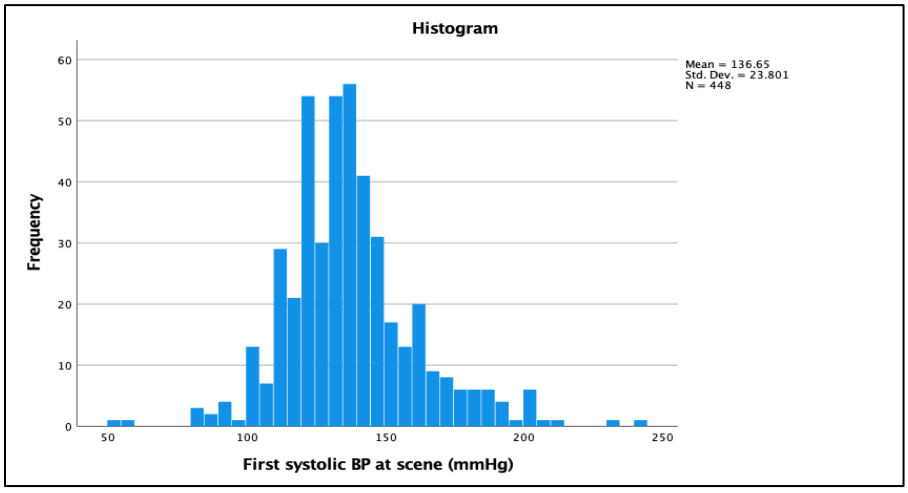
2. Most of the missing data could be imputed by using prehospital values to impute for missing ED values and using ED values to impute for missing prehospital values. Although variables may change between prehospital and ED measurements, the prehospital measurement gives the best indication of what the missing ED measurement would have been, and vice versa.

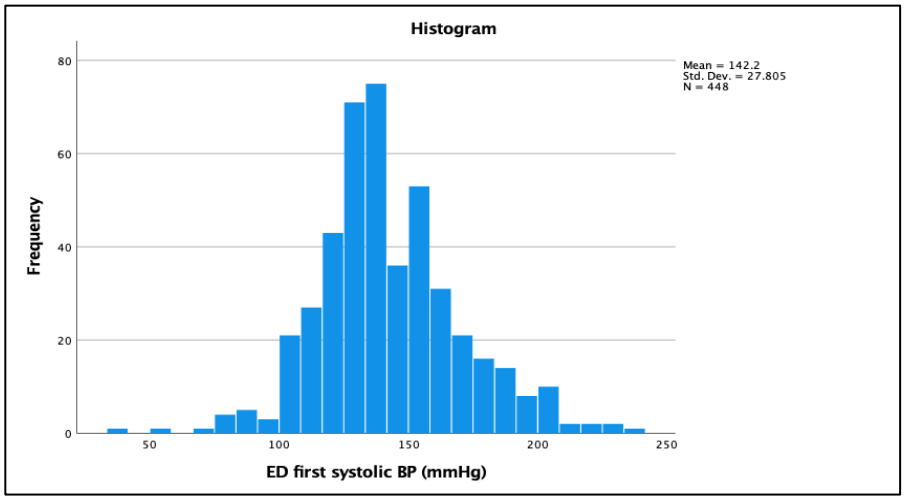
3. Regarding the few cases that had 1 or 2 missing variables, it was reasonable to impute the most frequent value for that continuous or categorical variable. The most frequent value represents the most likely estimate of the true value, in the absence of any other information.

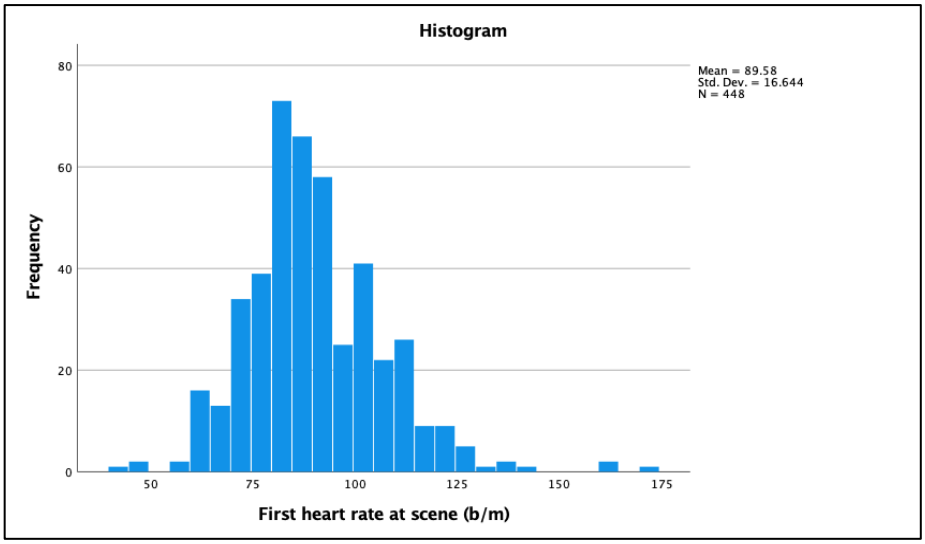
The above steps of imputation were undertaken as this relates to the multivariable analysis, where imputing missing data avoids having to exclude all cases from analysis that have any missing data (even if that involves only one missing predictor variable).

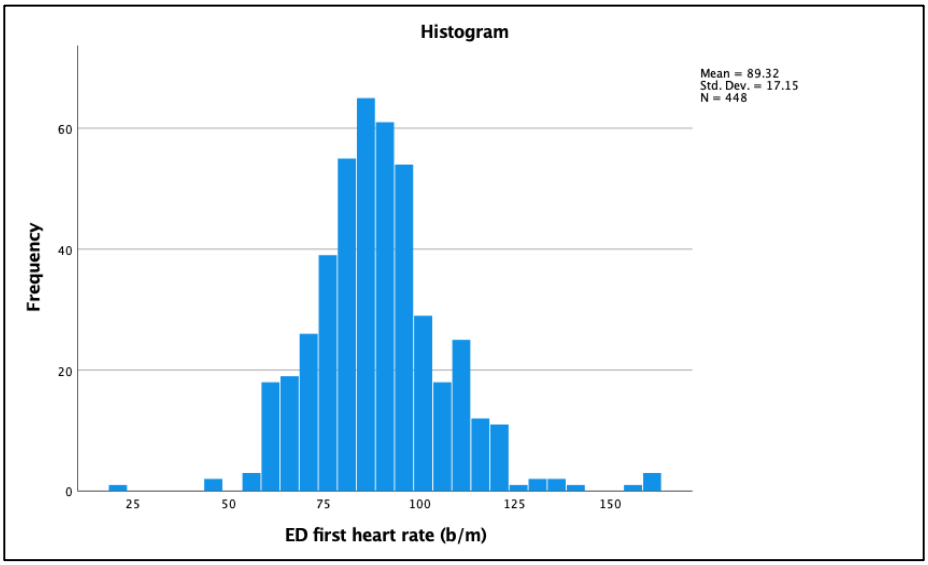
4.2.2 The data distribution of continuous variables:

Data distributions were checked for the continuous variables by plotting a histogram for each continuous variable and depending on the Shapiro-Wilk test for testing normality (**see Figure 4.3**) and (**see Table 4.3**):




Histogram
Mean = 142.2
Std. Dev. = 27.805
N = 448
Frequency
0
20
40
60
80
50
100
150
200
250
ED first systolic BP (mmHg)


Histogram
Mean = 89.58
Std. Dev. = 16.644
N = 448
Frequency
0
20
40
60
80
50
75
100
125
150
175
First heart rate at scene (b/m)


Histogram
Mean = 89.32
Std. Dev. = 17.15
N = 448
Frequency
0
20
40
60
25
50
75
100
125
150
ED first heart rate (b/m)

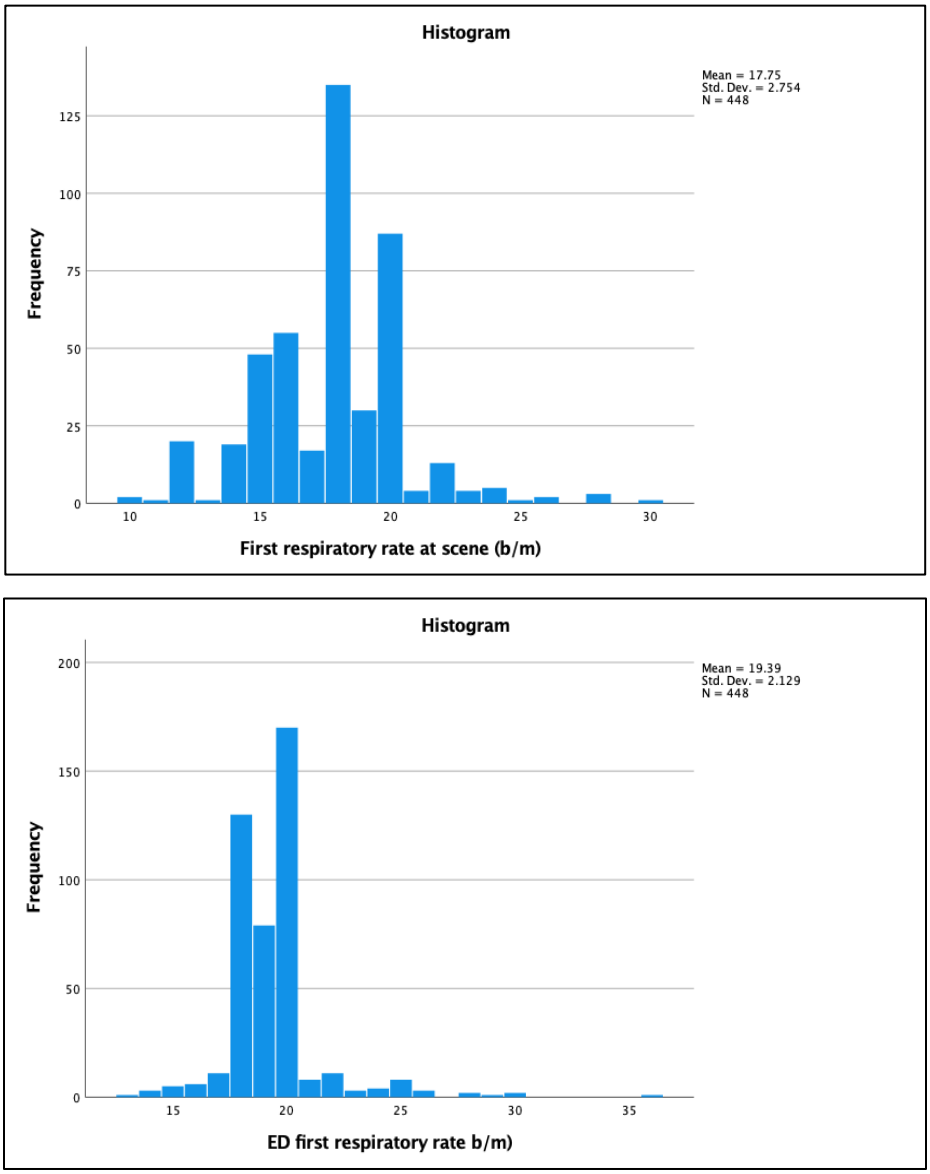


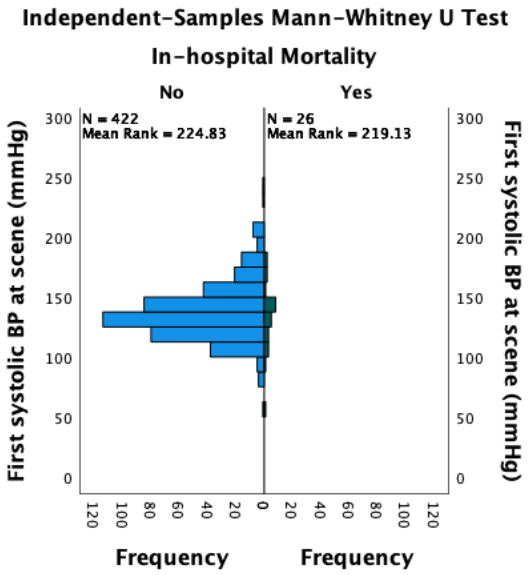
Figure 4.3: Plotting histograms for each of the continuous physiological variables

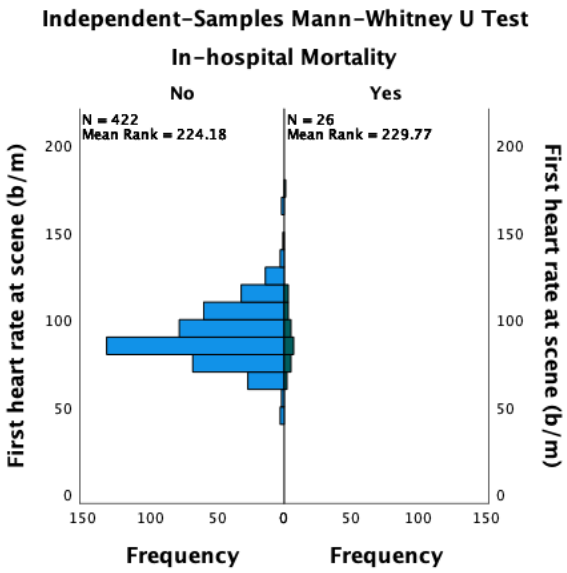
Continuous variables	***Shapiro-Wilk test for testing data normality***
Scene SBP	P-value = <.001, this value means skewness of the variable **as p ≤ 0.05**
ED SBP	P-value = <.001, this value means skewness of the variable **as p ≤ 0.05**
Scene heart rate	P-value = <.001, this value means skewness of the variable **as p ≤ 0.05**
ED heart rate	P-value = <.001, this value means skewness of the variable **as p ≤ 0.05**
Scene respiratory rate	P-value = <.001, this value means skewness of the variable **as p ≤ 0.05**
ED respiratory rate	P-value = <.001, this value means skewness of the variable **as p ≤ 0.05**

Table 4.3: Checking the data normality of the continuous physiological variables through the Shapiro-Wilk test

The histograms do not look markedly skewed, but Shapiro-Wilk test suggests that the data are not normally distributed. Therefore, I decided to use the Mann-Whitney test to compare distributions, rather than comparing means, because the Shapiro-Wilk test suggests that the distributions were significantly different to the normal distribution. The Mann-Whitney test compares differences between two independent groups when either the predictor variable is ordinal or continuous, but not normally distributed.

After that, I produced histograms for each continuous variable using the Mann-Whitney test into: (a) limited to cases who died, (b) limited to other cases who survived (**see Figure 4.4**), showing the following histograms:





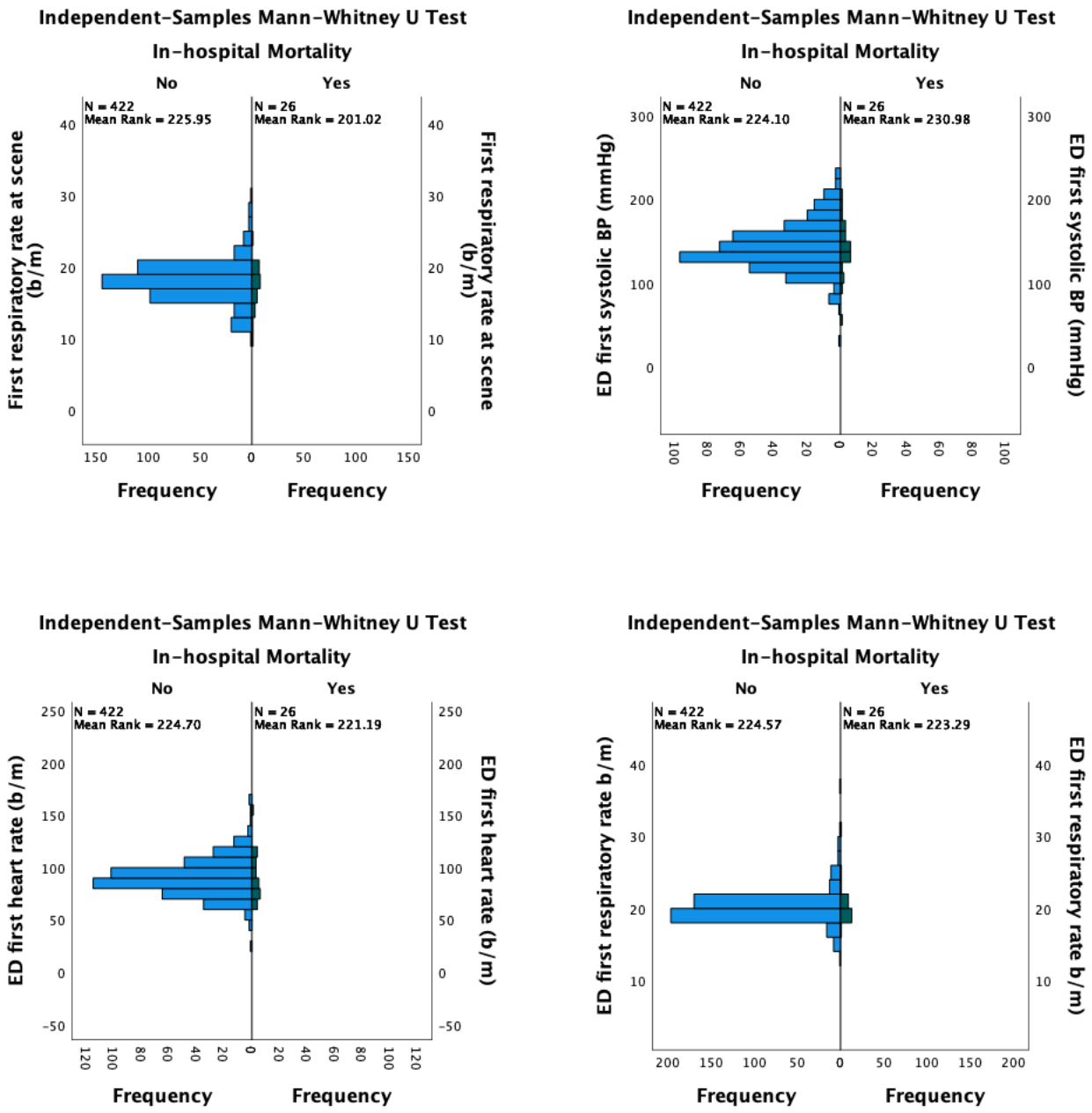


Figure 4.4: Plotting histograms for each of the continuous physiological variables limited to cases who died and limited to other cases who survived

These histograms in **the figure 4.4** suggest that for each variable, the distribution in the survivors was similar to the distribution in those who died.

4.2.3 Creation of deciles for continuous variables:

The process of creating deciles for continuous variables included all six continuous variables such as the scene SBP, heart rate, respiratory rate, ED SBP, heart rate, respiratory rate, by categorising variable values into ten deciles equally (10% of cases in each decile) from the lowest to highest values for these variables. The ten deciles were named as follows: Lowest, second, third, fourth, fifth, sixth, seventh, eighth, ninth, and highest.

Therefore, the 448 cases were divided into ten deciles as categories. 440 cases were initially divided into 44 cases into the ten deciles, followed by distributing the remaining 8 cases equally as the following **Tables 4.4 and 4.5**:

Deciles & rates of cases	***Arrangement of numbered cases in each decile***	***Number of cases***	***The decile values***
Lowest decile-10%	1 to 45	44+1	1
Second decile-20%	46 to 90	44+1	2
Third decile- 30%	91 to 135	44+1	3
Fourth decile- 40%	136 to 179	44	4
Fifth decile- 50%	180 to 224	44+1	5
Sixth decile- 60%	225 to 269	44+1	6
Seventh decile- 70%	270 to 313	44	7
Eighth decile- 80%	314 to 358	44+1	8
Ninth decile- 90%	359 to 403	44+1	9
Highest decile- 100%	404 to 448	44+1	10

Table 4.4: Distribution of the 448 cases into the ten deciles

Deciles & rates of cases	***Scene SBP mmHg***	***ED SBP mmHg***	***Scene heart rate b/m***	***ED heart rate b/m***	***Scene respiratory rate b/m***	***ED respiratory rate b/m***
Lowest decile-10%	52-110	37-111	42-70	21-69	10-15	13-18
Second decile-20%	110-120	111-121	71-77	69-76	15-15	18-18
Third decile- 30%	120-124	121-128	77-80	77-81	15-16	18-18

Fourth decile- 40%	124-130	128-134	80-84	81-85	16-18	18-19
Fifth decile- 50%	130-135	134-139	84-88	85-88	18-18	19-19
Sixth decile- 60%	135-139	139-144	88-90	88-91	18-18	19-20
Seventh decile- 70%	139-143	145-153	90-96	91-96	18-19	20-20
Eighth decile- 80%	143-150	154-163	97-102	96-102	19-20	20-20
Ninth decile- 90%	150-167	163-179	102-110	102-112	20-20	20-20
Highest decile- 100%	168-244	180-237	110-170	112-160	20-30	20-36

Table 4.5: Distributions of the ranges for each decile (each 10% of cases) under each decile variable

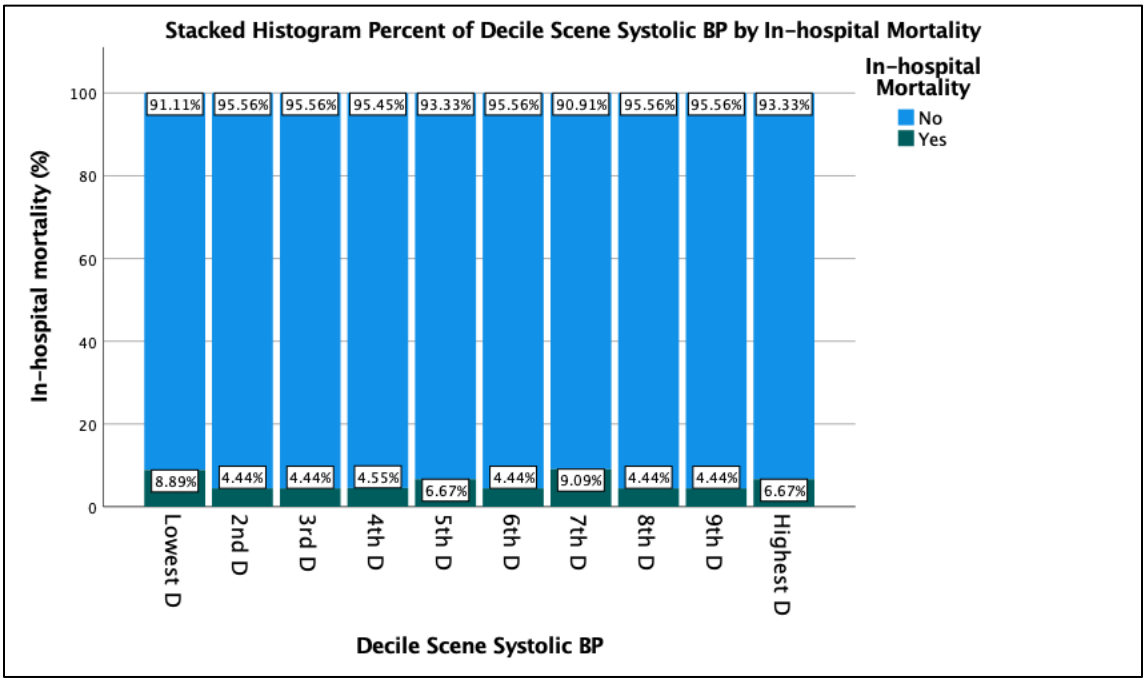
In **the table 4.5**, it can be helpful to check the upper limit of each variable in the "fifth decile-50%" row and use it as a median of each variable to be the same median values shown in **the Appendix 14**. In this table, we can notice that these continuous variables were divided into deciles, but values were different for prehospital and ED. Because deciles were examined to determine the relationship between each continuous variable and mortality, specifically whether it was a simple linear relationship. The size of the deciles depends on the underlying data, so it is appropriate that they will differ between prehospital and ED.

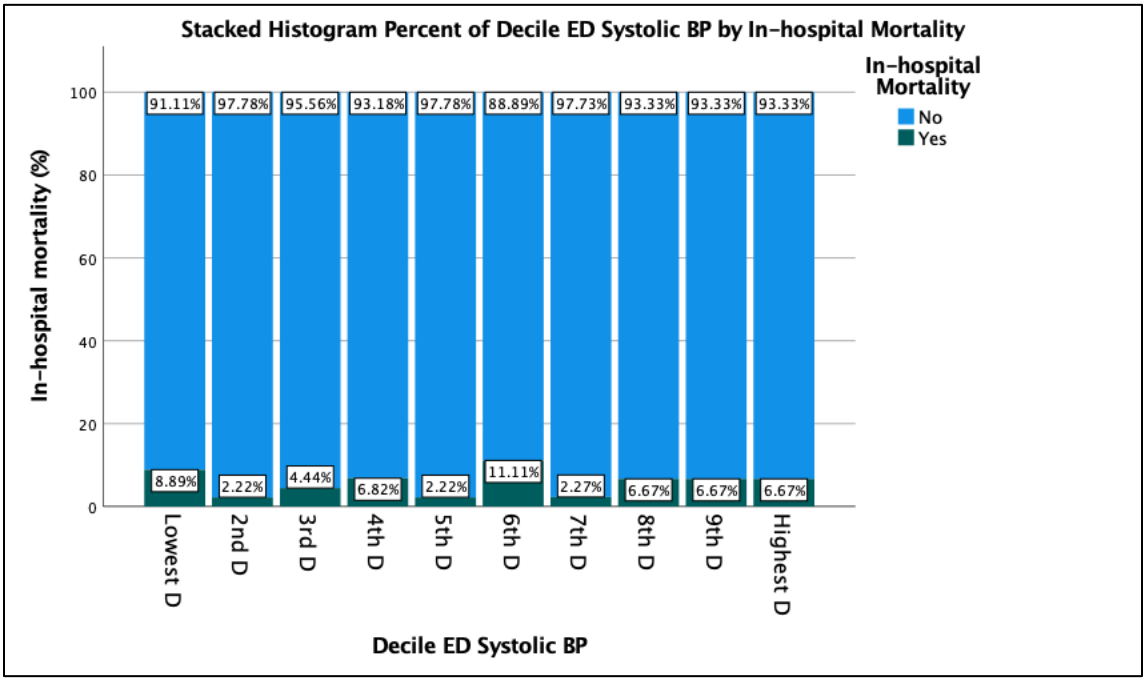
After that, the scene and ED physiologic variables were categorised into ten deciles to create decile scene and ED variables. The deciles of continuous variables were then analysed by cross-tabulating them with the in-hospital mortality in order to examine the percentages of died cases vary across the deciles (**see Table 4.6 and Figure 4.5**):

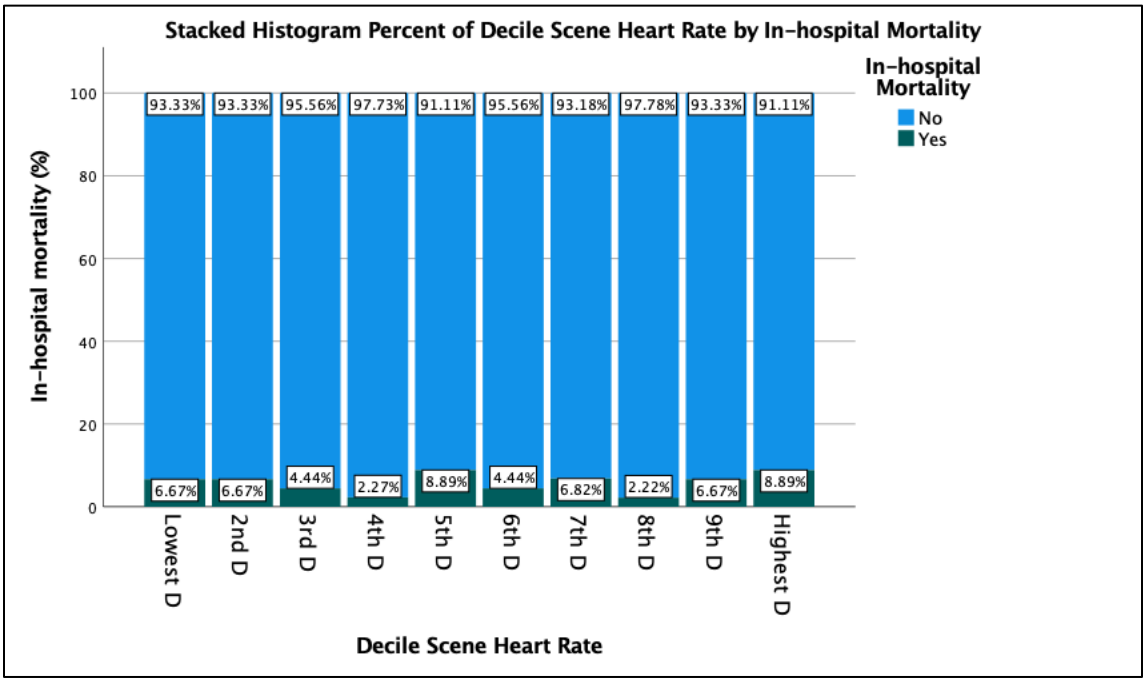
		In-hospital mortality (No. & % of died cases)									
Decile variables	***Mortality domains***	***Lowest decile***	***2nd decile***	***3rd decile***	***4th decile***	***5th decile***	***6th decile***	***7th decile***	***8th decile***	***9th decile***	***Highest decile***
Scene SBP	No	41 (91.1%)	43 (95.6%)	43 (95.6%)	42 (95.5%)	42 (93.3%)	43 (95.6%)	40 (90.9%)	43 (95.6%)	43 (95.6%)	42 (93.3%)
	Yes	4 (8.9%)	2 (4.4%)	2 (4.4%)	2 (4.5%)	3 (6.7%)	2 (4.4%)	4 (9.1%)	2 (4.4%)	2 (4.4%)	3 (6.7%)
ED SBP	No	41 (91.1%)	44 (97.8%)	43 (95.6%)	41 (93.2%)	44 (97.8%)	40 (88.9%)	43 (97.7%)	42 (93.3%)	42 (93.3%)	42 (93.3%)

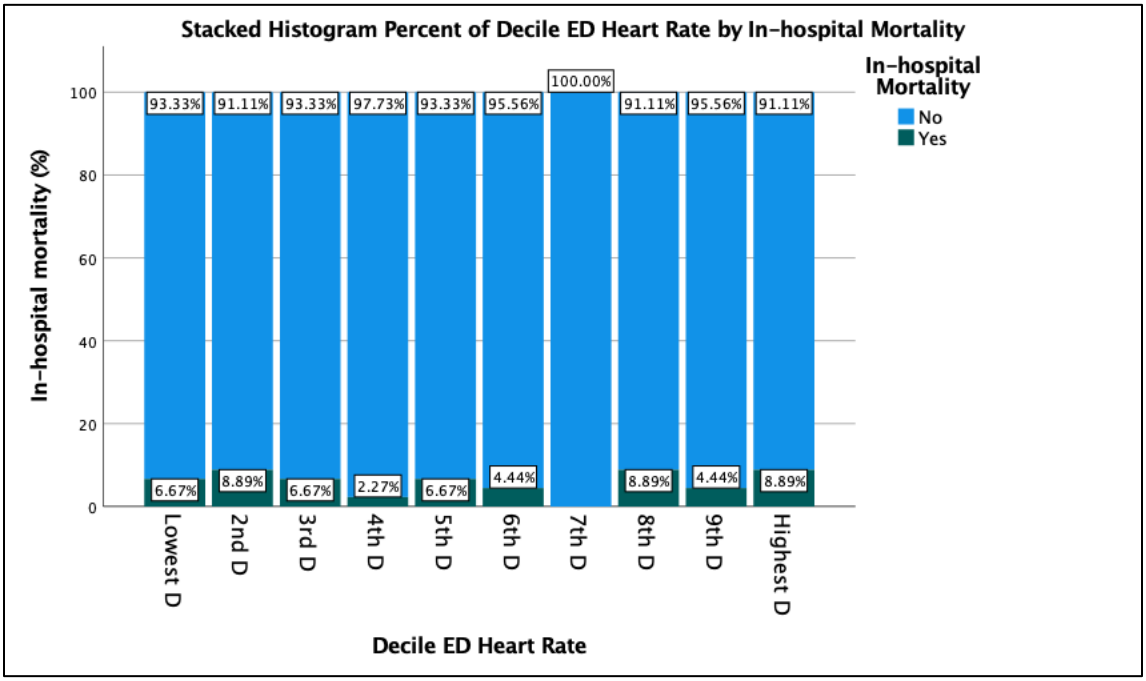
	Yes	4 (8.9%)	1 (2.2%)	2 (4.4%)	3 (6.8%)	1 (2.2%)	5 (11.1%)	1 (2.3%)	3 (6.7%)	3 (6.7%)	3 (6.7%)
Scene heart rate	No	42 (93.3%)	42 (93.3%)	43 (95.6%)	43 (97.7%)	41 (91.1%)	43 (95.6%)	41 (93.2%)	44 (97.8%)	42 (93.3%)	41 (91.1%)
	Yes	3 (6.7%)	3 (6.7%)	2 (4.4%)	1 (2.3%)	4 (8.9%)	2 (4.4%)	3 (6.8%)	1 (2.2%)	3 (6.7%)	4 (8.9%)
ED heart rate	No	42 (93.3%)	41 (91.1%)	42 (93.3%)	43 (97.7%)	42 (93.3%)	43 (95.6%)	44 (100%)	41 (91.1%)	43 (95.6%)	41 (91.1%)
	Yes	3 (6.7%)	4 (8.9%)	3 (6.7%)	1 (2.3%)	3 (6.7%)	2 (4.4%)	0 (0%)	4 (8.9%)	2 (4.4%)	4 (8.9%)
Scene respiratory rate	No	40 (88.9%)	44 (97.8%)	42 (93.3%)	41 (93.2%)	44 (97.8%)	41 (91.1%)	43 (97.7%)	40 (88.9%)	43 (95.6%)	44 (97.8%)
	Yes	5 (11.1%)	1 (2.2%)	3 (6.7%)	3 (6.8%)	1 (2.2%)	4 (8.9%)	1 (2.3%)	5 (11.1%)	2 (4.4%)	1 (2.2%)
ED respiratory rate	No	43 (95.6%)	42 (93.3%)	43 (95.6%)	40 (90.9%)	44 (97.8%)	40 (88.9%)	42 (95.5%)	44 (97.8%)	42 (93.3%)	42 (93.3%)
	Yes	2 (4.4%)	3 (6.7%)	2 (4.4%)	4 (9.1%)	1 (2.2%)	5 (11.1%)	2 (4.5%)	1 (2.2%)	3 (6.7%)	3 (6.7%)

Table 4.6: The in-hospital mortality for each continuous variable (numbers and percentages of died cases)


Stacked Histogram Percent of Decile Scene Systolic BP by In-hospital Mortality
In-hospital Mortality
No
Yes
In-hospital mortality (%)
100
80
60
40
20
0
91.11%
95.56%
95.56%
95.45%
93.33%
95.56%
90.91%
95.56%
95.56%
93.33%
8.89%
4.44%
4.44%
4.55%
6.67%
4.44%
9.09%
4.44%
4.44%
6.67%
Lowest D
2nd D
3rd D
4th D
5th D
6th D
7th D
8th D
9th D
Highest D
Decile Scene Systolic BP


Stacked Histogram Percent of Decile ED Systolic BP by In-hospital Mortality
In-hospital Mortality
No
Yes
In-hospital mortality (%)
100
80
60
40
20
0
91.11%
97.78%
95.56%
93.18%
97.78%
88.89%
97.73%
93.33%
93.33%
93.33%
8.89%
2.22%
4.44%
6.82%
2.22%
11.11%
2.27%
6.67%
6.67%
6.67%
Lowest D
2nd D
3rd D
4th D
5th D
6th D
7th D
8th D
9th D
Highest D
Decile ED Systolic BP


Stacked Histogram Percent of Decile Scene Heart Rate by In-hospital Mortality
In-hospital Mortality
No
Yes
In-hospital mortality (%)
100
80
60
40
20
0
93.33%
93.33%
95.56%
97.73%
91.11%
95.56%
93.18%
97.78%
93.33%
91.11%
6.67%
6.67%
4.44%
2.27%
8.89%
4.44%
6.82%
2.22%
6.67%
8.89%
Lowest D
2nd D
3rd D
4th D
5th D
6th D
7th D
8th D
9th D
Highest D
Decile Scene Heart Rate


Stacked Histogram Percent of Decile ED Heart Rate by In-hospital Mortality
In-hospital Mortality
No
Yes
In-hospital mortality (%)
100
80
60
40
20
0
93.33%
91.11%
93.33%
97.73%
93.33%
95.56%
100.00%
91.11%
95.56%
91.11%
6.67%
8.89%
6.67%
2.27%
6.67%
4.44%
8.89%
4.44%
8.89%
Lowest D
2nd D
3rd D
4th D
5th D
6th D
7th D
8th D
9th D
Highest D
Decile ED Heart Rate

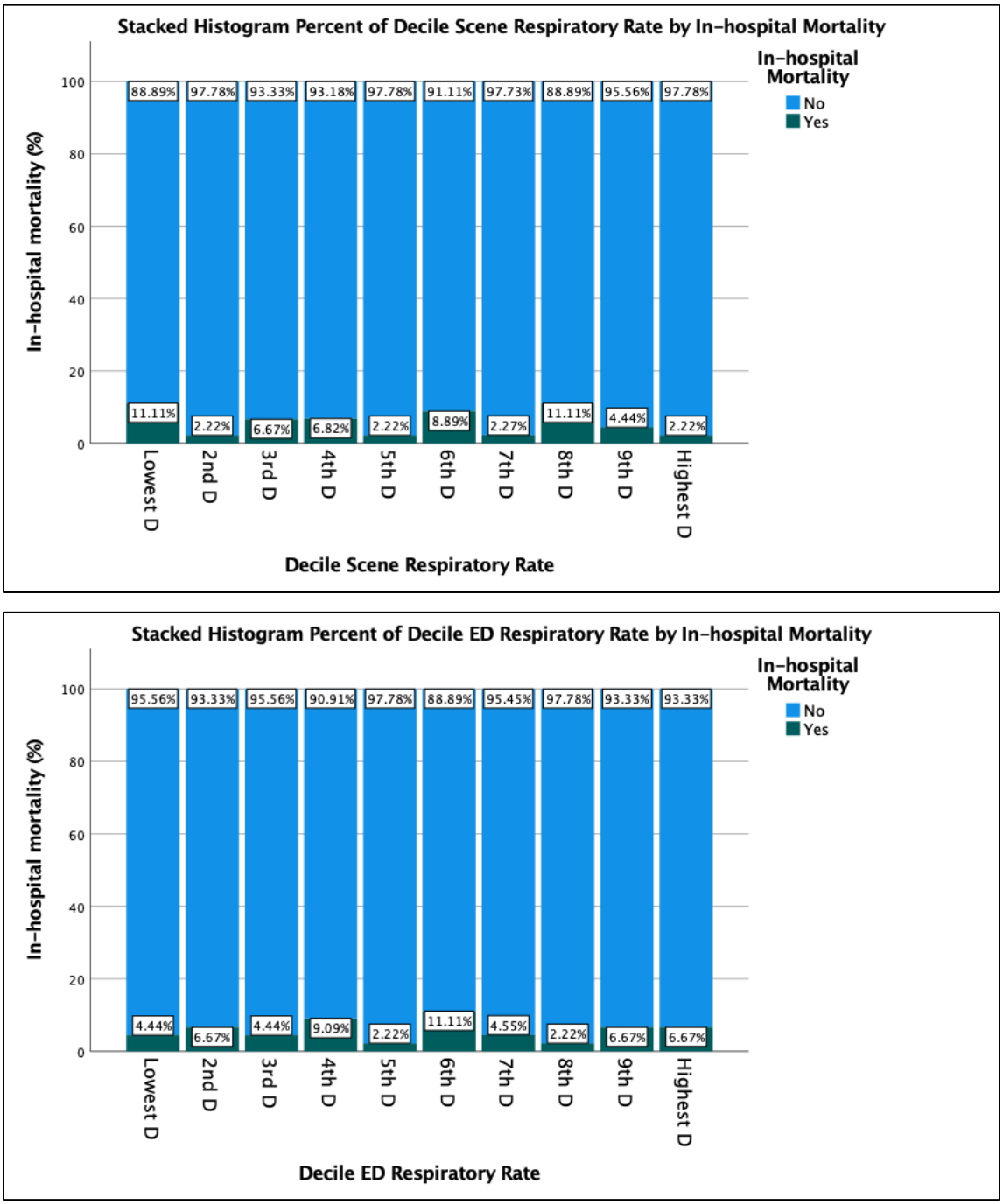


Figure 4.5: Varied percentages of in-hospital mortalities by deciles in each decile continuous variable

In **the figure 4.5**, the decile charts show no obvious variation in mortality across the deciles, apart from possible increased mortality in the lowest deciles. It is difficult to determine the relationship between the in-hospital mortality and decile continuous variables based on these histograms.

In **the table 4.6**, we can notice that mortality rates vary from one to five cases in each decile except the 7th decile of the ED heart rate. Therefore, the relationship of in-hospital mortality with these decile variables cannot be determined due to two possibilities: a) the variables are not associated with mortality and b) the impact of a limited number of recruited died cases.

After that, I have looked for categorising the continuous physiological variables into trauma scores by depending on previous studies focusing on prehospital and in-hospital trauma triage tools that use physiological variables to give patients a score (with a higher score indicating a higher risk of mortality). This action led to considering the following categories for the SBP, heart rate, and respiratory rate variables (**see Table 4.7**):

Continuous physiological variables	***The new categories***	***A category indicating a higher risk of mortality (based on the references)***	***Previous references used***	***Justification***
Scene SBP	SBP <90 mmHg SBP ≥90 mmHg	SBP <90 mmHg	(Caterino, Raubenolt and Cudnik, 2011; Werman *et al.*, 2011; Nakamura *et al.*, 2012; Staudenmayer *et al.*, 2013; Platts-Mills, Evans and Brice, 2016; Nishijima, S. D. Gaona, *et al.*, 2017; Brown *et al.*, 2019; Meyers *et al.*, 2019)	1)The authors of these studies used these two categories of the scene SBP in describing major trauma older cases in their studies or investigating for their local field-triage tools 2)The SBP <90 mmHg category was associated with high-risk older cases as investigated in the references.
Scene heart rate	<60 or >120 b/min 60-120 b/m	<60 or >120 b/min	(Grossman, M. D. , Miller, D. , Scaff, D. W. & Arcona, 2002).	This category was copied from the ED heart rate variable due to the lack of studies investigating prehospital heart rate for older cases, and no

			I used the ED heart rate ranges because the prehospital tools-related studies focus highly on the SBP, respiratory rate, GCS scores.	relevant studies use the heart rate as a part of field-triage tools.
Scene respiratory rate	<10 or >29 b/min 10–29 b/min	<10 or >29 b/min	(Werman *et al.*, 2011; Nishijima, S. D. Gaona, *et al.*, 2017; Brown *et al.*, 2019; Meyers *et al.*, 2019)	1)The authors of these studies used these two categories of the scene respiratory rate in describing major trauma older cases in their studies or investigating for their local field-triage tools. 2)The <10 or >29 b/min category was associated with high-risk older cases included in the references.
ED SBP	SBP <90 mmHg SBP ≥90 mmHg	SBP <90 mmHg	(Grossman, M. D. , Miller, D. , Scaff, D. W. & Arcona, 2002; Caterino, Raubenolt and Cudnik, 2011)	1)The authors of these studies used these two categories of the ED SBP in describing major trauma older cases in their studies or investigating for their local ED triage tools 2)The SBP <90 mmHg category was associated with high-risk older cases included in the references.
ED heart rate	<60 or >120 b/min 60-120 b/m	<60 or >120 b/min	(Grossman, M. D. , Miller, D. , Scaff, D. W. & Arcona, 2002)	1)The authors of this study used these categories of the ED heart rate in describing major trauma older cases in their studies or investigating for their local ED-triage tools. 2)The <60 or >120 b/min category was associated with high-risk older cases who were included in the references.
ED respiratory rate	<10 or >29 b/min 10–29 b/min	<10 or >29 b/min	(Anantha *et al.*, 2021)	1)The authors of this study used these categories of the ED respiratory rate in describing major trauma older cases in their studies or investigating for their local ED-triage tools. 2)The <10 or >29 b/min category was associated with high-risk older cases who were included in the references.

Table 4.7: The new categories of the continuous physiological variables based on previous geriatric trauma-related studies

Table 4.8 shows that very few cases would be categorised as having abnormal physiology based on the criteria outlined in **the Table 4.7**.

The variables	*Categories*	*No. of cases*	*Percent.*
Scene SBP	SBP <90 mmHg	7	1.6
	SBP ≥90 mmHg	441	98.4
ED SBP	SBP <90 mmHg	12	2.7
	SBP ≥90 mmHg	436	97.3
Scene heart rate	>120 b/m	14	3.1
	<60 b/m	5	1.1
	60-120 b/m	429	95.8
ED heart rate	>120 b/m	17	3.8
	<60 b/m	8	1.8
	60-120 b/m	423	94.4
Scene respiratory rate	>29 b/m	1	0.2
	<10 b/m	0	0
	10–29 b/m	447	99.8
ED respiratory rate	>29 b/m	3	0.7
	<10 b/m	0	0
	10–29 b/m	445	99.3

Table 4.8: The numbers and percentages of cases under the new categories of the prehospital SBP, heart rate, and respiratory rate, ED SBP, heart rate, and respiratory rate

4.2.4 The univariate analysis:

Univariate analysis was used to explore whether there are any associations between the patient characteristics and death followed by exploring any associations between patient characteristics and ISS:

4.2.4.1 Univariate analysis to explore associations between patient characteristics and death:

The Mann-Whitney test was used to test the association between continuous predictor variable and death by comparing the distribution of the predictor variables (the scene SBP, heart rate, respiratory rate, ED SBP, heart rate, or respiratory rate) between those who died and those who survived (**see Table 4.9**):

Continuous variables	***After the Mann-Whitney test use***
Scene SBP	P-value = 0.828 (2-tailed). P-value is higher than 0.05
ED SBP	P-value = 0.793 (2-tailed). P-value is higher than 0.05
Scene heart rate	P-value = 0.831 (2-tailed). P-value is higher than 0.05
ED heart rate	P-value = 0.893 (2-tailed). P-value is higher than 0.05
Scene respiratory rate	P-value = 0.331 (2-tailed). P-value is higher than 0.05
ED respiratory rate	P-value = 0.959 (2-tailed). P-value is higher than 0.05

Table 4.9: The P-values after testing the association between each continuous predictor variable and death using the Mann-Whitney test

After applying the Mann-Whitney test, we notice that the p-values are greater than 0.05 so these show no evidence of an association, which could be because there is no association each physiological variable and death or because the sample size was small to detect the association.

After that, all categorised physiological variables and other categorical variables were considered as predictor variables and then examined with the mortality by cross tabulating between each predictor variable (or other variables) and in-hospital mortality (**see Table 4.10**):

Variables	***Categories***	***Alive cases No. (%)***	***Died cases No. (%)***	***Total No. (%)***	***P-value (chi-square test)***	***Exact tests (if there are cells have expected count <5)***
Age subgroups (years)	55-64 65-74 75-84 85 and older	206 (94.5%) 97 (93.3%) 74 (93.7%) 45 (95.7%)	12 (5.5%) 7 (6.7%) 5 (6.3%) 2 (4.3%)	218 (100%) 104 (100%) 79 (100%) 47 (100%)	0.931	2 cells (25.0%) have expected count <5. P-value=0.923

Sex	Male Female	269 (95.1%) 153 (92.7%)	14 (4.9%) 12 (7.3%)	283 (100%) 165 (100%)	0.310	0 cell (0.0%) have expected count <5. P-value=0.305
Transport time from scene to MTC	<60 min ≥60 min	355 (94.7%) 67 (91.8%)	20 (5.3%) 6 (8.2%)	375 (100%) 73 (100%)	0.335	1 cell (25.0%) have expected count <5. P-value=0.408
MTC mode of arrival	Red Crescent ambulance Government ambulance Private ambulance	398 (94.5%) 22 (91.7%) 2 (66.7%)	23 (5.5%) 2 (8.3%) 1 (3.33%)	421 (100%) 24 (100%) 3 (100%)	0.104	3 cells (50.0%) have expected count <5. P-value=0.145
Injury cause	Fall-high Fall-low Fire, flames, or smoke Cutting or piercing object Motor vehicle accidents Motorcycle accidents Pedestrian accidents Struck by or collision with person or object	46 (95.8%) 226 (93.4%) 7 (100%) 0 (0.0%) 77 (97.5%) 3 (75%) 58 (95.1%) 5 (100%)	2 (4.2%) 16 (6.6%) 0 (0.0%) 2 (100%) 2 (2.5%) 1 (25%) 3 (4.9%) 0 (0.0%)	48 (100%) 242 (100%) 7 (100%) 2 (100%) 79 (100%) 4 (100%) 61 (100%) 5 (100%)	<0.001	10 cells (62.5%) have expected count <5. P-value=0.015
Affected body areas	Head Neck Thorax Abdomen, lower back, lumbar spine, and pelvis Hip and thigh Extremities Multiple body areas Burns of external surfaces	37 (88.1%) 2 (100%) 23 (85.2%) 69 (100%) 119 (96.7%) 109 (94.8%) 59 (92.2%) 4 (66.7%)	5 (11.9%) 0 (0.0%) 4 (14.8%) 0 (0.0%) 4 (3.3%) 6 (5.2%) 5 (7.8%) 2 (33.3%)	42 (100%) 2 (100%) 27 (100%) 69 (100%) 123 (100%) 115 (100%) 64 (100%) 6 (100%)	0.003	7 cells (43.8%) have expected count <5. P-value=0.003
Number of prior facilities	No prior facilities One prior facility Two prior facilities	398 (94.1%) 20 (95.2%) 4 (100%)	25 (5.9%) 1 (4.8%) 0 (0.0%)	423 (100%) 21 (100%) 4 (100%)	0.862	3 cells (50.0%) have expected count <5. P-value=1.000
Hospital destinations	Direct to MTC Indirect to MTC	398 (94.8%) 24 (85.7%)	22 (5.2%) 4 (14.3%)	420 (100%) 28 (100%)	0.047	1 cell (25.0%) have expected count <5. p-value=0.070

Trauma team activation	Yes No	28 (93.3%) 394 (94.3%)	2 (6.7%) 24 (5.7%)	30 (100%) 418 (100%)	0.834	1 cell (25.0%) have expected count <5. p-value=0.690
Mental status at scene (AVPU)	Alert Verbal Painful Unresponsive	356 (93.9%) 4 (100%) 51 (98.1%) 11 (84.6%)	23 (6.1%) 0 (0.0%) 1 (1.9%) 2 (15.4%)	379 (100%) 4 (100%) 52 (100%) 13 (100%)	0.271	4 cells (50.0%) have expected count <5. P-value=0.233
Scene SBP	<90 mmHg ≥90 mmHg	6 (85.7%) 416 (94.3%)	1 (14.3%) 25 (5.7%)	7 (100%) 441 (100%)	0.333	1 cell (25.0%) have expected count <5. p-value=0.344
Scene heart rate	<60 or >120 b/min 60-120 b/m	18 (94.7%) 404 (94.2%)	1 (5.3%) 25 (5.8%)	19 (100%) 429 (100%)	0.918	1 cell (25.0%) have expected count <5. p-value=1.000
Scene respiratory rate	<10 or >29 b/min 10–29 b/min	1 (100%) 421 (94.2%)	0 (0.0%) 26 (5.8%)	1 (100%) 447 (100%)	0.804	2 cells (50.0%) have expected count <5. p-value=1.000
ED GCS score	15 14 13 < 13	390 (94.4%) 7 (100%) 5 (100%) 20 (87%)	23 (5.6%) 0 (0.0%) 0 (0.0%) 3 (13%)	413 (100%) 7 (100%) 5 (100%) 23 (100%)	0.394	4 cells (50.0%) have expected count <5. P-value=0.455
ED SBP	<90 mmHg ≥90 mmHg	11 (91.7%) 411 (94.3%)	1 (8.3%) 25 (5.7%)	12 (100%) 436 (100%)	0.704	1 cell (25.0%) have expected count <5. p-value=0.516
ED heart rate	<60 or >120 b/min 60-120 b/m	24 (96%) 398 (94.1%)	1 (4%) 25 (5.9%)	25 (100%) 423 (100%)	0.691	1 cell (25.0%) have expected count <5. p-value=1.000
ED respiratory rate	<10 or >29 b/min 10–29 b/min	2 (66.7%) 420 (94.4%)	1 (3.33%) 25 (5.6%)	3 (100%) 445 (100%)	0.041	2 cells (50.0%) have expected count <5. p-value=0.165

Table 4.10: Cross-tabulation of categorical variables between each predictor variable or other variables and in-hospital mortality

Based on the results in **the table 4.10**, firstly, it is worth noting in the number of died cases between the different age subgroups that mortality does not increase with age. This could be due to selection bias, if older patients at high risk of mortality were not taken to the MTC. Secondly, the results suggest that there are univariate association between the injury cause (mechanism, of injury) and affected body areas variables and death, since the p values in these predictor variables were less than 0.05 based on the Exact tests.

This interpretation I made, were based on statistical significance on the Chi-square test or the two Exact tests (such as the Fisher's Exact test or Fisher–Freeman–Halton exact test). Pearson's Chi-square test compares observed and expected values in contingency tables that are used to express categorical associations (Hess and Hess, 2017). With Pearson's chi-square test, the data can be expressed in contingency tables in a wide range of ways; however, it requires the following assumptions: 1) the data are from a simple random sample, 2) the sample size is sufficient so that the expected cell counts are adequate, and 3) are independent of one another (Hess and Hess, 2017).

However, more appropriate tests to use if cells are sparsely populated so that any cell value is less than 5 are the Exact tests rather than the chi-square test (Hess and Hess, 2017). The Fisher's exact test is used with 2 x 2 contingency tables, whereas the Fisher-Freeman-Halton exact test is used with contingency tables that have 2 rows and more than 2 columns (Freeman and Halton, 1951; Ludbrook, 2008). Thus, I considered the p values of the Chi-square tests for cells in contingency tables with ≥5 observations in expressing the results of **the table 4.10**. But I used the Exact test p values for cells with <5 observations and percentages between brackets equal 25% or more (as shown in the Exact tests column).

Further, because I used multiple hypothesis tests in the univariate analysis to determine whether the predictor variables are associated with the death, I decided to adjust the p value (0.05) used across multiple hypothesis tests to a lower threshold. Jafari and Ansari-Pour (2019) argued, 0.05 is merely a convention, but completely arbitrary. They suggested that this value doesn't apply to all variables or research settings (Jafari and Ansari-Pour, 2019). For instance, an application of a stricter cut-off of 0.01 is recommended in some disease association studies (Jafari and Ansari-Pour, 2019).

Perneger (1998) justified adjusting the original p value by exemplifying that a significant difference (P value 0.05) can be observed by chance once in 20 trials if a null hypothesis is true (for example, no

difference between two treatment groups in a randomised trial). This is called a type I error, or α (Perneger, 1998). The original significance level of 0.05 should be adjusted due to the inflated probability of a false positive in this scenario (Jafari and Ansari-Pour, 2019). Perneger (1998) and Armstrong (2014) recommended, probability (p) values are adjusted using a Bonferroni correction when multiple statistical tests are performed and due to the risk of a type I error.

My univariate analysis examined 17 predictor variables (using Chi-square or Exact tests for each one) to determine which one was associated with mortality. The Bonferroni correction should be used by using this formula: $1 - (1 - \alpha) / T$, since α is the original alpha level and T is the number of tests undertaken (Armstrong, 2014). Therefore, $1 - (1 - 0.05) / 17 = 0.0029$ and $p<0.0029$ would be significant. By using this adjusted p value, I conclude that there are no univariate association between the predictor variables and death.

4.2.4.2 Univariate analysis to explore associations between patient characteristics and ISS:

I also conducted univariate analysis to explore whether there are significant associations between patient characteristics such (age, sex, mechanism of injury, affected body parts, and scene and ED physiological variables) and ISS (dichotomised into ISS <16 versus ≥16) (**see Table 4.11**):

Variables	***Categories***	***ISS <16 No. (%)***	***ISS ≥16 No. (%)***	***Total No. (%)***	***P-value (chi-square test)***	***Exact tests (if there are cells have expected count <5)***
Age subgroups (years)	55-64 65-74 75-84 85 and older	181 (83.0%) 93 (89.4%) 68 (86.1%) 42 (89.4%)	37 (17.0%) 11 (10.6%) 11 (13.9%) 5 (10.6%)	218 (100%) 104 (100%) 79 (100%) 47 (100%)	0.396	0 cells (0.0%) have expected count <5. P-value=0.434
Sex	Male Female	246 (86.9%) 138 (83.6%)	37 (13.1%) 27 (16.4%)	283 (100%) 165 (100%)	0.337	0 cell (0.0%) have expected count <5. P-value=0.401
Injury cause	Fall-high Fall-low Fire, flames, or smoke Cutting or piercing object	44 (91.7%) 214 (88.4%) 5 (71.4%) 0 (0%)	4 (8.3%) 28 (11.6%) 2 (28.6%) 2 (100%)	48 (100%) 242 (100%) 7 (100%) 2 (100%)	0.009	7 cells (43.8%) have expected count <5. P-value=0.020

	Motor vehicle accidents Motorcycle accidents Pedestrian accidents Struck by or collision with person or object	64 (81%) 3 (75%) 50 (82%) 4 (80%)	15 (19%) 1 (25%) 11 (18%) 1 (20%)	79 (100%) 4 (100%) 61 (100%) 5 (100%)		
Affected body areas	Head Neck Thorax Abdomen, lower back, lumbar spine, and pelvis Hip and thigh Extremities Multiple body areas Burns of external surfaces	26 (61.9%) 2 (100%) 23 (85.2%) 62 (89.9%) 121 (98.4%) 115 (100%) 33 (51.6%) 2 (33.3%)	16 (38.1%) 0 (0%) 4 (14.8%) 7 (10.1%) 2 (1.6%) 0 (0%) 31 (48.4%) 4 (66.7%)	42 (100%) 2 (100%) 27 (100%) 69 (100%) 123 (100%) 115 (100%) 64 (100%) 6 (100%)	<0.001	4 cells (25.0%) have expected count <5. P-value=0.015
Mental status at scene	Alert Verbal Painful Unresponsive	319 (84.2%) 3 (75%) 51 (98.1%) 11 (84.6%)	60 (15.8%) 1 (25%) 1 (1.9%) 2 (15.4%)	379 (100%) 4 (100%) 52 (100%) 13 (100%)	0.055	3 cells (37.5%) have expected count <5. P-value=0.014
Scene SBP	<90 mmHg ≥90 mmHg	7 (100%) 377 (85.5%)	0 (0.0%) 64 (14.5%)	7 (100%) 441 (100%)	0.276	1 cell (25.0%) have expected count <5. p-value=0.600
Scene heart rate	<60 or >120 b/min 60-120 b/m	19 (100%) 365 (85.1%)	0 (0.0%) 64 (14.9%)	19 (100%) 429 (100%)	0.069	1 cell (25.0%) have expected count <5. p-value=0.090
Scene respiratory rate	<10 or >29 b/min 10–29 b/min	1 (100%) 383 (85.7%)	0 (0.0%) 64 (14.3%)	1 (100%) 447 (100%)	0.683	2 cells (50.0%) have expected count <5. p-value=1.000
ED GCS score	15 14 13 < 13	353 (85.5%) 6 (85.7%) 5 (100%) 20 (87%)	60 (14.5%) 1 (14.3%) 0 (0%) 3 (13%)	413 (100%) 7 (100%) 5 (100%) 23 (100%)	0.830	4 cells (0.0%) have expected count <5. P-value=1.000
ED SBP	<90 mmHg ≥90 mmHg	10 (83.3%) 374 (85.8%)	2 (16.7%) 62 (14.2%)	12 (100%) 436 (100%)	0.811	1 cell (25.0%) have expected count <5. p-value=0.684

ED heart rate	<60 or >120 b/min 60-120 b/m	22 (88.0%) 362 (85.6%)	3 (12.0%) 61 (14.4%)	25 (100%) 423 (100%)	0.737	1 cell (25.0%) have expected count <5. p-value=1.000
ED respiratory rate	<10 or >29 b/min 10–29 b/min	3 (100%) 381 (85.6%)	0 (0.0%) 64 (14.4%)	3 (100%) 445 (100%)	0.478	2 cells (50.0%) have expected count <5. p-value=1.000

Table 4.11: Cross-tabulation of categorical variables between the patient characteristics and ISS

According to the findings of **the table 4.11**, it is obvious that overall, most patients in the cohort admitted to the MTC have ISS<16. This also could be caused by selection bias, since ambulance services transport older patients with minor injuries to the MTC despite that most of those patients are males compared to females, had normal physiology, falls from standing, with limb injuries including hip injuries. The results also suggest there are univariate associations between the injury cause, affected body area and mental status variables and ISS ≥16, since the p values in these predictor variables were less than 0.05 based on the Exact tests. I then decided to use the Bonferroni correction as follows: $1 - (1 - \alpha) / T = 1 - (1 - 0.05) / 12 = 0.0041$ and $p<0.0041$ would be significant. By using this adjusted p value, I conclude that there are no univariate association between the predictor variables and death.

4.2.5 The multivariable analysis:

At this stage, I have decided to undertake a binary logistic regression to identify predictors of in-hospital mortality in older people by selecting each variable with a $p<0.2$ association with death as covariates and in-hospital mortality as the outcome by selecting covariates from **the table 4.10**. This action led to identifying the included and excluded variables (**see Table 4.12**):

Variables	***Decision***	***Justification***
Age subgroups, sex, Transport time from scene to MTC, Number of prior facilities, Trauma team activation, Mental status at the scene, Scene SBP, Scene heart rate, Scene respiratory rate, ED GCS, ED SBP, and ED heart rate.	Excluded	Variables are not with a $p<0.2$ association with the in-hospital mortality.

MTC mode of arrival, Injury cause, Affected body parts, Hospital destinations, and ED respiratory rate	Included	Variables are with a p<0.2 association with the in-hospital mortality.

Table 4.12: The included and excluded variables for the binary logistic regression model

The binary logistic regression then was undertaken using the five included variables. During logistic regression modelling, it is essential to determine a reference in one of the categories of each selected variable. I decided then to consider the following references: "Private ambulance" category in the MTC mode of arrival, "Cutting or piercing object" category in the injury cause, "Burns of external surfaces" category in the affected body parts, "Indirect transport to MTC" category in the hospital destination, and "10-29 b/min" category in the ED respiratory rate variable.

To justify my selection for these reference categories, I chose normal categories in physiological variables as reference categories so that I can compare the likelihood of mortality when deviations from normal values are observed. In other injury-related variables, the lowest rate categories were used as reference categories because it allows me to compare different categories relating to mortality with the least common or least severe.

The results of the binary logistic regression are as follows (**see Table 4.13**):

Covariates	***Categories***	***Adjusted odds ratio***	***95% confidence intervals***		***P-value***
			Lower	***Upper***	
MTC mode of arrival	Red Crescent ambulance	0.07	0.01	0.96	0.046
	Government ambulance	0.13	0.01	2.90	0.197
	Private ambulance (Ref)	1.00			
Injury cause	Fall-high	0	0	.	0.999
	Fall-low	0	0	.	0.999
	Fire, flames, or smoke	0	0	.	0.999
	Motor vehicle accidents	0	0	.	0.999
	Motorcycle accidents	0	0	.	0.999
	Pedestrian accidents	0	0	.	0.999
	Struck by or collision with person or object	0	0	.	0.999
	Cutting or piercing object (Ref)	1.00			

Affected body parts	Head	0.24	0.03	1.86	0.172
	Neck	0.29	0.03	2.63	0.273
	Thorax	0.00	0.00	.	0.997
	Abdomen, lower back, lumbar spine, and pelvis	0.08	0.01	0.63	0.016
	Hip and thigh	0.12	0.02	0.84	0.032
	Extremities	0.18	0.02	1.36	0.095
	Multiple body areas	0.00	0.00	.	0.999
	Burns of external surfaces (Ref)	1.00			
Hospital destinations	Direct transport to MTC	0.45	0.11	1.89	0.274
	Indirect transport to MTC (Ref)	1.00			
ED respiratory rate	<10 or >29 b/min	17.47	1.10	277.23	0.043
	10–29 b/min (Ref)	1.00			
Constant		0.000			0.999
a Variable(s) entered on step 1: KSMC mode of arrival, Injury cause, Affected body areas, Hospital destination, ED respiratory rate.					

Table 4.13: The multivariable logistic regression model using the five selected variables

Considering the odds ratio in **the table 4.13**, if the odds ratio equals 1, it will show no effect, while if it is greater than 1, the predictor variable will show an increase in the odds of the outcome or vice versa (Garson D. G., 2013). Therefore, results indicate that regarding the MTC mode of arrival, the probability of in-hospital mortality among older trauma cases who were admitted by the Red Crescent Authority ambulances is 0.07 less likely compared to cases who were admitted by private ambulances. The affected body parts variable was then considered. The results show that the probability of death among older trauma cases who had abdomen, lower back, lumbar spine, and pelvis injures is 0.08 less likely compared to older cases who had burns injuries. Also, the probability of death among older trauma cases who had hip and thigh injures is 0.12 less likely compared to older cases who had burns injuries. Lastly, the probability of death among older trauma cases who had abnormal respiratory rates (<10 or >29 b/min) in the MTC ED is 17.47 more likely compared to older cases who had ED normal respiratory rates. These odds ratios were indicated after considering the significance of all variables' categories included in the model (if p-value showed <0.05 in each variable category meaning that there

is a significance). Overall, despite these findings, this multivariable analysis is limited by small numbers of deaths.

4.2.6 Hypothesis testing

As in the third chapter, I hypothesised that the GCS, SBP, pulse rate, and respiratory rate (continuous predictor variables) could be used as initial field geriatric criteria in Saudi Arabia to reduce undertriage and overtriage. However, I did not consider the GCS variable in this analysis, since I used another trauma registry that collected mental status AVPU (categorical) data instead of scene GCS (continuous) data.

I proposed this hypothesis to determine whether the predictor variables (prehospital SBP, heart rate, and respiratory rate) differ between the age strata (55-64, 65-74, 75-84 and ≥ 85 years old), by conducting a secondary analysis to identify whether the predictive association of these continuous variables with the outcome variable differs between the strata by repeating the multivariable analysis in each age strata. This is to examine if I obtained different results in different strata with taking into consideration that I may face insufficient statistical power if there are small numbers of outcomes (in-hospital mortality) in each age strata.

This secondary analysis was conducted by repeating the multivariable analysis for each age strata as the following (**see Table 4.14**) shows number of the included cases based on different variables' categories through the age subgroups and (**see Appendix 16**) presents the repeated multivariable analysis results.

Age subgroups (years)	*No. of cases in each subgroup*	*In-hospital mortality (Frequency)*		*Variables*	*Categories*	*No. of cases in each category*
		No	*Yes*			
55-64	218	206	12	Scene SBP	<90 mmHg	4
					≥90 mmHg	214
				Scene heart rate	<60 or >120 b/min	9
					60-120 b/m	209

				Scene respiratory rate	<10 or >29 b/min 10–29 b/min	1 217
65-74	104	97	7	Scene SBP	<90 mmHg ≥90 mmHg	2 102
				Scene heart rate	<60 or >120 b/min 60-120 b/m	6 98
				Scene respiratory rate	<10 or >29 b/min 10–29 b/min	0 0
75-84	79	74	5	Scene SBP	<90 mmHg ≥90 mmHg	1 78
				Scene heart rate	<60 or >120 b/min 60-120 b/m	3 76
				Scene respiratory rate	<10 or >29 b/min 10–29 b/min	0 0
85 and older	47	45	2	Scene SBP	<90 mmHg ≥90 mmHg	0 0
				Scene heart rate	<60 or >120 b/min 60-120 b/m	1 46
				Scene respiratory rate	<10 or >29 b/min 10–29 b/min	0 0

Table 4.14: Number of the included cases based on different variables' categories through the age subgroups

Based on the results in **the table 4.14**, I conclude that the analysis was limited by the small number of deaths, with many categories of predictor variable having no deaths, so I cannot draw meaningful conclusions.

4.3 Discussion:

In this study, I sought to address two objectives: describe injury characteristics in older population and identify predictors of in-hospital mortality. 452 eligible older cases with injuries were recruited. These objectives were discussed as the following:

4.3.1 Discussing the first objective of the study:

For this objective, the age was divided into four subgroups, and I found that (55–64-year-old) cases were the majority of older cases admitted to the MTC (220 cases – 48.8%), followed by 65-74 subgroup (104 cases – 23.1%), 75-84 subgroup (80 cases – 17.7%), and ≥85 subgroup (47 cases – 10.4%). In terms of gender, the study included 285 male cases representing 63.2% and 166 female cases (36.8%). In terms of the mechanisms of injury, the majority of the cases admitted to the MTC by the fall-low (242 cases - 53.7%), followed by MVC cases (81 cases – 18.0%), pedestrians' injuries (61 cases – 13.5%), fall-high (49 cases – 10.9%), and so on. Regarding the in-hospital mortality, ISS, and length of stay in hospital, overtriage issue was noticed by admitting minor trauma patients to the MTC. As the study included 426 alive cases representing 94.2% against only 26 died cases (5.8%), and only one patient with missing outcome. Also, in terms of outcomes, 235 cases (52.1%) of the included cases were with ISS= 9-15 moderate, followed by 152 cases (33.7%) who had ISS= 0-8 minor, and 64 cases (14.2%) who had ISS= ≥16 serious. Moreover, half of the included cases (50.7% - 229 cases) who stayed in the hospital from 1 to 10 days, followed by 150 cases (33.2%) who stayed from 11 to 20 days in the hospital, and 73 cases (16.2%) who stayed in the hospital for >20 days. The relatively low mortality rate and ISS indicate that non-seriously injured patients are being taken to the MTC, and this therefore can indicate over-triage. This can be supported by Alharbi *et al.* (2020) since they argue Saudi paramedics and EMTs transport all trauma patients to nearest hospitals regardless of the level of care required due to the absence of clear triage guidelines. Therefore, I found the majority of recruited cases admitted to the KSMC MTC were minor cases. Also, it is expected that Saudi paramedics and EMTs transport older trauma patients to non-trauma hospitals (nearest hospitals) despite lower levels of care provided (undertriage).

Overall, this study highlights the lack of abnormal physiology among the admitted older patients. According to the findings, they tended to have fallen from standing, with high prevalence of limb injuries including hip injuries, low prevalence of abnormal physiology, relatively long hospital stays, and relatively low mortality rates. In terms of comparison, three relevant North-American studies that have studied the length of stay and in-hospital mortality (Staudenmayer *et al.*, 2013; Newgard *et al.*, 2014; Benjamin *et al.*, 2018). Staudenmayer *et al.* (2013) in Utah and California states, have recruited 2,446 (40.7%) older trauma patients (55 years and older) of 6,015 recruited trauma patients and reported

that 140 (5.7) older patients of 2,446 have 60 days-mortality and length of stay among those 140 patients were (1.0 to 5.0 days, median=3.0 days). Newgard *et al.* (2014) also conducted study in 7 regions of the western United States, recruited 44,890 older patients from 122 trauma and non-trauma hospitals and then divided them into two groups: (ISS ≥ 16=2,328 patients versus ISS < 16=42,562 patients). Newgard *et al.* (2014) then reported that 1,189 (2.7%) patients have died during hospital stays including 359 (15.4%) who died with ISS ≥ 16 and 830 (2.0%) who died with ISS < 16, the median length of stay among the 44,890 older trauma patients was 2 days (IQR=0 to 5 days). Lastly, Benjamin *et al.* (2018) have recruited 644,846 younger cases (<60 years) and 358,504 older cases (≥ 60 Years). They reported that 9,282 (2.6%) of older trauma patients died during their hospital stays. These findings are consistent with the characteristics of my cohort because these three studies also showed relatively low mortality rates and ISS. Newgard *et al.* (2014) and Benjamin *et al.* (2018) also indicated the overtriage and undertriage issues while Staudenmayer *et al.* (2013) reported that high rates of undertriage in their cohort.

4.3.2 Discussing the second objective of the study:

For the second objective, univariate analysis followed by multivariable logistic regression were conducted. The results showed there is no obvious association between the predictor variables and death. This issue also can be caused by potential factors from the perspective of Saudi Arabia: a) limited number of death cases and a low prevalence of abnormal physiology, b) population demographics, c) Saudi paramedics and EMTs' response to older patients, d) the MTC's policies in receiving those patients, or e) patient selection process in analysis:

Firstly, limited number of death cases and a low prevalence of abnormal physiology in this study's cohort that led to reduced statistical power. The other point worth noting is that there was little evidence of a non-significant trend toward an association between known predictors and mortality. Linking this to the population characteristics, this could be because mortality is difficult to predict in a population of older people who have fallen from standing and have normal physiology. Comorbidities or medications may be the main predictors of death rather than markers of acute injury (such as abnormal physiology).

Secondly, population demographics in Saudi Arabia can play important roles in determining number of older cases admitted to the Saudi hospitals compared to the younger populations. According to the Saudi Ministry of Health, the older population (65 years old and over) in Saudi Arabia represent 3.5% of the population while younger population represent about 72 % (15-64 years old) and 24.5 % of the population represent people under 15 years old (MOH, 2021). This issue was clear in a Saudi study that recruited all trauma patients from a MTC's trauma registry at the same city since it has included 401 older trauma cases (65 years old and over), representing 10.6% of the sample, 2490 younger patients (15-64 years old - 65.7%), and 896 pediatric cases (23.7%), who were admitted to the ED through three years (Abolfotouh *et al.*, 2018). In comparisons to other countries, studies of population demographics worldwide suggest that 20% of the US population will be aged over 65 by 2030, 23% of the UK population aged 65 or more by 2035, 30% aged over 65 in Europe by 2050, and 21% in Australia by 2054 (Office for National Statistics, 2012; United Nations, 2014; Australian Institute of Health and Welfare, 2015; Dalton, NPM and Monroe, 2015).

Thirdly, it was indicated in chapter one how Saudi paramedics and EMTs respond to older patients. It stated that paramedics and EMTs transport trauma patients to the nearest hospital regardless of the level of care needed because there are no clear trauma triage guidelines (Alharbi *et al.*, 2020). This suggests that there may be more major trauma cases received by non-trauma hospitals in Saudi Arabia than those received by the MTCs, along with issues of transporting high rates of minor trauma cases to the MTC rather than major cases to the MTCs. This was clear in the number of recruited cases in the Abolfotouh *et al.* (2018)'s study.

Fourthly, current unclear KSMC-MTC's policies in receiving those patients can be a contributory factor. Ideally, major trauma patients should be transported to MTCs, and those who have less severe injuries are transported to non-trauma hospitals. However, the two MTCs in Saudi Arabia still have unclear and modest application of their policies in receiving and managing trauma patients. According to Alharbi *et al.* (2020), unclear trauma team activation protocols, absence of quality assurance programmes for trauma care, lack of trauma-related research, and suboptimal quality of trauma care in the Saudi MTCs led to low classifications based on the ACS criteria employed to assess the level of prehospital care. Therefore, these issues in the two Saudi MTCs and other trauma units can lead to a lack of clear policies to distinguish between major and minor trauma cases and coordinate with the

prior prehospital services to bypass only major trauma cases to MTCs. Consequently, the mortality rate was lower in this cohort. Another recent Saudi study also recruited all trauma patients admitted to the same MTC (Alsenani *et al.*, 2021). This study recruited 2436 trauma cases for one year involving 233 older cases (older than 60 years old – 9.6%), 1906 younger cases (15-60 years old – 78.3%), and 297 pediatric cases (0-14 years old – 12.2%). Regarding the ISS, 1734 cases (78.1%) were within ≤12 score, followed by 401 cases (18.1%) were within 13-25 score, 64 cases (2.9%) were within 26-40 score, and 13 cases (0.6%) were within >40 score (Alsenani *et al.*, 2021). These findings might reflect the issue of employing the MTC in receiving and treating minor trauma cases rather than major cases. The authors then indicated that the sample size was relatively small leading to limited interpretation of the results and data was not generalisable to the whole population in the country (Alsenani *et al.*, 2021).

Lastly, the patient selection process in a quantitative study may influence on the analysis of findings. At the beginning of this study, I described the process of including and excluding cases in order to ensure accurate eligibility of cases (**as shown in the Figure 4.1**), followed by describing and comparing the included and excluded cases. Describing and comparing between the 452 included and 894 excluded cases showed there are no clear differences in the percentages of variable categories between these two groups of cases (**as shown in the Table 4.1**). Therefore, due to similar characteristics between the included and excluded cases, patient selection in my study is unlikely to explain the lack of associations.

I compared my study's results with six relevant pre-hospital and in-hospital studies (five US and one UK) that have shown poor outcome prediction in older trauma populations: a) two studies that investigated patient characteristics such as SBP, heart rate, shock index, and ISS to predict outcomes in older population (Brooks *et al.*, 2014; Newgard *et al.*, 2014), and b) four studies that compared between older and younger adult patients and investigated GCS and vital signs in predicting outcomes in older people (Heffernan *et al.*, 2009; Lehmann *et al.*, 2009; Kehoe, Rennie and Smith, 2015; Nishijima, S. D. Gaona, *et al.*, 2017). As Brooks *et al.* (2014) found that the ISS is a poor predictor of deaths in geriatric patients with injuries while Newgard *et al.* (2014) reported that the SBP, heart rate, shock index are poor predictors of major trauma in older patients. Compared to younger patients, Kehoe, Rennie and Smith (2015) found that the median GCS of older patients was higher than in younger patients reflecting that this variable has poorly predicted outcomes in older people, while the

other three studies reported that vital signs were poor predictors of deaths in older trauma patients compared to younger counterparts (Heffernan *et al.*, 2009; Lehmann *et al.*, 2009; Nishijima, S. D. Gaona, *et al.*, 2017). The results of these six studies were consistent with my study's results in showing poor prediction of outcomes in older trauma patients.

4.3.3 Comparing the study findings with the relevant studies:

The literature review's studies were checked and four relevant studies were then considered (Staudenmayer *et al.*, 2013; Cox *et al.*, 2014; Benjamin *et al.*, 2018; Brown *et al.*, 2019), to discuss the following aspects:

4.3.3.1 Comparing the characteristics of patients in previous studies to the characteristics of this study's cohort:

Age differences may be explained by differences in selection criteria such the age definition for older patients in my study compared with an one US study and one Australian study (Staudenmayer *et al.*, 2013; Brown *et al.*, 2019). In my study, I used age threshold (55 years old and over) to define older population in Saudi Arabia. This was consistent with the study of Staudenmayer *et al.* (2013) who used a similar age threshold when they recruited 6,015 older trauma patients representing California and Utah states. In contrast, Brown *et al.* (2019) used the 65 years old and over threshold to define older trauma patients to recruit 576 older patients sgainst 1,049 younger patients (16-64 years old) in Perth, Western Australia. Regarding gender, I included 285 (63.2%) male cases against 166 (36.8%) female patients. In Australia, Brown *et al.* (2019) found that they included 307 (53%) male patients out of included 576 cases and in the US, Cox *et al.* (2014) found that they included 60.5% of the cases were female from 3054 eligible cases (55 years and older). The results of these studies were also inconsistent with my study's age and gender related results. My study reported fewer older patients and fewer female patients while in these US and Australian studies, older patients had a higher sample size and female cases comprised almost half or more of the total number of cases.

For the mechanism of injuries, I found most cases were admitted to the MTC due to low falls, followed by motor vehicle accidents, pedestrian injuries, and high falls. This is consistent with previous studies. As Staudenmayer *et al.* (2013) reported that 3,092 (51.4%) of 6015 older cases were fallers,

followed by 791 cases (13.2%) who were exposed to MVC injuries in California and Utah states. Whilst Brown *et al.* (2019) found that 358 (62%) out of 576 cases were injured by low falls, followed by 81 cases (14%) by high falls, and 63 cases (11%) were exposed to MVCs in Perth, Western Australia. Regarding the mortality, I found 26 (5.8%) deaths among the older trauma patients recruited. In contrast, Brown *et al.* (2019) found that 199 (34.5%) died across four hospitals that use the Perth State Trauma Registry, Australia. Whilst Benjamin *et al.* (2018) reported that they included 11,010 (1.1%) deaths against 992,340 (98.9%) survivors from the National Trauma Data Bank (2007–2012 years), United States.

Regarding the ISS, I found 235 cases (52.1%) admitted to the MTC with 9-15 moderate ISS, followed by 152 cases (33.7%) with 0-8 minor ISS, and only 64 cases who were admitted with ≥16 serious ISS. In Victoria state, Australia, Cox *et al.* (2014) recruited older and younger trauma patients and classified them based on the ISS into major trauma patients ISS >12. They also found that 52.3% of the older patients had major trauma (ISS>12) (Cox *et al.*, 2014). They then reported that mortality occurred with 32.1% of recruited major trauma older patients at non-MTCs and 20.2% at MTCs (Cox *et al.*, 2014). Whilst in California and Utah states, US, Staudenmayer *et al.* (2013) recruited 6,015 older patients (55 years and older) and 244 (4.1%) of these cases were recruited with ISS >15. Staudenmayer *et al.* (2013) then found that 80 (32.8%) of these 244 cases were admitted to non-MTCs while 164 (67.2%) cases were admitted to the MTC. The results of these studies were inconsistent with my study's results because the ISS thresholds differ between Saudi Arabia, the US, and Australia to define major trauma patients.

Lastly, the length of hospital stay was considered only in one US study (Benjamin *et al.*, 2018). Benjamin *et al.* (2018) found that 4253 (39%) of their study cohort died after 7 days in hospital, 45% died between 2 and 7 days, and 16% died within 1 day. This is inconsistent with my study which indicates that 229 (50.7%) of the cohort who stayed in the hospital between 1 and 10 days, including 11 (4.8%), died between those days.

4.3.3.2 Comparing selection process for cases in previous studies to case selection in my cohort:

It is important to compare the patient selection process of this study (**described in the Figure 4.1**) to the selection process in two studies from different countries such US and Australia (Benjamin *et al.*,

2018; Brown *et al.*, 2019). Both studies were identified from the scoping review, and both examined predictors of deaths as I did. The selection processes in such studies can be impacted by data-related circumstances that vary from nation to nation or from registry to registry, so I show how the inclusion and exclusion processes in these studies differ from my study (**see Table 4.15**):

Items	***My study***	***Benjamin et al. (2018)***	***Brown et al. (2019)***
Country and states or cities	Riyadh city in Saudi Arabia	California and Utah states in United States	Perth State in Australia
Sources of data	The King Saud Medical City's trauma registry	The national trauma data bank	The Perth State Trauma Registry (four hospitals)
Initial number of cases received	1346 older trauma cases (≥55 years old), admitted to the MTC ED by all different modes of arrivals from 1st/8/2017 to 31st/10/2021.	4,146,428 blunt trauma patients (<60 vs 60≥ years old) who were registered between 2007-2012	1,904 younger cases (≥16 years old) and older cases (>65 years old) and admitted between 2013-2016
Inclusion criteria	All older trauma cases who were admitted to the KSMC's MTC ED by only ambulances.	All cases who were stable (GCS 13-15, SBP ≥90 mmHg, heart rate ≤120 b/m).	Cases who had major trauma with ISS >15 caused by blunt, penetrating or thermal injuries.
Exclusion criteria	All older trauma cases (≥55 years old) who were admitted by other modes of ED arrivals.	Two phases: 1) Patients <16 years old, interfacility transfers, and cases with missing ISS data. 2) Cases have had early decline during transports due to instable hemodynamic or declined GCS.	Cases exposed to drowning, hanging or poisoning related injuries, not transported primarily by ambulances, and who had late impacts of injury (>24 hours after trauma)
The final included data	452 older trauma cases	644,846 (64%) younger and 358,504 (36%) older cases	1,049 younger (65%) and 576 (35%) older cases

Table 4.15: The key differences between my study and two US and Australian studies in terms of patient selection process

4.4 Strengths and limitations of this study:

Regarding the strengths, the retrospective data of this study included prehospital data for the recruited cases leading to consider and describe scene and ED physiological data for each eligible case.

This study's data were received from the KSMC's trauma registry, including prehospital data, which makes it different to the previous KAMC registry's data, which only included in-hospital variables. In terms of limitations, firstly, using a hospital-based registry is a limitation. This is because prehospital data systems are not sufficiently developed to support research in Saudi Arabia. Secondly, no initial sample size estimation in this retrospective study was undertaken and the sample size was determined by the number of eligible cases in the registry. This should depend on the planned analysis and requires balancing the need for optimum precision with the time and resources needed to maximize sample size. This process was undermined by using registry data, because I cannot control how the data is collected. Third, this study has recruited a limited sample size that may have several impacts: a) the study findings cannot be generalisable to the whole population in Saudi Arabia. b) The study lacked statistical power to identify weak predictors of mortality. c) Patient characteristics in this study might not represent older population's characteristics in Saudi Arabia. d) Using retrospective data of only one hospital can influence on generalisability of the results.

Fourth, there are missing data for older patients who die elsewhere after discharge as the trauma registry does not follow up the discharged patients. Fifth, data errors may arise from using retrospective data, and exclusion from the registry of patients who are discharged after ED assessment. Sixth, in terms of type 1 and type 2 errors, type 1 errors means the possibility of finding a significant association even when one does not exist (false positive), and type 2 errors refer to the risk of failing to find a real association when it exists (false negative) (Perneger, 1998). These two types of errors may negatively impact my retrospective study's findings and interpretation, as the sample size was limited by the availability of relevant data that constrained the number of cases included in the study. Seventh, patient selection process in this study can influence on the sample size leading to selection bias that might then lead to missed important cases data. Eighth, it is known that measuring pupillary response in trauma patients is an essential action. However, the trauma registry does not consider this element within the registry variables. However, relying on the GCS scores can be sufficient when the registry does not contain data on the pupillary responses in older patients with injuries. Lastly, the selection process of this study was inconsistent with other relevant studies.

4.5 Discussing how the findings of this study could influence the plans for the qualitative study:

By addressing the objectives of this retrospective study, its findings can play an important role in emerging additional relevant ideas that need to be further explored. Firstly, this study reported the low falls in older trauma patients as the most common mechanism, as well as the poor associations between patient characteristics and outcome. Therefore, the qualitative study in next chapter explored whether paramedics' perceptions of the characteristics of older trauma victims aligned with those of the retrospective cohort. Secondly, it is worth exploring that how also they consider impacts of ageing changes on prehospital care and patient outcomes differing between older and younger trauma patients. This was explored under the first objective of the qualitative study which explored the Saudi paramedics and EMTs understanding of the impacts of ageing changes on geriatric trauma care and how they acquire their knowledge. Thirdly, it is worth exploring that how Saudi paramedics and EMTs decide which hospital to transport older patients to. This issue was explored as a part of the second objective of the qualitative study, which explored how the Saudi paramedics and EMTs apply their knowledge when attending to scene.

4.6 Conclusion:

This study has described the characteristic of the cohort by highlighting a high prevalence of falls from standing among the older people in Saudi Arabia, most of them were sustained by limb and hip injuries, they were admitted to the MTC with low prevalence of abnormal physiology, relatively low mortality and long hospital stay. This study also highlighted a lack of prediction from known predictors. This could be due to lack of power but could also reflect characteristics of the cohort such as limb injuries, falls from standing, and normal physiology and the difficulty of predicting outcomes in older trauma victims due to comorbidities and medications. This issue occurred, despite previous studies have identified age (≥ 60 years), and with chronic heart failure, a history of stroke after injury were significant predictors of early mortality in the US. Also, age (≥ 65 years), ISS ≥25, prehospital GCS ≤8 or a respiratory rate ≤9 or >29 beats per minutes were significant predictors of in-hospital mortality in Australia. Further qualitative investigations required by considering the findings of this study in order to explore whether paramedic perceptions of older trauma victims align with the characteristics of the cohort of this study such as the prevalence of falls from standing, limb injuries, normal physiology and whether paramedics recognise the difficulty of predicting death in older trauma victims.

Chapter 5

The Qualitative Study: Data Collection & Analysis

(Chapter title: Paramedics and EMTs' Perceptions of Geriatric Trauma Care)

Chapter overview:

"This chapter reports a qualitative study undertaken in order to explore the Saudi paramedics and EMTs' understanding of impacts of ageing changes on prehospital trauma care and patient outcomes, how they acquire and apply their knowledge as well as barriers and facilitators to provide improved care. These also include an additional objective emerged from the quantitative study which was to explore whether their perceptions of older trauma victims align with the characteristics of the cohort (such as falls from standing, limb injuries, and normal physiology of the cohort) and whether they recognise the difficulty of predicting death in older trauma victims".

5.1 Introduction:

In the fourth chapter, I conducted the retrospective cohort study aimed at describing the injury characteristics of older patients with injuries in Saudi Arabia and identifying predictors of in-hospital mortality among those patients. This study's findings showed that older trauma patients in Saudi Arabia suffer from low falls, normal physiology, and limb injuries, with poor predictions of their adverse outcomes from these injuries. In this fifth chapter, this qualitative study aimed to explore Saudi paramedics and EMTs' understanding of the impacts of ageing changes on geriatric trauma care, how they acquire and apply their knowledge when attending to scenes as well as identify the facilitators and barriers to providing improved care for older patients with injuries (**as shown in the table 3.1**). This study addressed an additional objective that emerged from the quantitative study, to explore whether the paramedics and EMTs' perceptions of older trauma victims align with the characteristics of the quantitative study's cohort and whether they recognise the difficulty of predicting death in older trauma victims. The results of this study will be integrated with the quantitative study's results in the next chapter to address the main aim of the primary PhD research.

5.2 The results of the qualitative study:

A total of 20 interviews were conducted, including 9 paramedics and 1 EMT from Riyadh, and 9 paramedics and 1 EMT from Makkah and they were all male, as males still dominate the paramedic profession in Saudi Arabia (AlShammari, Jennings and Williams, 2017; Alobaid *et al.*, 2022). The sample size and the participants' criteria should be shown, such as the number of interviews, the interviewees' codes, their position, city, and length of experience, as it helped analysing the data (Ritchie and Lewis, 2003). I could then link each quotation and response to each participant, which helped me to return to the demographic information for each participant (**see Table 5.1**):

No.	*ID*	*Demographics (position, city, and experience years)*	*No.*	*ID*	*Demographics (position, city, and experience years)*
1	A11	EMT, Makkah, 11 years	11	A1	Paramedic, Makkah, 7 years
2	A7	Paramedic, Riyadh, 9 years	12	A12	Paramedic, Riyadh, 2 years
3	A10	Paramedic, Makkah, 12 years	13	A18	Paramedic, Riyadh, 14 years

4	A6	Paramedic, Makkah, 1 year - 2 months	14	A17	Paramedic, Makkah, 7 years
5	A9	Paramedic, Riyadh, 1 year - 8 months	15	A19	Paramedic, Makkah, 7 years
6	A5	Paramedic, Makkah, 2 years	16	A20	Paramedic, Riyadh, 1 year
7	A8	EMT, Riyadh, 12 years	17	A21	Paramedic, Riyadh, 1 year - 6 months
8	A13	Paramedic, Riyadh, 4 months	18	A22	Paramedic, Riyadh, 8 months
9	A15	Paramedic, Riyadh, 4 years	19	A23	Paramedic, Makkah, 1 year - 6 months
10	A14	Paramedic, Makkah, 1 year - 10 months	20	A24	Paramedic, Makkah, 13 years

Table 5.1: The participants' criteria of the qualitative study

Further, following is a table that illustrates the various sections (domains) of the results for each study objective, which are used as headings in the results section for illustrating how I mapped the data (**see Table 5.2**). The domains were created and named accordingly to reflect the voice of the interviewees' perceptions of their experiences, such as 'physiological', 'organisational', 'cultural', 'individual' etc. (Hackett and Strickland, 2019).

The five Study objectives as headings	***Domains for addressing each study objective***
a. Explore Saudi paramedics and EMTs' understanding of the impacts of ageing changes on the prehospital trauma care.	**1.** Age-related changes in the individual patient's anatomy and physiology
b. How Saudi paramedics and EMTs acquire knowledge regarding ageing impacts on prehospital trauma care and how they apply their knowledge when attending to the scene.	**2.** Knowledge gaps **3.** Applicability of the current knowledge when responding to older trauma patients
c. Explore the barriers to providing improved care for older patients with injuries.	**4.** Organisational barriers **5.** Individual barriers **6.** Cultural barriers
d. Explore the facilitators to providing improved care for older patients with injuries.	**7.** Organisational facilitators **8.** Individual facilitators
e. Explore whether their perceptions of older trauma victims align with the characteristics of the cohort and whether they recognise the difficulty of predicting death in older trauma victims.	**9.** The consistency of Saudi paramedics and EMTs' perceptions with the retrospective cohort's injury characteristics **10.** Difficult predictions of adverse outcomes in older trauma patients

Table 5.2: The structure of domains for addressing each study objective

Once the data had been charted and mapped, I used the constructed framework which involved my understanding of "what is happening within a single subtopic" (Ritchie and Lewis, 2003, p.239). Each study objective has a table reflecting the thematic framework structure that was used to summarise and interpret each domain's themes and subthemes (or only themes) (**see Appendix 17**). These themes and subthemes reflect participants' responses that were grouped thematically and then categorised according to different levels of generality producing an index with a hierarchy of themes and subthemes (Ritchie J, 1994). Serial numbers were assigned to each theme and subtheme to facilitate the process of coding and picking up new information and quotes from the subsequent interviews (Ritchie J, 1994). As the data were interpreted under each study objective as follows:

5.2.1 How do Saudi paramedics and EMTs understand ageing changes impacts on prehospital trauma care?

The participants expressed that they struggle with the physiological changes, communication difficulties and polypharmacy that influence prehospital care of older patients compared to younger patients. These three age-related challenges were identified and considered as themes within one domain that they encounter when responding to older patients with injuries (**see Table 5.3**). The participants reported that they struggle with these challenges because of a lack of geriatric care training courses and care guidelines. It is possible that there may be training courses and guidelines that they are not aware of as discussed within the second section of results **(no. 5.2.2)**.

Domains	***Themes***
1. Age-related changes in the individual patient's anatomy and physiology	**1.1** The physiological changes impacts: responding to severe injuries caused by medical conditions or low mechanism of injuries and difficult procedures to older trauma patients
	1.2 Difficult communications with older patients due to hearing issues and cognitive challenges.
	1.3 Polypharmacy leading to difficult predictions of adverse outcomes in older trauma patients

Table 5.3: The domains and their themes for addressing the first study objective

5.2.1.1 Age-related changes in the individual patient's anatomy and physiology:

Compared to younger patients, participants reported having difficulty responding to older patients with severe injuries related to underlying medical problems. Due to these conditions, they reported having difficulty obtaining medical history and medication information. Identification of these conditions helps determine appropriate treatment plans for older patients with co-morbidities, and when transporting patients to hospitals to disclose these conditions. Two participants also suggested that older patients may be less sensitive to pain than younger patients, limiting the identification of severe injuries. Participants reported struggling with older patients' major injuries that happened to due to low mechanism of injuries such low falls as a result of osteoporosis. Further, respondents noticed more serious injuries, higher complications, and deteriorations as a result of low mechanisms of injury in older people than in younger people.

"their injuries are more severe than in younger patients that may happen due to an *underline cause such as stroke or MI, shock* which happened due to an accident. This is an important point because we *should extract information* for an issue in older patients in detail because in hospitals, we should describe how injuries happened with the patient…". (Interviewee A12, paramedic, Riyadh)

"From my experience, most of older cases had low falls in homes, not high falls. These low falls can lead to risky injuries. Most of these injuries were minor and some of them were critical. Some minor injuries lead to death". (Interviewee A13, paramedic, Riyadh)

Further, participants reported that physiological changes lead to difficulties while carrying out care procedures: difficult intravenous IV cannulations due to unclear veins or tortuous veins and it is inappropriate to use intraosseous IO route due to osteoporosis. Difficult lifting or moving due to frail bodies or osteoporosis in buildings that lack lifts or wider ladders that may lead to further injuries or pains due to use of rigid backboards. Difficult control of bleeding due to use of anticoagulants by older patients who have cardiac or diabetic histories.

"When you have an older patient with *haemorrhage*, and you must give him *fluids* and you have only one *solution* which is *opening an IV*. But *opening the IV* can be unsuccessful and difficult due to unclear or tortuous *veins*. Also, the *IO* route is inappropriate due to the *osteoporosis*". (Interviewee A17, paramedic, Makkah)

"the challenges that I face is uncontrolled bleeding in older people and level of consciousness decreases and becomes *weak* rapidly in them compared to younger patients… in older people who have 65 years and over, they use medications such as

aspirin or have *cardiac or diabetic histories*. So, controlling bleeding in *young* patients is *easier* than in *geriatric* patients". (Interviewee A19, paramedic, Makkah)

Additionally, conditions such as hearing loss and dementia can cause communication difficulties and lead to problems in history taking, explaining care procedures or difficulty in identifying injuries as reported by participants. One participant suggested using tags or IDs carried by older patients with diabetes or Do Not Resuscitate DNR directives to reduce communication problems when responding to confused older patients.

"Due to the ageing impacts that occur in older people such weak hearing, I will need to be closer to their ears and speak loudly to hear me. This is one of circumstances that I encounter in the scene that can impact on *taking medical history*. If I could not take the *medical history* clearly, this will impact on the care provision for older people". (Interviewee A18, paramedic, Riyadh)

"You should try and talk with older patients using the same of their language *accent*… Because you cannot predict their behaviours and they may hit you". (Interviewee A15, paramedic, Riyadh)

"I suggest using a *system of tags* in Saudi Arabia. Using *tags for diabetes and DNR*. For example, every older person has *a tag or ID* showing that he is *diabetic* and his medical information". (Interviewee A8, EMT, Riyadh)

In addition, participants reported difficulties in predicting adverse outcomes for older trauma patients who use polypharmacy. There are medications that hide signs of shock cause inaccurate parameters such as heart rate and blood pressure. For this reason, experienced paramedics instead rely on general impressions, blood loss, and physical examination to be prepared for any deterioration in shocked older patients.

"Sometimes older patients use *medications* that make *the shock* difficult to be identified clearly. Some patients use *aspirin* that can make the *bleeding* higher. Some of them use *beta blockers or calcium channel blockers* and this can lead to unclear *vital signs* such as inaccurate *blood pressures or heart rates*. These are *challenges*". (Interviewee A8, EMT, Riyadh)

5.2.2 How do Saudi paramedics and EMTs acquire and apply their knowledge?

Participants acquired knowledge from multiple sources such as school study, internship year, textbooks, booklets, research, internet, experienced colleagues, work guidelines, and relevant sections in short courses but did not feel that these gave them sufficient knowledge.

Most participants struggle to apply knowledge on female older cases. They gained knowledge from North American Mosby and Nancy Caroline textbooks distributed throughout the Saudi Arabia. These knowledge sources do not take into account differences between cultures and genders in acceptance of care. They only mentioned this cultural barrier but later mentioned other organisational and individual barriers to providing improved care.

The participants reported that the current care guidelines do not consider the roles of age, so they use relevant knowledge acquired after employment to provide appropriate care. These findings were identified through the following two domains and their themes (**see Table 5.4**):

Domains	***Themes***
2. Knowledge gaps	**2.1** Acquiring insufficient knowledge from multiple sources before and after employment.
	2.2 No related courses available and organisations provide such courses
	2.3 A lack of prehospital geriatric trauma care research in Saudi Arabia.
3. Applicability of the current knowledge when responding to older trauma patients	**3.1** Difficult application of knowledge when responding to and caring for female cases due to the local culture.
	3.2 Confidence or nonconfidence in applying specific skills when responding to older trauma patients.
	3.3 Using own knowledge to make arbitrary EMS decisions due to the current guidelines that apply to all trauma patients and a lack of geriatric specific guidelines.

Table 5.4: The domains and their themes for addressing the second study objective

5.2.2.1 Knowledge gaps:

Within this first domain, three themes were identified (**as shown in the Table 5.4**). Firstly, both inexperienced and experienced participants reported insufficient theoretical knowledge while inexperienced ones reported a lack of clinical skills due to lack of relevant training. Before being employed, they acquired knowledge from university study, internship year, textbooks, and research. However, their university studies did not cover the geriatric care sufficiently, unlike paediatrics and gynaecology that have separate modules.

After being employed and starting to respond to older cases and identify their knowledge and practice gaps, they try to use different sources. These included US EMS textbooks available in Saudi Arabia, searching the internet for international guidelines, asking experienced colleagues, reading relevant research, relaying on relevant sections in short training courses accredited by US EMS organisations such as ITLS and PHTLS, and gaining experience from managing older patients as reported.

"Honestly*, the geriatric care knowledge* in my university study was insufficient. It did not have a specific *module* like *paediatric and gynaecology patients* that have specific *modules*. We were studying limited *geriatric care*. Currently, I am satisfied with my current *knowledge* to deal with older patients. I acquired this *knowledge by reading books*". (Interviewee A5, paramedic, Makkah)

"the Red Crescent Authority started providing *courses* for *the prehospital care*. They collect *the top ten most common cases* of the special considerations' cases in Saudi Arabia… These *courses* were given if the *medical directors* noticed weakness among *paramedics* of a specific ambulance station regarding the *geriatric care*… These courses were insufficient because they covered only *the most common* cases". (Interviewee A18, paramedic, Riyadh)

Participants identified a lack of specific courses for prehospital geriatric care in Saudi Arabia. Currently, the Saudi ambulance clinicians depend on trauma care courses such as ITLS which has a section for geriatric care and PHTLS which has section covers geriatric care within special considerations. Most participants reported their need for further training, but also identified a lack of organisations providing training or funding for ambulance clinicians to attend. Some hospitals provide such courses, but they are only designed for managing cases related to hospitals.

"Unfortunately, the *prehospital care* has *a shortage of courses*. When we take a course in trauma, we find it covers *paediatric, adult, and geriatric patient*s together. No courses special for geriatric patients. There is a shortage*".* (Interviewee A15, paramedic, Riyadh)

"Our issue is that the centres that provide *prehospital care*-related *courses* are so limited. Additionally, regarding the *budget* and funds, we cannot compare the Ministry of Health or military hospitals' funds with the Red Crescent Authority's funds". (Interviewee A18, paramedic, Riyadh)

Respondents also identified a lack of specific geriatric trauma care research in Saudi Arabia as contributing to lack of knowledge. One respondent reported a lack of research teams conducting relevant research to improve prehospital geriatric care.

"Honestly, we have a weakness in *the EMS research* that focus on *elderly patients*. If you want to improve this, we should have *a research centre, research administration or research team* working on *the geriatric care in EMS*. If you want to do that, you need *data*, and the *data* is available, but we do not have *research teams work on the geriatric care*". (Interviewee A18, paramedic, Riyadh)

5.2.2.2 Applicability of the current knowledge when responding to older trauma patients:

Three themes were identified within this domain (**as shown in the Table 5.4**). Participants compared between the ITLS and PHTLS courses in terms of applicability of knowledge. They reported that the applicability of the ITLS is better than the PHTLS because the former has a section for geriatric care while the latter has a section for all paediatric and geriatric patients within special considerations. They also recommended the North American Mosby and Nancy Caroline textbooks, clinical simulations, and trainings in hospitals on the difficult clinical skills.

"The *ITLS* provides the relevant knowledge better than the *PHTLS course* because the *ITLS* has section for *geriatric care* and the *PHTLS* has a section for *special considerations* including *geriatric and paediatric patients…* The above two *courses* are *applicable*. The *applicability* of *ITLS* in Saudi Arabia is higher than the *PHTLS* regarding the *prehospital geriatric care".* (Interviewee A10, paramedic, Makkah)

Most participants highlighted cultural barriers to applying knowledge when responding to older female patients. Older cases or their relatives may refuse examination for identifying injuries or applying ECGs. An experienced participant mentioned that they gained knowledge from Saudi Universities' US curricula and US Mosby and Nancy Caroline EMS textbooks that do not consider differences between cultures and genders in acceptance of care. They also reported that the SRCA started campaigns on the media, distributing leaflets to raise the public's awareness of paramedic roles and consequences of refusing care to reduce such cultural barriers. However, one participant reported these cultural issues

can be eased by gaining better communication skills and using a polite way of approach to female cases and convince relatives in accepting care.

"This knowledge is difficult to be applicable because some older patients socially do not accept our care, depends on the *culture*… I responded to a *female* older patient who has 70 years old with *a chest pain, hypertension, and diabetes*. We decided to apply *ECG* for her, but her relatives refused. She also refused and she was aware of that. She said: no, I do not want... Also, relatives refuse the physical examination especially, when we want to check for any injuries, *infections*, or anything else". (Interviewee A1, paramedic, Makkah)

"honestly, *Mosby and Nancy Caroline* textbooks were helpful. Because it is difficult that *paramedics* talk *to medical directions* or colleagues and say to them that I have lacked knowledge. But not everything in these North American textbooks we can apply in our society. Because these textbooks deal with all males and females equally". (Interviewee A18, paramedic, Riyadh)

Ambulance clinicians reported different levels of confidence in applying knowledge and that this is affected by experience. Experienced participants reported high confidence obtained from self-learning, working with experienced colleagues, a previous work in hospitals' ED, ICU, or clinics or work experience in ambulance services. They reported high confidence in applying skills (examples: communication skills with older cases and relatives, identifying hidden injuries, providing medications for older cases, opening IV cannulations, and making better transport decision). Non-experienced participants reported struggling with applying different skills (examples: providing medications to older cases, communication skills and IV cannulations). Some participants reported that their colleagues lacked knowledge or understanding, but no participants admitted to a lack of their own knowledge or understanding. All participants reported wanting more training and guidance.

"At the beginning of my profession, I was unconfident… I needed more time for my skills as I remember that I have requested a special *training* on *cannulations* of older patients in a hospital which has a department of internal medicine caring for the older people. It is correct that I was feeling fears and non-confidence but with the experience, I have become better after spending one to two years to become capable in my skills". (Interviewee A18, paramedic, Riyadh)

"I see a lot of colleagues deal with older people inappropriately. They do not know to deal with them. I see it differs from a paramedic to another. Some of them deal with older patients like any trauma case or routine cases until completing the care". (Interviewee A17, paramedic, Makkah)

In addition, because there are no guidelines specific to geriatric trauma patients, most participants relied on simple guidelines considered by the SRCA to be used by all ambulance clinicians. These simple guidelines were applied to all younger adults and older patients equally without considering their age as reported. As a result, some participants use these guidelines, feel that they should treat older and younger people equally, and feel comfortable making the same decisions for older and younger people. While others who want to improve their knowledge and skills, use their own acquired knowledge by applying UK or US related guidelines instead of these simple guidelines. Because they realise that these guidelines are inappropriate and geriatric patients require guidelines appropriate to their age cut-off.

The current simple SRCA guidelines were reported by all participants as follows:

a) Ambulance clinicians in Saudi Arabia should transport all major trauma cases including older patients to nearest hospitals that have neurosurgery, orthopaedics, vascular and trauma surgeons. If the nearest hospital does not have the needed specialities, they will consider a farther hospital.
b) If they responded to a major trauma patient, they could transport him/her to a nearest hospital at least to stabilise Airway, Breathing, and Circulation ABC. If the patient needed a specialised surgeon, they will then be transported to another hospital by the hospital's private ambulances.
c) If the nearest hospital was a non-trauma facility, major trauma cases will be directly admitted due to ED staff's fears to be accountable legally if they refused admitting cases. Therefore, if the case needed a trauma surgeon, they will then be transported to a trauma centre by private ambulances.

"if the patient was with *a life-threatening condition*, the transport should be to *a nearest hospital* until becoming stable by *stabilising ABC* and he then will be transported to another *hospital* that has the needed specialty by using the Ministry of Health's ambulances". (Interviewee A1, paramedic, Makkah)

"If *hospital A* is nearer than *hospital B*. But *hospital A* is unready to receive trauma cases, we will consider *hospital B*. However, if we transported the case to the *hospital A*, they will not refuse receiving our case because there are fears to be accountable legally if they refused the case… they do not have a *trauma surgeon*. Therefore, they will use their own *ambulances* to transport the patient to *a trauma centre*". (Interviewee A18, paramedic, Riyadh)

d) If older trauma patients were minor, they will be transported to facilities they or their relatives desire.

e) In terms of triage, currently ambulance clinicians use a triage tool only for mass casualty accidents using three coloured tags: red, yellow, and green tags. Red tags for serious patients, yellow tags for moderate cases, and green tag for mild cases. Patients with red and yellow tags will be transported to nearest hospitals and patients with green tags will be transported to hospitals based on their desire.

f) The ambulance teams and hospitals lack coordination to make better decisions on which hospital to send trauma patients to.

"We transport *life-threatening condition* patients to *a nearest hospital* and *stable* patients based on their desires… That is the *protocol* we follow". (Interviewee A15, paramedic, Riyadh)

"Based on the current protocol, dealing with older patients does not differ from caring for younger patients. They have the same care steps… So, dealing with older patients differently depends on the paramedics themselves based on *the personal and scientific experience*". (Interviewee A8, EMT, Riyadh)

"there is *no communication* between the prehospital and in-hospital settings. So, I can only decide which hospital is more appropriate to my older patient". (Interviewee A18, paramedic, Riyadh)

5.2.3 What are the barriers to providing improved care to older patients with injuries?

The interviewees reported organisational, individual, and cultural categories (three domains) of barriers influencing providing improved care for older trauma patients with their themes (**see Table 5.5**).

Domains	***Themes***
4. Organisational barriers	**4.1** Lack of necessary equipment or manpower while caring for older trauma patients
	4.2 Restricted on-scene time to caring for older patients by the SRCA while older patients need longer time
	4.3 Lack of care guidelines
	4.4 No data of older patients' history shared to paramedics
5. Individual barriers	**5.1** Refusals of paramedics' care by older patients or relatives and difficulties in convincing them
	5.2 Older people or relatives' unawareness of the medical conditions and medications
	5.3 Responding to aggressive, nervous, fearful, or non-cooperative older patients or relatives

	5.4 Older patients and relatives' lack of confidence in paramedic care.
	5.5 Relatives neglect older patients' needs
	5.6 Language barriers
6. Cultural barriers	**6.1** Difficulties treating female patients

Table 5.5: The domains and their themes for addressing the third study objective

5.2.3.1 Organisational barriers:

I identified four categories of organisational barriers (**as shown in the Table 5.5**). Firstly, participants struggle with equipment and manpower shortages. Limited equipment can be padded backboards, blankets, short cannulas, nasal cannulas or C-collars that hindered providing required care. One participant reported that when using splints for trauma patients and delivering those patients to ED, the ED staff often do not return the splints back to the ambulance staff for use with next patients. One year's use of such equipment is required before ordering alternatives. In terms of manpower shortages, ambulances have only two paramedics on staff during en route to hospitals; one will drive, the other will splint fractures, open veins, prepare fluids, and administer painkillers. If heavier older patients were dealt with, additional staff would be needed.

"we have *splints* used for *femur fractures*. When we use them, you not then see them again because they will go with the patients to hospitals… Our organisation gives us splints to be used for one year and then they will give us alternatives… we are two persons, one is a driver, and another is a care provider. We have *a heavyweight geriatric patient,* and we cannot move him… If we were three people, we could provide something helpful for the patient". (Interviewee A15, paramedic, Riyadh)

The SRCA recommends a limited duration of time around 10 to 15 minutes for caring for any case. The participants reported that older cases require longer time due to difficulties in communicating, convincing older patients who refuse care and some care procedures needing longer time to be applied by one paramedic. The participants suggested that increasing number of paramedics could shorten these durations of time when caring for older patients.

"the Red Crescent Authority restricts our time of stay in the field which each patient. They expect we stay *10 to 15 minutes in the field*. Spending more than that can cause some issues and lead to investigation with us by our organisation. Spending time in convincing the patient for transports, then moving them from bed to *stretchers* to ambulance from second or third levels to ambulance can take 20 to 25 minutes". (Interviewee A14, paramedic, Makkah)

The participants reported that there were no clear protocols or guidelines specific for treating or transporting older trauma patients, because age is not considered in the current guidelines. The current guidelines provide only general information regarding fluid replacement and amounts required for geriatric and paediatric patients. Some participants indicated that they provide better geriatric care by following international care guidelines they learned from internet rather than following the current guidelines.

"We do not have *protocol* for *geriatric patients*. The current *protocol* used for all adult patients. But we can give older people more care based on their *differences* to others". (Interviewee A10, paramedic, Makkah)

Some participants identified that ambulance clinicians do not have access to medications and medical history information of trauma patients, including older patients. This is an important barrier because the lack of access to medical records is an obstacle to identifying older cases' medical histories who have polypharmacy, difficult communication, memory problems or no relatives. The Saudi ambulance clinicians currently use tablets to send patients' reports electronically, but they cannot retrieve the necessary information, thus hindering the provision of needed care.

"Currently, when we go to the scene, we record our patient's report *electronically* via *an iPad application* we use… paramedics record the patient's information such *as vital signs, provided interventions* and others, and then send them to the targeted hospital… but cannot obtain any information about the patient… *the past medical history* is rich by information of *polypharmacy and medical events* that if we did not obtain them, it will be difficult *to assess and diagnose* cases in the prehospital setting". (Interviewee A18, paramedic, Riyadh)

5.2.3.2 Individual barriers:

Six categories of individual barriers were reported and considered as themes (**as shown in the Table 5.5**). Firstly, ambulance clinicians reported that they struggle with older patients or relatives who

refuse trauma assessment, care, or transports. Older patients also may refuse care instructions when they fear increased pain when moving or changing positions or fear dying in hospitals while transporting to hospitals. Participants reported that some patients and relatives did not provide important medical histories or medications information without any clear reason.

"When we asked them about kind of *medications* that are used by their older patients, they refuse to give us this information and the patient himself can also refuse giving us this information. This one of challenges that I mostly face". (Interviewee A9, paramedic, Riyadh)

Ambulance clinicians reported struggling with older people or relatives' unawareness of the medical conditions, medications or do-not-resuscitate DNR information which makes finding the necessary information more complicated. This issue becomes worse when responding to older trauma patients with no relatives. Unavailability of relatives during injury event can prolong the time duration between the injury time and paramedics' arrivals to scenes and hinder taking the necessary information. These all relate to difficulties in taking histories or knowing the background for the older cases that may then lead to adverse outcomes as reported.

"Some relatives do not know the *conditions* of their older patients completely especially their *diseases and DNR* information. I have noticed a lot of these issues in some calls". (Interviewee A20, paramedic, Riyadh)

"If there are no relatives or bystanders with older patients, it will be difficult to take the medical history… We will not know anything about the patient. So, taking the past medical history will be a challenge for me... Taking *history* is important because I do not want to apply a procedure that can harm the patient". (Interviewee A15, paramedic, Riyadh)

Most participants stated that they responded to older patients who could be aggressive, nervous, fearful, or uncooperative. They also reported that unknowledgeable older patients and patients who mistrusts paramedics' roles due to their lack of education can also be fearful and uncooperative. Some participants reported that all these issues lead to difficult communications and physical examinations, which then complicate patients' care. These happen commonly among older female patients who refuse care or transport by denying injuries or pains due to fears as reported by some participants. Participants mentioned that relatives can also be agitated or non-polite and prevent paramedics from

providing care or only request transports to hospitals without care, especially with female patients. They can behave aggressively and blame paramedics for arriving late, which can upset the patients and paramedics.

"Always, we should be aware of that older people have levels of fears or nervousness higher than in younger patients. So, it is difficult to communicate with them or examine them… non-cooperativeness of relatives will not help you to providing improved *geriatric care*… when we respond to an older patient, his relatives can ask you why you did not come earlier and why did you come late! These behaviours can agitate their older patient rather than making their patient comfortable". (Interviewee A8, EMT, Riyadh)

Some ambulance clinicians reported that some older patients or relatives show a lack of respect for paramedics' care and request direct transports to hospitals without providing prehospital care. This may reflect a lack of confidence or understanding of paramedics' role. A participant suggested that these behaviours might have emerged as a result of older technicians with lower qualifications acting as transporters or mistreating older patients, which negatively affected the Saudi new and highly qualified paramedics' reputation. Therefore, participants suggested that paramedics should improve their attitude and gain training to help dealing with older people with a high sense of self-confidence.

"Sometimes, relatives request from us only 'load and go' rapidly to hospitals without providing any care to their patients. The reasons for this issue can be presence of worries or fears for their older patients, non-confidence in the paramedic roles, or both. I blame some paramedics in the issue of non-confidence in paramedic roles… They must *trust themselves* because if the *paramedic* trust himself, dealing with the patients will be better. The paramedic's *attitude* is important". (Interviewee A19, paramedic, Makkah)

Some participants highlighted that some relatives contribute to older patients' difficulties taking prescribed medications, preventing better care from being provided. Participants suggested that these issues are most prevalent among low-income families who cannot afford all the equipment and facilities needed for caring for bedridden older patients in homes. Older patients from high-income families can benefit from home nurses caring for and high-quality medical equipment. As reported,

relatives neglecting older people who live in deprived locations can affect the ability to provide better care than those who have better living and care arrangements.

"I mean they are *negligent*. This happens in some districts due to their financial circumstances. Because *negligent* patients can have unclean clothes and bad odours that influence on us during *transports*. But with rich people, we can find their patients have *a nurse or two nurse*s in the home, medical mattresses, and some devices such as *ventilators and suction units*". (Interviewee A1, paramedic, Makkah) (Note: the participant used quite a judgemental term 'negligent' to describe something that may be due to lack of resources).

Lastly, a participant reported that dealing with non-Arabic speaking older patients can be a barrier to obtaining the necessary medical history information. This issue can be sustained by pilgrims from multiple nationalities who come during annual Islamic events in Makkah or when dealing with confused older patients who have non-Arabic speaking nurses or caregivers at home hindering providing improved care.

"I always face the *language barrier*. Some older patients do not understand me who are from different nationalities. I have difficulties in giving information to them" (Interviewee A5, paramedic, Makkah)

5.2.3.3 Cultural barriers:

These were reported by participants as a barrier to applying knowledge, but they also reported the difficulty in caring for female older patients as a barrier to providing improved care. Previously, the participants discussed this issue as a consequence of a knowledge gap in the Saudi Universities' US curriculum that does not take cultural differences into account, which necessitates gaining ambulance clinicians' knowledge and communication skills to face this issue before they become employed. Here, they discussed this cultural issue in relation to the need for organisational interventions and campaigns and raising public awareness to help them providing improved care that could be hindered by this cultural barrier.

Most interviewees reported that older female patients or their relatives refuse assessment procedures such as ECGs, vital signs, and physical examinations until they have a female nurse at the hospital, or they only accept care on scene after much convincing. Some relatives can contribute to this

problem once a paramedic started physical examination leading to difficult identification of injuries and delayed care. Participants suggested that the Saudi Red Crescent Authority should intervene by employing female paramedics, since female patients accept female care. Campaigns could raise public awareness of the consequences of refusing care by the female patients or their relatives as reported by some participants.

"We feel that there is a *distance* between us and female patients. We face difficulties due to the *culture* in *applying ECGs, checking vital signs and clinical examination.* Sometimes, it is impossible to apply a *12-lead ECG and physical examination*". (Interviewee A14, paramedic, Makkah)

"Regarding the *culture* or local traditions, *female patients* accept *females' care* more than *males' care*. This can be solved by employing f*emale paramedics to deal with female geriatric patients*". (Interviewee A10, paramedic, Makkah)

5.2.4 What are the facilitators to providing improved care to older patients with injuries?

A number of themes to providing improved care were identified and then sorted within two domains: organisational and individual facilitators (**see Table 5.6**).

Domains	***Themes***
7. Organisational facilitators	**7.1** Developing geriatric-specific care protocols
	7.2 Availability of adequate equipment and manpower
	7.3 Raising older patients and relatives' awareness of consequences of care refusals and roles of paramedics
8. Individual facilitators	**8.1** Improved communication skills
	8.2 Working in partnership with cooperative older patients and relatives to facilitate providing improved care
	8.3 Relatives' awareness of patients' conditions
	8.4 Sufficient training and knowledge

Table 5.6: The domains and their themes for addressing the fourth study objective

5.2.4.1 Organisational facilitators:

I identified three categories of organisational facilitators. Some participants suggested that developing international prehospital protocols for geriatric care is required to help providing a clear

care pathway and improved care. There are no clear guidelines for treating and transporting older trauma patients, as discussed within the organisational barriers.

"it is possible to add a part in the current *protocol* specific for *medical and trauma older patients* in order to improve the service". (Interviewee A10, paramedic, Makkah)

Participants reported that the SRCA should contribute to facilitating improved care by ensuring the availability of the right care equipment to care such as vacuum mattresses and stretchers with sufficient manpower to use such equipment for lifting and moving frail patients from difficult locations.

"Presence of *the right equipment* to provide *a high quality of patient care*… I need *vacuum mattresses* to facilitate lifting and moving the patient especially if the patients in first or second levels. At the beginning, I need *manpower* to move the patient safely towards the ground floor and then use the *vacuum mattress* to move the patient to the *ambulance*". (Interviewee A12, paramedic, Riyadh)

Participants also suggested that older patients and relatives should be more aware of the consequences of care refusals. Those who refuse treatment and transport can be educated within the paramedics' duties and health organisation efforts rather than only providing care. They also suggested that public awareness of paramedics' roles and capabilities could be increased through use of media, educational courses, and leaflets.

"Patients' relatives must have sufficient knowledge about us in the Red Crescent Authority. They must know that we are qualified as I do not need to say to them that I am qualified. Originally, it is not the relatives' responsibility, but it is the responsibility of the Red Crescent Authority or the organisation that provide the care. The Red Crescent Authority should start working on the media, distribute educational courses and leaflets everywhere for public". (Interviewee A17, paramedic, Makkah)

5.2.4.2 Individual facilitators:

Within this domain, I identified four categories of facilitators occur individually either by older patients, relatives, or ambulance clinicians to help providing improved care (**as shown in the Table 5.6**). A participant mentioned that paramedics should be trained to build relationships with older

patients by being kind and respectful rather than just offering health care so that they will accept care more quickly. Some participants expressed the need for better communication skills in order to manage patients with dementia and avoid potential aggression.

"older cases seek *emotional and social* care more than *healthcare*. This is the most important challenge we deal with… I always try to build links with them before starting the *assessment,* which will facilitate giving us *important information*, become cooperative with us, and make it easier *to deal* with them". (Interviewee A6, paramedic, Makkah)

A15: "You should try and talk with older patients using the same of their language *accent*. You should explain to them. I see these actions will facilitate all next actions of care". (Interviewee A15, paramedic, Riyadh)

Participants also suggested that improved care is facilitated by older patients and relatives cooperating with ambulance clinicians. This should include providing paramedics with clear information on chief complaints, mechanisms of injuries, and medical histories, trusting the care provided, accept paramedics' explanations of care procedures, and then approve procedures. Some participants mentioned the impacts of these actions will then include easier identification of injuries, shortening the time it takes to intervene, and help paramedics gain high confidence when providing care. One participant stated that some hospitals provide older patients with printed reports showing their medical conditions, medications, times and dates of previous admissions and discharges which was also felt to be helpful.

"Aware and cooperative relatives when we respond to their patients, and they trust our care. They should be aware of their patients' situation. Also, they approve what procedures that I want to do for their patients… if I discovered the patient's *hypoglycemia*, they would let me provide *D50* for their patient because they are aware and cooperative". (Interviewee A1, paramedic, Makkah)

Moreover, a few participants perceived that it would be easier if relatives had an understanding of their patients' conditions, medications, medical histories and injury details, which would help paramedics gain the necessary information to provide improved care.

"if relatives know the patient's medical conditions and *medications*. For example, if the patient has an injury, they could see the patient's *mechanism of injury*… because this is the most important point… As *relatives* facilitate our care for their patients". (Interviewee A6, paramedic, Makkah)

It was reported that sufficient training, knowledge, experience, and using continuing education programmes are critical to providing improved care for ambulance clinicians who deal with older patients as they deal with younger patients due to inexperience or lack of knowledge.

"*Well-training* with sufficient experience will facilitate providing improved *geriatric care* because anyone who has no experience, he will deal with older patients like any patient. This is a mistake because older patients are different". (Interviewee A8, EMT, Riyadh)

5.2.5 Do Saudi paramedics and EMTs perceptions of older trauma victims align with the cohort characteristics and do they recognise the difficulty of predicting death in those victims?

Exploring whether the participants' perceptions of older trauma victims align with the retrospective study's cohort characteristics (such as falls from standing, limb injuries, and normal physiology) and whether they recognise the difficulty of predicting death in older trauma victims was addressed through the following two domains with their themes (**see Table 5.7**).

Domains	***Themes***
9. The consistency of Saudi paramedics and EMTs' perceptions with the retrospective cohort's injury characteristics.	**9.1** Prevalent low-falls due to medical conditions, normal physiology, head, pelvic, and extremities injuries (consistent perceptions).
	9.2 Most geriatric patients are car accidents victims with abnormal physiology and injuries in pelvis and lower extremities (inconsistent perceptions).
10. Difficult predictions of adverse outcomes in older trauma patients	**10.1** Difficult identification of severe injuries in older people due to perceived differences in pain sensitivity
	10.2 Unpredictable abnormal physiology in older trauma patients due to polypharmacy

Table 5.7: The domains and their themes for addressing the fifth study objective

5.2.5.1 The consistency of the participants' perceptions with the retrospective cohort's characteristics:

Consistently, the respondents reported that they mostly responded to older people injured by falls from bed or from standing due to underlying medical conditions such as hypertension, diabetes, neural deficits, or strokes. These mechanisms of injuries usually occur at late nights or early mornings as reported. They also reported that car accidents were the second most common cause of injuries after falls from standing. Participants reported that most older cases have been assessed with normal on-scene physiology and head, pelvic, or extremities injuries. However, one participant inconsistently reported that older victims of car accidents with abnormal physiology were the most common presentation. He also reported that the back and lower extremities injuries are prevalent among older cases. He noted that he did not respond to lots of older trauma cases in his area.

"*Neck of femur fractures are most common. Also, fall down in older cases are most common* especially they mostly fall down in late nights or early morning when they wake up and go to baths. As they lift their legs to baths and then *traumas* occur. Regarding the *vital signs*, most of them have *normal* signs if they do not have *history*. I mean that depend on their *histories*. Usually, older cases with *history* are *hypertensive*". (Interviewee A1, paramedic, Makkah)

5.2.5.2 Difficult predictions of adverse outcomes in older trauma patients:

The two themes of this domain were previously described within the section (**see 5.2.1.1 Age-related changes in the individual patient's anatomy and physiology** for more details). The participants discussed that they struggle with predicting adverse outcomes due to two reasons: 1) difficult in identifying risky injuries in older cases due to their perceived differences in pain sensitivity compared to younger patients and 2) use of polypharmacy that mask abnormal signs of shock and bleeding.

5.3 Discussion:

This study addressed the five objectives by recruiting Saudi paramedics and EMTs from Makkah and Riyadh, which are the two largest cities in Saudi Arabia and have the largest number of ambulance stations and clinicians. In both cities, the participants identified similar ageing-related challenges when responding to older trauma patients, as well as barriers and facilitators to providing improved care. In addition to investigating the participants' understanding and knowledge of prehospital geriatric trauma care, they also reported a number of organisational, individual, and cultural issues they struggle with.

Therefore, this discussion section will summarise the main findings and compare them with the findings of other studies.

5.3.1 The Saudi paramedics and EMTs' current understanding and confidence regarding their geriatric trauma care:

The participants expressed their understanding of ageing related challenges such as the physiological changes, communication difficulties and polypharmacy that influenced prehospital care of older patients compared to younger patients. All reported a need to develop their skills to allow them to implement their knowledge, so they wanted training and guidelines. These findings were congruent with a previous study that assessed ambulance services providers and stakeholders' perceptions of geriatric care (Peterson *et al.*, 2009), two previous reviews (Dalton, NPM and Monroe, 2015; Eichinger *et al.*, 2021), and an EMS education-related study which found that paramedics face unique challenges such as comorbidities, polypharmacy, and communication difficulties (Shah *et al.*, 2012). The ability to distinguish fit from frail individuals is an initial step in identifying common geriatric issues that may influence care needs and outcomes (Goldstein, Andrew and Travers, 2012).

Some participants reported that their colleagues lacked knowledge, but no participants admitted to a lack of their own knowledge. However, all participants wanted training and guidance. This suggests a work culture that discourages the admission of uncertainty or lack of knowledge. This behaviour might threaten the patient's safety which prevents and reduces the risk of injuries, errors, and harms during the treatment process (CDC-NIOSH, 2017; WHO, 2021). It is crucial for ensuring a safe patient experience and ensuring successful outcomes for all patients and their wellbeing that patient safety culture exists (Brborović et al., 2014; Brborović, Brborović and Hrain, 2022). It is also possible that a culture of fear from punishment causes people to identify a lack of understanding in others rather than in themselves. Aggressive disciplinary action and an emphasis on finding fault rather than identifying and correcting weaknesses, could lead to ambulance services exhibiting a culture of fear, which can negatively impact accurate adverse event reporting (Bigham et al., 2011). Some paramedics are unwilling to admit their mistakes for fears of the consequences, and even if they are willing to do it, it can sometimes be hard to know who to inform (Atack and Maher, 2009).

5.3.2 The Saudi paramedics and EMTs' current acquisition and application of their own knowledge:

Ambulance clinicians reported that they lacked knowledge due to insufficient university studies regarding geriatric care before being employed in the SRCA and reported shortages of relevant training courses. This resulted in difficult application of important skills such as communication difficulties, predicting adverse outcomes, and IV cannulations. It has been shown that paramedics acquire limited geriatric-specific knowledge in Canada and the US, which results in the need for further education in geriatric care in order to provide better care, apply their knowledge in a broader context, and make advanced decisions (Goldstein, Andrew and Travers, 2016). Also, according to a US study, prehospital providers are less aware of age-related challenges than in-patient healthcare professionals (Duong *et al.*, 2018). A UK qualitative study examined paramedics' knowledge, practice, and attitude towards older patients and frailty. It reported that paramedics lack an understanding of frailty and ageing changes despite their responsibility to provide optimal geriatric care (Green, Kirby and Hope, 2018). Green, Kirby and Hope (2018) also reported that some paramedics wanted more training in geriatric care, which is also reported by my participants. They specifically reported a lack of knowledge and difficulties applying their knowledge due to cultural factors that may require better communication skills.

In terms of issues that were not identified, the participants, including the experienced ones, did not raise issues relating to triage, such as undertriage and overtriage. This may reflect the fact that paramedics in Saudi Arabia lack clear trauma care tools (Alharbi *et al.*, 2020). Undertriage and overtriage were identified as issues in the literature review, but these issues were not explicitly asked in the interviews. The reasons were as follows: 1) In this qualitative study, the primary purpose is to gain insights into ambulance workers' perceptions and understanding of ageing-related impacts on patient care and outcomes when the interview schedule does not include explicit questions regarding undertriage and overtriage. 2) The qualitative research is often exploratory in nature, allowing participants to express their perspectives and experiences without predefining concepts or assumptions (Gudkova, 2017). 3) Identifying such triage-related issues they failed to mention is helpful in identifying their knowledge gaps and needs within exploring their understanding and knowledge. 4) It is likely that the participants won't mention triage-related issues as they have already indicated that they don't use triage tools.

Additionally, the participants did not report concerns around frailty, maybe because they were unaware of this concept. There are limited guidelines for paramedics in assessing frailty in routine trauma assessments, according to a Canadian study (Goldstein, Andrew and Travers, 2012). Two recent Australian studies recommended frailty assessments be integrated into all patient assessments for those 65 and older (Dent *et al.*, 2019; Harris *et al.*, 2021). The participants didn't refer to any tools for identifying older patients at high risk. The participants reported that all older patients should be transported to hospitals, but evidence suggests not all older patients are transported, which makes frailty an effective criterion for identifying vulnerable older individuals (Goldstein, Andrew and Travers, 2012). A lack of attention to geriatric care-related research, factors affecting the design of the EMS system, or a lack of understanding of how to use these tools while caring for elderly trauma patients may explain this problem (Goldstein, Andrew and Travers, 2012). As a result of a lack of geriatric care presence within prehospital literature, current protocols and practices reflect this lack (Goldstein, Andrew and Travers, 2012).

5.3.3 The barriers and facilitators to providing improved care:

This section discusses the barriers and facilitators to providing improved care together because there are factors acting as both barriers and facilitators.

5.3.3.1 Organisational barriers and facilitators:

The participants reported that there are no geriatric-specific guidelines available, and current simple guidelines are used for all trauma cases without taking age into account. The participants reported only using a simple triage tool during disasters and mass casualties. A Saudi study reported that Saudi paramedics and EMTs only use the Simple Triage and Rapid Treatment START tool during disasters or mass casualties to classify, distribute, and transport patients to the appropriate healthcare facilities instead of overloading the nearest hospitals (Althunayyan et al., 2021). All major trauma patients can be transported to nearest hospitals (either trauma centres or trauma units) based on the current prehospital guidelines (Alharbi et al., 2020). According to a recent Dutch review, most EMS protocols fail to accurately identify severely injured patients, which may contribute to undertriage (Van Rein et

al., 2017). Due to a lack of clear guidelines, some participants use their own knowledge instead of following current guidelines leading to arbitrary EMS transport decisions.

I identified that there is no communication between ambulance services and hospitals that would allow them to coordinate trauma patient pathways between the two settings. According to two studies assessing the Saudi trauma system, the current trauma system lacks collaboration between prehospital services and hospitals (Alharbi *et al.*, 2020; Chowdhury, Mok and Leenen, 2022). While in other systems, the ambulance team should provide in-field medical care and transport trauma patients to hospitals, as well as collecting and communicating patient information to ED staff (Zhang *et al.*, 2020). In preparation for the patient's arrival, the information is used to prepare materials, design a treatment plan, and plan for the patient's initial diagnosis (Zhang *et al.*, 2020). Ambulance and ED teams must communicate and coordinate effectively to provide rapid and effective care to patients (Faraj and Xiao, 2006).

The participants reported the lack of necessary equipment and personnel on scene as organisational barriers to providing improved care. There is a lack of manpower and equipment in various developed and developing countries. According to a recent Thai study, many developing countries, including Thailand, have limitations in accessing healthcare services for older patients, insufficient manpower, inadequate equipment, and a lack of resources and budgets (Shatpattananunt *et al.*, 2022). A recent Israeli mixed-methods reported that paramedics struggle with lack of personnel and equipment despite the calls doubling in the last ten years without doubling the required resources (Dopelt *et al.*, 2019).

Participants reported that ambulance clinicians do not have access to the patient's medical records to help identifying important information. Currently, they use a tablet application to send patient reports, but they cannot access patients' medical histories or polypharmacy. The tablet applications are used in developed countries such as the UK to retrieve patient information needed to provide care. Lastly, the study found that the Saudi ambulance clinicians lack research into prehospital care for older people. One participant reported that they lack research teams or funds to conduct such research, while the SRCA has research teams for trauma care, stroke care, and cardiac care. In accordance with a US study, limited funding and research capacity, as well as methodological difficulties, lead to serious limitations

in EMS research, including limited randomisation and blinding interventions, and difficult outcomes assessment (Brown *et al.*, 2014).

5.3.3.2 Individual and cultural barriers and facilitators:

It is worth highlighting that some of the individual barriers could also be considered as cultural barriers, particularly the issue of patients and relatives mistrusting paramedics. Dealing with older patients or relatives who are unaware or mistrusting of the paramedics' roles can be associated with refusals of care or requesting direct transports to hospitals without care. AlShammari, Jennings and Williams (2017) reported that EMS services are not well known in Saudi Arabia. Alanazi (2012) reported that ambulance clinicians in Saudi Arabia perceive mistrust from patients as well as ED clinicians that hinders their ability to provide quality care. Ambulance clinicians have failed to challenge misconceptions around their role, leading to low trust in their competencies (Alanazy, Fraser and Wark, 2022). Further, some older patients or relatives refuse transports to the nearest hospitals, preferring transport to farther hospitals, which can mean that older patients deteriorate before arrival to the ED. A recent Saudi study reported similar findings, with some patients refusing to be transported by ambulance to the nearest hospital because they prefer a hospital that is far from home (Alanazy, Fraser and Wark, 2022). Moafa *et al.* (2022) stated that currently, the reasons for this problem are unknown, and further research into this issue would be beneficial. Spending time in convincing older patients or relatives who refuse care can be problematic. Recent evidence indicated that prolonged on-scene time is associated with adverse outcomes including mortality (Brown *et al.*, 2016; Ruelas *et al.*, 2018).

In contrast, dealing with cooperative older patients and families can be a facilitator to providing improved care compared with dealing with aggressive and noncooperative relatives and patients. One participant reported that ambulance workers prefer working with knowledgeable older patients and relatives who understand their medical history, consequences of refusing care, and paramedic roles. Ambulance clinicians may need longer times to convince unknowledgeable patients or relatives to accept treatment or transport. There may be many reasons for patients to refuse ambulance transports to EDs, including negative past experiences, concerns about ED waiting times, or simply wanting medical reassurance (Keene, Davis and Brook, 2015; Moafa *et al.*, 2021). Refusal of

transportation could be considered a waste of resources because it delays the response of other patients on the dispatching waiting list (Moafa *et al.*, 2021). Therefore, relatives can have a potentially important role in providing medical history and polypharmacy information and supporting patients to facilitate better care for their older patients.

Culturally, some relatives can play an important role in determining whether female patients accept prehospital care or transportation to hospital. Moafa *et al.* (2022) indicated that it is most common in Saudi Arabia for men to decide on the transportation of older patients, as some women insist upon having a male relative present when they discuss their health or future plans. Ambulance transportation can be prohibited by the female patients' relatives (Aldosari, 2017), and there is a higher refusal rate of ambulance transportation among Saudi female patients than among male patients (Moafa *et al.*, 2020). Due to this, the ambulance crew may need to spend more time discussing transportation decisions with female patients (Moafa *et al.*, 2022). One Saudi qualitative study reported that the recruited paramedics suggested employing female paramedics (Alanazy, Fraser and Wark, 2022). They are unable to provide on-scene emergency services because of a lack of female staff, and female patients also tend to resist having a male member of EMS treat or transport them (Alanazy, Fraser and Wark, 2022). However, Alanazy, Fraser and Wark (2022) argued that as a result of the prevailing culture of Saudi Arabia, more female paramedics may not be included in the EMS in the future.

Saudi Arabia has no female paramedics working in the prehospital setting despite the gradual increase in qualified female paramedics, and most female graduates are unemployed (Alobaid *et al.*, 2022). Three categories of factors contributed to this issue: personal, social and employment-related (Alobaid *et al.*, 2022). Personal factors include being away from family, being single, feeling guilty for neglecting family responsibilities, financial difficulties, being married and caring for children, and being pregnant contribute to mental health issues (Alobaid *et al.*, 2022). Social factors include discrimination from society and being denied employment as paramedics for responding to cases in private residences in violation of Saudi culture norms (Alobaid *et al.*, 2022). A number of factors are related to employment, including being female, having less physical ability, working nights and long hours, and being verbally and physically assaulted (Alobaid *et al.*, 2022). Alobaid *et al.* (2022)'s qualitative study was undertaken in a hospital that employs female paramedics as nurses rather than in ambulance

stations. Female paramedics in Saudi Arabia are recruited for public and private hospitals only, and they practice in hospitals or in totally female communities (Alharthy *et al.*, 2018). Alobaid *et al.* (2022) recommended 1) female paramedics' employment and the unique challenges they face could be discussed with officials from the SRCA. 2) The Saudi Ministry of Human Resources and Social Development can also participate to make sure gender is not an issue in the recruitment and selection of paramedics. 3) Physical activity and fitness could be improved for qualified women and undergraduates. 4) Visiting gymnasiums regularly and integrating sport lessons and activities into undergraduate curricula could help achieve this goal (Alobaid *et al.*, 2022).

Furthermore, the participants suggested that improving communication skills requires kindness and respect of older patients. A qualitative study in three EDs in England found that frail people aged 75 and over expressed a wish for caring, responsive staff to treat them with dignity, respect and appropriate care regardless of their age (Regen *et al.*, 2022). My findings suggest that the participants regard relatives only as a barrier to providing care and not as a facilitator. As Regen *et al.* (2022) argued the importance of providing timely information to patients as well as their relatives in a clear and honest manner, not least in enabling patients to participate in treatment decisions. Therefore, training could be used to improve communication with relatives so they can be engaged as a facilitator to providing better care rather than a barrier.

Lastly, the participants reported that dealing with non-Arabic speaking older patients and their relatives can act as a barrier to providing improved care. As it can be difficult to communicate with non-Arabic speaking older patients and relatives, especially during the Islamic seasons in Saudi Arabia. The large crowds of people from around the globe speaking multiple languages during the Hajj make it challenging to provide care during this time (Al-Wathinani *et al.*, 2021). While providing ambulance service, it can sometimes be difficult to locate interpreters who can communicate in the patient's native language and use a common language (Alazmy, Samarkandi and Williams, 2020; Al-Wathinani et al., 2021). Ambulance staff could be trained in advanced communication technology, such as an audio translator device or mobile applications, to identify and translate the languages spoken by pilgrims during the Hajj (Alazmy, Samarkandi and Williams, 2020).

5.4 Strengths and limitations of this study:

In terms of strengths, this study was conducted in two Saudi cities that have similar themes and subthemes, reflecting the same response and care guidelines, organisational, individual, and cultural challenges and barriers. This study included both experienced and non-experienced participants who added the role of experience in identifying and addressing these relevant challenges and barriers to providing better health care. Moreover, while the interviews and analyses were conducted in Arabic, a local supervisor with a qualitative and paramedic background carried out a back-translation to verify my forward-translation.

In terms of limitations, firstly, this study gave us the interviewee's perspective but did not feature interviews with older patients or relatives, which prevented valuable insights and experiences from the prehospital trauma care. Considering Saudi Arabia's unique healthcare system, cultural norms, and regulatory considerations, the Saudi culture places a high value on privacy and confidentiality in healthcare matters, which can make gaining consent from patients, interviewing them, or visiting them challenging. Secondly, other methods such as interviews with patients or direct observation of practice, might produce different findings as the interviews also tell us what the interviewees think is happening but not what is actually happening. I tried to address this limitation by adding a question in the interview schedule to ask participants about a recent older patient with the trauma they managed. They then described their recent older cases without needing observation. Third, only male participants were interviewed, as males still dominate the paramedic profession, and females remain constrained from participating in paramedicine due to culture and tradition (AlShammari, Jennings and Williams, 2017; Alobaid *et al.*, 2022).

Fourth, despite intending to balance between paramedics and EMTs in participation, this was limited to two EMTs from the two cities. The number of EMTs became limited after many of them enrolled in EMS bridge study programmes to become paramedics and some participants were EMTs before they became paramedics. As a result, each ambulance crew in the Saudi Red Crescent Authority has either two paramedics or a paramedic and an EMT. Lastly, this study may be limited by participant selection, with those who are interested in the topic or have strong opinions being more willing to participate. This can lead to missing important perspectives, particularly from those who have limited knowledge or interest in trauma care or the management of older people.

5.5 Implications for policy and practice and future research priorities:

The study identified a need to improve Saudi paramedics' and EMTs' understandings of how age impacts older patients. In addition to this need, the following issues need to be taken into consideration to solving organisational, cultural, and individual issues (**see Figure 5.1**):

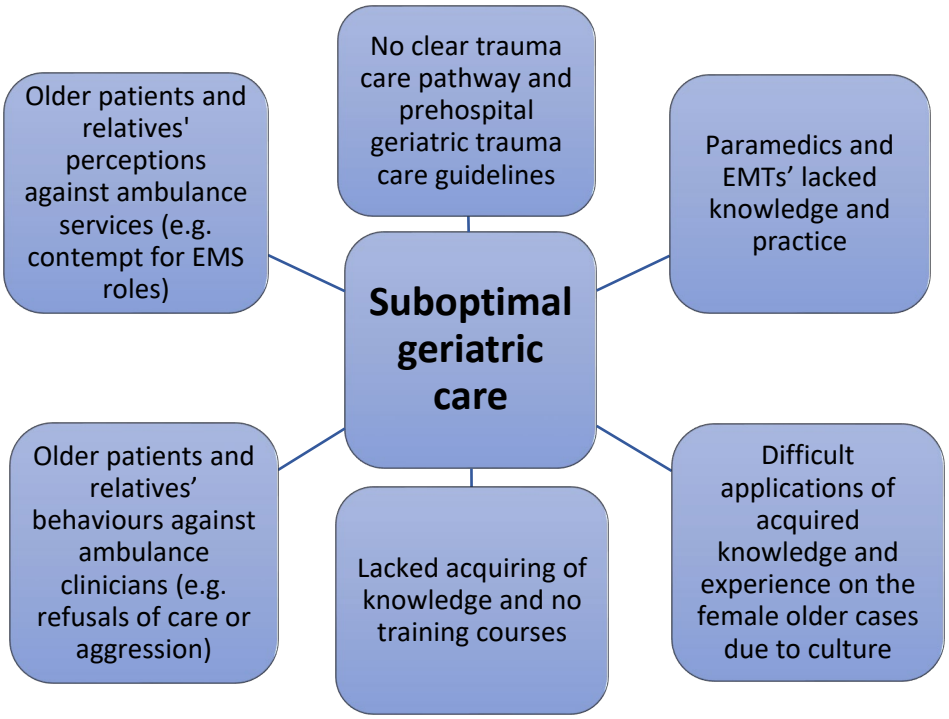


Figure 5.1: The current issues to improve the ambulance clinicians understanding and their geriatric trauma care in Saudi Arabia

Considering these issues requires multifactorial actions by relevant body organisations through the following ways:

5.5.1 Using the identified multifactorial issues to improve the current Saudi trauma system's gaps:

These multifactorial issues (**as shown in the Figure 5.1**) require collaboration between the SRCA, general hospitals, trauma centres, and educational institutions. These efforts are required to develop trauma care networks, clear prehospital trauma care guidelines, and clear pathways between prehospital and in-hospital settings. This requires collaboration to develop a trauma care pathway

encompassing injury prevention, prehospital care, acute care units, and post-hospital care (Peterson and Vaca, 2003).

Currently, Saudi Arabia lacks an organised trauma system that takes into account the complexity, range, and time-critical nature of injuries requiring immediate and integrated care (Chowdhury, Mok and Leenen, 2022). The vast distances, harsh climatic conditions, and lack of communication infrastructure contributed to this issue (Chowdhury, Mok and Leenen, 2022). Two recent Saudi studies indicated that the rates of mortality and trauma events still pose a burden to the government and also researchers (Alshamrani *et al.*, 2020), and that there is increased in-hospital mortality and disability among trauma patients who require prevention strategies (Abolfotouh *et al.*, 2018). Participants' responses concerning the organisational barriers and challenges reflect the issues in the Saudi trauma care system. Therefore, future research is required to identify the current gaps and weaknesses in Saudi trauma care and improve it, as well as its prehospital care component.

Additionally, the prehospital care in Saudi Arabia needs to be improved for all trauma patients including older patients as part of the trauma care system. To improve care, guidelines or protocols should be developed to help identifying major trauma older patients and differentiate them from minor trauma older patients and determine what level of care they need. Paramedics' use of technology should also be improved by following up on technology and practice updates from developed countries. As an example, process of integrating care protocols into tablet applications is important (El-Masri and Saddik, 2012). A Saudi study proposed a model that incorporates a patient's Online Health Record OHR to transfer patient data from hospitals to ambulances and vice versa so ambulance members could retrieve patient information to provide better care (El-Masri and Saddik, 2012). This project should be considered to improve the current clinical practice.

5.5.2 Improving the Saudi paramedics and EMTs' knowledge and practice in geriatric care:

Training on geriatric care is needed to address common issues such as delayed injury identification, unconscious age bias, cultural issues within trauma care systems that lead to unconscious age bias, and how to identify differences in care between older and younger patients (Ordoobadi *et al.*, 2022). Recent literature also recommended use of mastery education models that include initial acquisition of knowledge, deliberate practice, simulations, meta-cognition learning approaches, and also taking

feedback from ED staff about outcomes and treatments when delivering older cases (Barcinas and Braithwaite, 2022; Ordoobadi *et al.*, 2022). Duong *et al.* (2018) recommended a new training course in the US called Advanced Geriatric Education for Emergency Medical Services GEMS, developed by the National Association of Emergency Medical Technicians and American Geriatric Society. This course incorporates complex, realistic scenarios and unique technologies that paramedics and EMTs may encounter when assessing, treating, and transporting geriatric patients (Duong *et al.*, 2018). This course would be helpful for the Saudi paramedics and EMTs to be better equipped to identify and treat major trauma older patients.

Educating the Saudi ambulance members should include improving their attitudes and behaviours towards the older patients and their relatives. The preparation of healthcare professionals should emphasise developing positive attitudes towards older patients since positive attitudes contribute to providing high-quality care (Pope, 2012; Hanson, 2014). Attitudes affect the way we interpret information, how we acquire knowledge, and how we behave (Evers, Ploeg and Kaasalainen, 2011). Fisher, Bates and Banerjee (2017) advised that in addition to increasing medical professionals' knowledge and skills related to trauma in older patients, a change in attitudes towards older people is also necessary through simulation-based education. Furthermore, the EMS curricula should be improved by expanding its geriatric care-related knowledge. The acquisition of knowledge and experience, starting from the undergraduate years, can play a key role in shaping positive attitudes and, ultimately, result in better prehospital treatment for the older patients (Ross, Jennings and Williams, 2016). In their regression analysis of experience, knowledge, and attitudes, Ross, Jennings and Williams (2016) found higher knowledge and level of experience were associated with more positive attitudes.

Additionally, improving the Saudi paramedics and EMTs' knowledge should include improving their working and patient safety culture. To achieve this, healthcare professionals must foster a culture of openness among themselves and within their organisations (Firth-Cozens, 2001). To improve the patient safety, organisations need learning cultures that connect errors and learning intimately to healthcare, as well as encouraging and advising their staff to learn from one another and their mistakes (Firth-Cozens, 2001). Also, it is important to emphasise a shift in cultural attitudes away from blaming individual caregivers for errors (Milligan and Dennis, 2005). Culture shifts away from blame do not

condone reckless or malicious behaviour, but enable open debates about what errors happened, how, and when they happened (Milligan and Dennis, 2005). Therefore, further research is needed to investigate the Saudi paramedics' attitudes and behaviours towards older patients, and the contribution of their negative working culture, a lack of knowledge, practice, and policy research to the lack of patient safety.

5.5.3 Saudi health and educational institutions efforts to raise public awareness and geriatric care research:

A national public education programme about the role and limitations of ambulance services in Saudi society would help address some perceived misunderstandings about inappropriate calls for ambulances (Alanazy, Fraser and Wark, 2022). Public awareness of what EMS's job is and what is expected of them will improve Saudi community satisfaction with EMS (Hamam *et al.*, 2015). It could be helpful to examine how older people perceive EMS and whether they are satisfied with it (Moafa *et al.*, 2021). These programmes should address cultural barriers that impede paramedics' application of their acquired knowledge. Alanazy, Fraser and Wark (2022) indicated that attempting to correct the current sex imbalance within the EMS will take a long time and require public awareness campaigns, improved educational access, and general and specific advocacy.

Additionally, there is a shortage of prehospital geriatric care research in Saudi Arabia. The key role of healthcare research is to assess the quality and safety of care and to guide policymakers and professionals to improve patient outcomes (van de Glind *et al.*, 2016). However, the prehospital setting has a limited amount of scientific knowledge, making the delivery of evidence-based prehospital care increasingly difficult (Brown *et al.*, 2014). A further investigation of how EMS can assist in fall assessment, screening, and intervention before patients are transferred to the ED is necessary, as well as whether EMS can connect patients to existing resources (Hammouda *et al.*, 2021). There is a need for further research involving older patients and relatives to determine their perspectives and insights regarding prehospital trauma care or to employ other methods such as direct observation of practice, which may produce different outcomes or what is actually happening. To reduce cultural issues that hinder providing improved care to female patients, further research is needed on recruiting female paramedics to ambulance stations.

5.6 Conclusion:

Few studies have explored the ageing-related challenges encountered while responding to and caring for older trauma patients. Saudi paramedics and EMTs described their understanding, how they acquire and apply their knowledge, as well as the challenges they face when responding to and managing older trauma patients. This study identified barriers and facilitators that influence the provision of better geriatric trauma care. As a result of identifying physiological, organisational, individual, and cultural factors, it is possible to make multifactorial improvements through the development of clear guidelines, trauma care pathways, training for paramedics and EMTs, and increased awareness of cultural barriers. Additionally, the next chapter will provide a comprehensive, in-depth discussion of the PhD research problem by integrating the findings of this study with the previous retrospective findings to address the main aim of the primary PhD research.

Chapter

6

The Discussion: Integration of the Findings

(Chapter title: Integration of the Quantitative and Qualitative Findings)

Chapter overview:

"This discussion chapter integrating the findings of the quantitative and qualitative studies to address the main aim of the primary PhD research which is to improving understanding and knowledge of prehospital geriatric trauma care in Saudi Arabia".

6.1 Introduction:

This chapter discusses the sequential explanatory mixed methods research findings of the retrospective and qualitative studies. Having conducted a narrative review on the research topic in chapter one, the scoping review of international literature on prehospital geriatric trauma care was conducted in chapter two. It identified five topic areas with their research gaps: field-triage, ageing changes, decision-making, paramedic's awareness, and paramedic's behaviour. Future research is required to investigate the undertriage, overtriage, triage sensitivity and specificity, paramedics' awareness of ageing impacts, EMS decision-making processes, and paramedics' behaviour in dealing with older patients. The retrospective cohort study was then undertaken to collect and analyse cohort data from the KSMC trauma center in Riyadh city, which represented older trauma patients admitted by ambulance. I found a high prevalence of low-fallers admitted with normal physiology and extremity injuries, and poor prediction of in-hospital mortality in such patients.

The qualitative study was then conducted by recruiting Saudi paramedics and EMTs from the SRCA's ambulance stations in Makkah and Riyadh. They identified ageing-related challenges such as the physiological changes, communication difficulties and polypharmacy that influence prehospital trauma care of older patients compared to younger patients. All perceived that they needed to develop their skills to allow them to implement their knowledge, so they wanted training and guidelines. When responding to older female patients with injuries, cultural restrictions created a barrier to them applying their knowledge leading to female patients or their relatives refusing care. Interviewees reported that there are no clear trauma care guidelines, which results in arbitrary EMS decisions depending on participants' level of acquired knowledge. They also encounter number of organisational, individual, and cultural barriers to providing improved care, and identified facilitators to address these barriers. This chapter integrates retrospective and qualitative research to improve understanding, which is the main aim of this PhD research, as well as improving prehospital geriatric trauma care in Saudi Arabia.

6.2 Discussing integrated findings:

Following the advice of Creswell and Plano Clark (2017) to writing a side-by-side narrative discussion as an alternative integration process, I divided the discussion into four components as deficiencies

identified by my PhD research that hinder providing optimal care for older patients with injuries (**see Figure 6.1**):

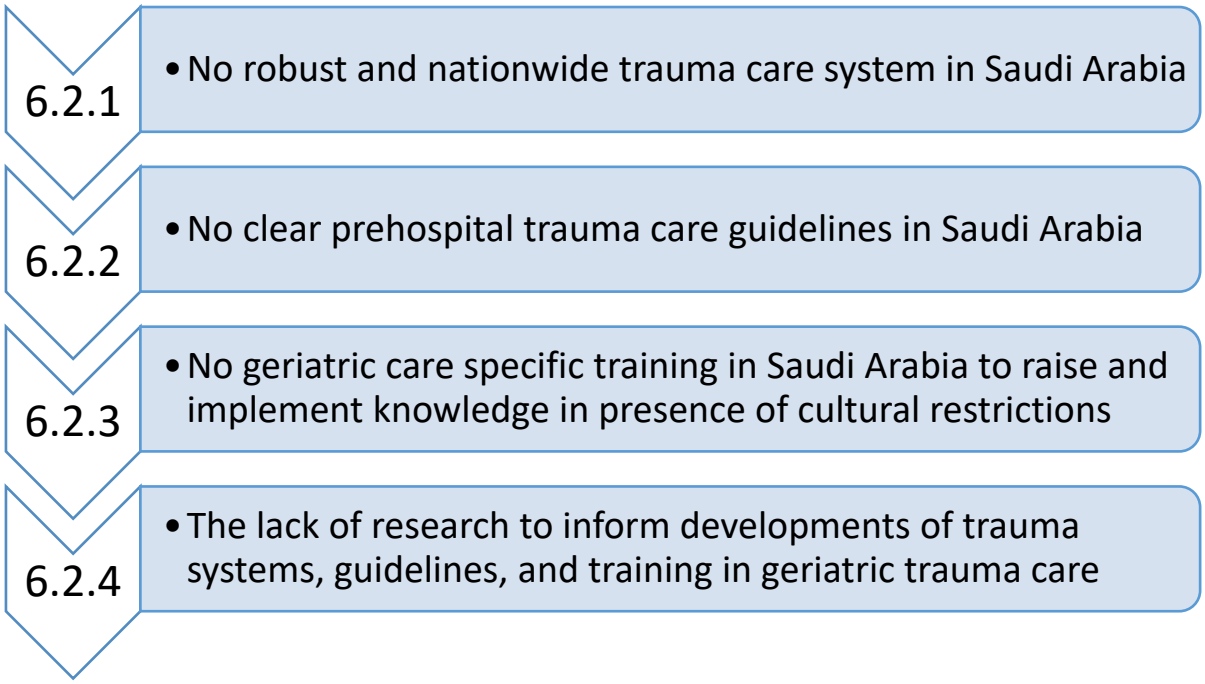


Figure 6.1: The main components of the mixed-methods study's discussion

These components existed as follows: *'No robust and nationwide trauma care system…'* and *'No clear prehospital trauma care guidelines…'* from the interviews and quantitative study's interpretation, *'No geriatric care specific training…'* from only the interviews, and *'The lack of research to inform the developments of…'* from interpretation based on the findings of the scoping review, quantitative and qualitative studies.

6.2.1 No robust and nationwide trauma care system in Saudi Arabia:

At this section, I discuss three relevant issues that were identified from the interviews and the interpretation of the quantitative study (**see Figure 6.2**):

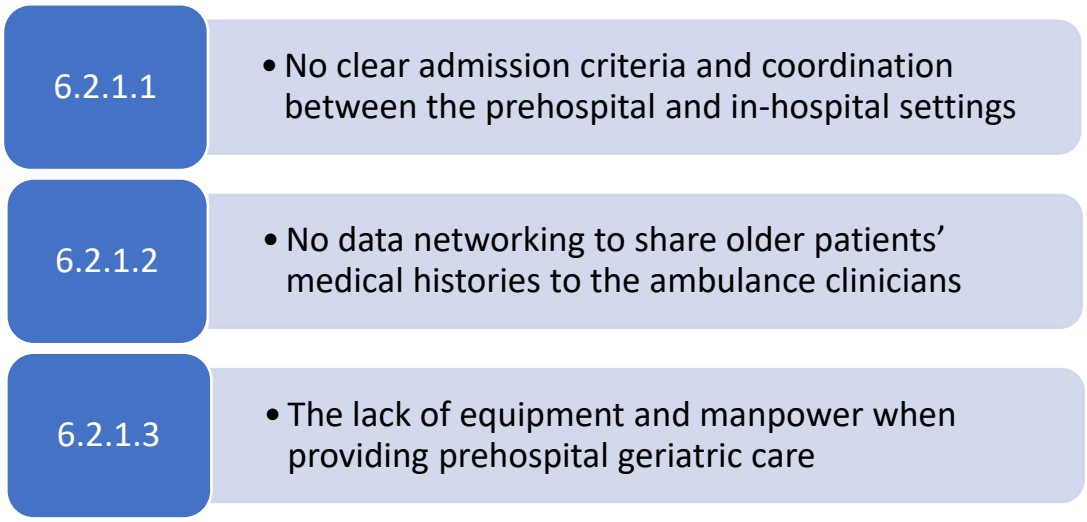


Figure 6.2: The three issues related to the issue of no robust and nationwide trauma care system in Saudi Arabia

These identified three issues are situated under a major issue which is no organised and nationwide trauma care system and unified trauma registry that I have previously discussed in the first chapter.

6.2.1.1 No clear admission criteria and coordination between the prehospital and in-hospital settings:

Participants in the qualitative study report that admitting older patients to either MTCs or non-MTCs lack clear criteria and the prehospital and hospital coordination is limited. Major trauma older patients are transported to nearest hospitals, while minor trauma patients are transported to hospitals that older patients or relatives desired based on the current guidelines. Further, some ED staff have fears that they may be held liable if they refused to admit those patients from ambulance clinicians, according to some interviewees. Most older trauma cases who were admitted to the KSMC's MTC by ambulances were minor with normal prehospital and ED physiology. This finding reflects the issue of admitting minor older cases to the MTC, potentially leading to overtriage. These findings of the two studies were consistent with recent Saudi studies that evaluated the current trauma care system. Alharbi *et al.* (2020) stated that the prehospital guidelines, trauma bypass or field triage tools to transport trauma patients to suitable facilities are lacking. Alharbi *et al.* (2020) and Chowdhury, Mok and Leenen (2022) indicated that there is little effort to link prehospital triage to receiving hospitals

and no collaborative networks between these settings. Because ambulance and ED teams need to communicate and coordinate using patient information effectively to provide rapid preparation and effective care to patients (Faraj and Xiao, 2006).

6.2.1.2 No data networking to share older patients' medical histories to the ambulance clinicians:

The participants in the qualitative study reported that medications and medical histories data of older patients are not shared with them from a formal database to help them make definitive care decisions, especially when dealing with older patients with mental health and hearing issues or patients with no relatives. Although they currently use tablets to send patients' reports electronically to targeted hospitals, they cannot access the necessary information of those patients. Consistently, evaluating the current trauma system led to identify that there is no linkage of data and no networking between the prehospital and hospital settings in Saudi Arabia (Alharbi *et al.*, 2020; Chowdhury, Mok and Leenen, 2022). These may contribute to arbitrary EMS decisions when ambulance clinicians decide either trauma centre or trauma unit and provide suboptimal treatment care. This may explain why the majority of the cohort in the retrospective study were admitted with normal physiology. I identified that most of the participants who were unaware that these tablets could have access to the necessary patient information to support care. This technology is used in some developed countries, such in the UK, along with other built-in care tools such as decision-support, care directories, and referral applications (Porter *et al.*, 2020).

6.2.1.3 The lack of equipment and manpower when providing prehospital geriatric care:

The participants in the qualitative study struggled with a lack of equipment such as backboards, blankets, short cannulas, nasal cannulas, or cervical collars. They also struggle with limited manpower when providing care for older trauma patients. There are only two paramedics on each ambulance; one will drive, the other will splint fractures, canulate veins, prepare fluids, and administer painkillers. If heavier older patients were dealt with, additional staff would be needed. These findings were consistent with two Saudi studies evaluated the current system and found that there is a lack of prehospital transport resources and capabilities and the prehospital trauma care needs improvement (Alferdaus and Shaher, 2021; Chowdhury, Mok and Leenen, 2022). Further to this, some participants

reported relying on relatives or bystanders to lift and move injured older patients due to a lack of manpower. These people lack training in patient lifts and moves, which poses a risk to patient safety.

6.2.2 No clear prehospital trauma care guidelines in Saudi Arabia:

The participants in the qualitative study reported difficulties in predicting major injuries, making accurate transport decisions, and using insufficient treatment guidelines for older trauma patients. Therefore, the following three categories of issues in this discussion component reflect what they want in terms of guidelines based on the interviews and quantitative study's interpretation (**see Figure 6.3**):

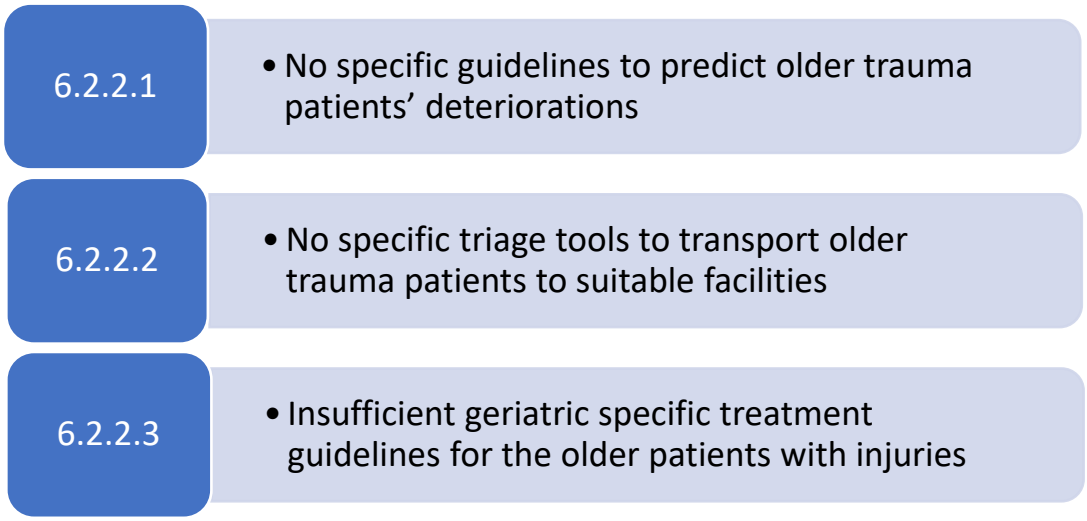


Figure 6.3: The three issues related to the issue of no clear prehospital trauma care guidelines in Saudi Arabia

6.2.2.1 No specific guidelines to predict older trauma patients' deteriorations:

Participants in the qualitative study expressed that they are unable to predict the deterioration and complications of older patients when responding to them. They struggle with making transport decisions for older patients who deteriorate due to hidden internal bleeding or injuries caused by low mechanisms of injuries compared to younger patients with similar injuries. Major injuries were traditionally understood as a condition of younger populations caused by high-energy mechanisms of injury (Kehoe *et al.*, 2015). Physiological changes like low pain sensations and mental issues that hide older patients' complaints, as well as polypharmacy that mask signs of shock, were linked to this issue.

Most of the retrospective study cohort were minor cases that may be transported due to arbitrary decisions to the MTC. Further, in this retrospective study, poor predictions of in-hospital mortality among older people who were admitted to the MTC by ambulances aligned with participants' difficult predictions of deteriorations. Therefore, some of the participants wanted geriatric specific guidelines to help them identifying major injuries. Some of the participants reported applying the knowledge they acquired from self-learning and continuing education to make transport and treatment decisions for the older trauma patients. In the light of the gradual increase in older populations worldwide, prehospital care guidelines are needed that consider age-related criteria for older patients who are at risks of major injuries due to minor injury mechanisms (Nakamura *et al.*, 2012; Staudenmayer *et al.*, 2013; Alshibani, Singler and Conroy, 2021).

6.2.2.2 No specific triage tools to transport older trauma patients to suitable facilities:

Arbitrary EMS decisions can lead to lengthy transport times and unnecessary activation of costly trauma teams, with increased care costs because costs in MTCs are nearly twice as high as in other hospitals (Durham *et al.*, 2006). Most participants in the qualitative study reported that they transported major cases to nearest hospitals and minor cases to facilities that older patients and relatives desired. Undertriage and overtriage issues is likely in Saudi Arabia because the participants reported use of similar transport guidelines with all adult trauma cases without age considerations. International research has found that geriatric patients with injuries were significantly undertriaged with the prehospital setting (Cox *et al.*, 2014; Newgard *et al.*, 2014, 2019; Garwe *et al.*, 2017; Brown *et al.*, 2019; Meyers *et al.*, 2019). Consistently, as previously mentioned by Alharbi *et al.* (2020), paramedics currently transport all trauma patients to nearest facilities (either MTC or trauma unit) without clear guidelines for field triage, trauma destination protocols, or trauma bypass tools. This can then influence the prehospital triage accuracy and lead to poorer outcomes due to the impacts of physiological changes, multiple diseases and polypharmacy (Newgard *et al.*, 2019). However, there is insufficient evidence to support guidelines or changes to prehospital triage for older people since the current trauma systems and guidelines were based on evidence from younger trauma victims and on models of trauma care that suit younger trauma victims. The interviewees reported their difficulties in finding geriatric care related research in Saudi Arabia to improve their implementation of their

knowledge. This may reflect international need to develop a completely different trauma system for older people; focusing on rehabilitation and multidisciplinary teams, rather than surgery or critical care, one that provides care closer to the patient's home, and one that values improving quality of life and longevity.

The participants wanted geriatric specific guidelines, so the recent international relevant evidence from developed countries such as UK, US, and Australia should be taken into consideration. Along with the age factor, the observational literature from these developed countries have considered on further factors such as physiologic changes, comorbidities, and polypharmacy. In Saudi Arabia, these actions could be considered after firstly developing care guidelines and triage tools for caring for younger trauma patients who need clear tools to reduce their increased mortality based on the recent Saudi observational literature (Alghnam, Palta, Hamedani, Alkelya, et al., 2014; Alghnam, Palta, Hamedani, Remington, et al., 2014; Abolfotouh et al., 2018). Participants in the qualitative study reported that younger trauma patients receive better prehospital care than geriatric patients. Further, some older patients were seen at the ED and nothing was done for them according to a participant who had a second duty in a hospital's ED. Therefore, geriatric specific transport guidelines could be developed by adding age, physiological parameters, comorbidities, and polypharmacy factors into the current tools, based on the studies included in the scoping review, which evaluated the effectiveness of these tools on geriatric trauma patients after adding these factors. However, it will be difficult to achieve these actions in Saudi Arabia since there is no unified trauma registry, no robust evidence of trauma, and no organised trauma system.

6.2.2.3 Insufficient geriatric specific treatment guidelines for the older patients with injuries:

The ambulance clinician's greatest challenge is providing care to the growing population of older individuals (Duong *et al.*, 2018). Participants in the qualitative study reported that they have treatment guidelines for older patients, including trauma and medical treatment, showing only the general information of IV fluids replacements. Those guidelines are installed on tablets they use to provide care instructions for geriatric patients. Consequently, some paramedics and EMTs use their acquired knowledge to provide treatment for those patients. An evaluation of current North American EMS curricula indicated that EMT curricula focuses on assessing, treating and physiology differences

between older and younger patients due to ageing, while advanced EMT curricula has an additional relevant section that focuses only on fluid resuscitations (Duong *et al.*, 2018). Older patients more frequently need life-saving interventions and the EMTs and paramedics must be prepared to deal with the unique needs of those patients who often have illnesses and polypharmacy which increase the potential harm of interactions between drugs (Carpenter *et al.*, 2011; Duong *et al.*, 2018). Prehospital care models currently emphasise diagnostics and therapeutics but fail to acknowledge the subtleties involved in addressing the older patients' complex needs (Duong *et al.*, 2018).

6.2.3 No geriatric care specific training in Saudi Arabia to raise and implement the knowledge in presence of cultural restrictions:

This discussion component is divided into the following three issues identified from the qualitative study's interviewees (**see Figure 6.4**), when they expressed their understanding, reported lacked knowledge and cultural restrictions as barriers to providing improved care.

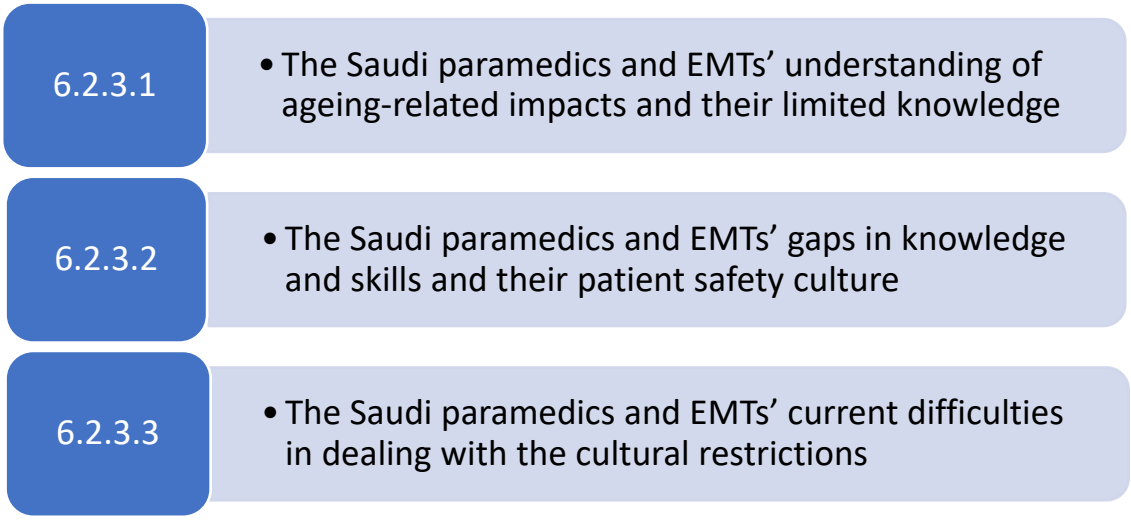


Figure 6.4: The three issues related to the issue of no geriatric care specific training in Saudi Arabia

6.2.3.1 The paramedics and EMTs' understanding of ageing-related impacts and their limited knowledge:

The participants in the qualitative study reported that they encountered ageing-related challenges such as physiological changes, communication difficulties and polypharmacy in older people compared

to younger patients. Shah *et al.* (2012) similarly reported that paramedics face unique challenges such as comorbidities, polypharmacy, and communication difficulties. Paramedics must be prepared for the unique needs of older patients as a result of these challenges on the EMS system and the burden they are imposing on the national system (Duong *et al.*, 2018). For example, prehospital physical examinations are difficult, and geriatric patients are known to present with atypical physical characteristics (Esmer *et al.*, 2017). Further, older patients have illnesses and use polypharmacy, which increases the potential harm of interactions between drugs (Carpenter *et al.*, 2011; Duong *et al.*, 2018). Communication may be especially difficult for older patients with declining hearing and cognitive abilities. Taking older patients out of familiar environments and exposing them to excessive stimulation can easily make them feel disoriented (Yorkston, Bourgeois and Baylor, 2010; Shah *et al.*, 2012). The majority of the qualitative study's participants reported that they had insufficient knowledge and wanted training and guidelines to improve and implement their knowledge and skills. Improving knowledge regarding these ageing-related challenges and impacts is important and understanding the characteristics of older people is crucial to improving EMS care for them (Duong *et al.*, 2018). However, according to US study, prehospital care provided to older patients has not been described. For instance how often these prehospital patients are referred, what are characteristics of those patients, what type of clinical care episodes they receive, what methods they receive, and how they respond (Duong *et al.*, 2018). The current EMS training curriculum does not provide adequate training for caring for older patients, despite the older patients' unique needs according to relevant research (Shah *et al.*, 2008, 2010, 2012; Peterson *et al.*, 2009). Duong *et al.* (2018) argued that while inpatient and long-term care personnel are well aware of the challenges of older patients, ambulance clinicians are less aware (Duong *et al.*, 2018), resulting in suboptimal evaluation of injury severity and judgements (Alshibani, Singler and Conroy, 2021).

The participants in the qualitative study reported that they transported major cases to nearest hospitals and minor cases to facilities that older patients and relatives desired, regardless of the level of care each facility provides. These emphasise that ambulance clinicians need better knowledge, training and guidance to help them determine the best hospital for the older patients. Further, the qualitative study participants did not raise any issues related to overtriage or undertriage that they might not have been aware of, since they do not use clear guidelines or tools for trauma care (Alharbi

et al., 2020). Also, they have not mentioned any frailty related issues and assessments. It seems that the participants had lack of awareness and knowledge about these issues. I identified these issues from the scoping review, which suggested they were important but were not mentioned by the qualitative study participants. The current paramedics' clinical practices provide limited directions in assessing frailty in routine trauma assessments, according to a Canadian study (Goldstein, Andrew and Travers, 2012), and frailty assessment could be integrated into all assessments of patients over 65 years old, according to two Australian studies (Dent *et al.*, 2019; Harris *et al.*, 2021). Further, a recent UK study included older cases from 23 MTCs to investigate the effect of frailty on clinical outcomes in those patients (Carter *et al.*, 2022). They indicated that the frailty determines a person's level of ability to cope with a stressor event such as a serious disease, an operation, or trauma, and is correlated with an ageing process, although they noted that frailty is not universal among older people. They also found that older people's inpatient mortality after major injury is associated with preinjury frailty (Carter *et al.*, 2022). Another study argued that clinicians should not use frailty exclusively in predicting outcomes, but that frailty could be used to support clinical decisions (Lewis *et al.*, 2021).

6.2.3.2 The Saudi paramedics and EMTs' gaps in knowledge and skills and their patient safety culture:

Participants in the qualitative study explicitly reported lacks of knowledge and skills, while others attributed these to their colleagues rather than to themselves. All wanted more training. They identified some areas requiring improvement through training, including communication difficulties, difficulty predicting deterioration, complications, hidden injuries or bleeding, providing medications, challenging cannulations, decision-making skills, and impacts of polypharmacy and comorbidities on vital signs. The difficulties were similar to those identified in a US study indicating that paramedics face unique challenges related to geriatric care, such as comorbidities, polypharmacy, and communication difficulties (Shah *et al.*, 2012). A qualitative study in the UK explored paramedics' current knowledge, practice, and attitudes toward older patients and frailty, and reported that paramedics have a limited understanding of frailty and common aging changes, and relevant information is limited to one to two interviewees, despite their responsibilities to provide optimal geriatric care (Green, Kirby and Hope, 2018). Green, Kirby and Hope (2018) also reported that some participants suggested that more

geriatric care training and even paramedics specialising in geriatric care are needed as the population becomes older, consistent with the Saudi participants in this study. Training could include discussing common issues such as delayed injury identification, unconscious age bias, cultural issues within trauma care systems that might increase unconscious age biases, and identifying differences in patient care between older and younger patients to improve quality care and outcomes (Ordoobadi *et al.*, 2022). Research also recommended that integrated mastery education models be used to acquire knowledge, practice, simulate scenarios, learn metacognition, and use feedback from ED staff about outcomes and treatments of older patients delivered so that we have a better understanding and experience of what to expect (Barcinas and Braithwaite, 2022; Ordoobadi *et al.*, 2022).

Regarding the barriers to providing improved trauma care, the qualitative study participants reported individual barriers such as a lack of confidence in paramedics, aggressive behavior, and relatives neglecting patients' needs. They also reported cultural issues such as difficulties with female older patients and relatives' refusals of care. The practical steps to addressing these barriers could involve training or educating paramedics rather than changing patients, relatives, or society. Therefore, some experienced participants suggested communication skills training for their colleagues including dealing with older people with kindness and respect, giving them a space to express, listening to them carefully without ignorance, explaining procedures before applying to convince them to accept care. Further, two participants have recommended that their colleagues can request training at different hospital geriatric clinics or intensive care units that offer training for paramedics to practice cannulations on older patients and work with specialised physicians to address their knowledge gaps. They reported that their knowledge and skills have improved as a result of these training sessions. Moreover, policymakers could develop organisational strategies to cultivate patient safety culture among the Saudi ambulance clinicians. Some participants in the qualitative study were reluctant to admit their knowledge and practice gaps but they still wanted training. As I have mentioned in the previous chapter that the healthcare professionals must foster a culture of openness among themselves and within their organisations (Firth-Cozens, 2001). It is important to emphasise a shift in cultural attitudes away from blaming individual caregivers for errors (Milligan and Dennis, 2005). Culture shifts away from blame do not condone reckless or malicious behaviour, but enable open debates about what errors happened, how, and when they happened (Milligan and Dennis, 2005).

6.2.3.3 The Saudi paramedics and EMTs' current difficulties in dealing with the cultural restrictions:

The cultural issues were identified as barriers faced by the participants when responding to and caring for older female patients with injuries. Guidelines are required for older trauma patients, but cultural issues can hinder implementation of guidelines and improved geriatric trauma care. Female patients or their relatives may refuse care action due to local habit and tradition, which the qualitative study participants reported to have difficulty responding to and providing improved care for. A Saudi qualitative study reported that EMS providers encounter difficulties in responding to female patients especially during obstetric cases and suggested employing female paramedics (Alanazy, Fraser and Wark, 2022). Some older patients require more time due to communication difficulties, convincing those who refuse care and care procedures needing longer time to be applied, according to the participants. The Saudi paramedics may also have difficulty providing emergency services on-scene due to a noticeable resistance among female patients to having a male EMS member generally treat or transport them (Alanazy, Fraser and Wark, 2022). The contributory factors of this issue are cultural restrictions of face coverage by older female patients, care of female cases by all-male crews, difficult communications, severity of comorbidities, presence of older patients' relatives, and designs of Saudi houses (Moafa *et al.*, 2022). Moafa *et al.* (2022) identified a challenge of women using EMS less than men in Saudi Arabia. Regardless of older patients' gender, the qualitative study's participants reported that some male cases refuse EMS treatment due to a lack of trust in paramedics or fears of ambulances. It remains unclear why older patients in Saudi Arabia don't use ambulances when visiting EDs (Abualenain *et al.*, 2017). Their fears could include that the ambulance may take longer time to respond, that they lack awareness about the service, or that they might not be taken to their preferred hospital where they receive follow-up care (Abualenain *et al.*, 2017).

Alanazy, Fraser and Wark (2022) argued that as a result of the prevailing culture of Saudi Arabia, more female paramedics may not be included in the EMS in the future. Attempting to correct the current sex imbalance within the EMS will take a long time and require public awareness campaigns, improved educational access, and general and specific advocacy (Alanazy, Fraser and Wark, 2022). Despite the current gradual increase in qualifying female paramedics, there was no significant increase in women employed as paramedics; most female graduates are unemployed, and no female

paramedics work in the prehospital setting in Saudi Arabia (Alobaid *et al.*, 2022). By improving the Saudi ambulance clinicians' communication skills, they will be able to better approach older female and male trauma patients and families to convince them to accept physical assessment and care. According to an experienced participant who also works as a trainer, improving communication skills can strengthen older patients and families' trust in paramedics and help facilitate next care steps. There needs to be confidence in the knowledge and attitudes of care givers towards older patients without discrimination (Cheng *et al.*, 2022). Therefore, forming training courses in Saudi Arabia would include these skills to facilitate implementation of developed guidelines. Instilling gerontological principles and enhancing its training through medical education would be a more efficient and accessible way of creating caregivers with an understanding of geriatric needs and willingness to accommodate them (Amsalu, Messele and Adane, 2021).

6.2.4 The lack of research to inform the developments of trauma systems, guidelines, and training in geriatric trauma care:

This discussion component focuses on how the lack of research limits the development of trauma systems, guidelines and training towards geriatric trauma care and explains the importance of undertaking research before changing policy and practice. As the scoping review included studies from other countries, it reflected the lack of prehospital geriatric trauma care research in Saudi Arabia. Further, most participants reported a lack of research into geriatric trauma care in the country and my findings of poor prediction of mortality in the quantitative study may reflect the lack of evidence to guide trauma system development, guidelines, or training. In terms of trauma systems, the foundation for trauma care system development and performance improvement is research, which is at the core of trauma care systems (Al-Naami, Arafah and Al-Ibrahim, 2010; Alferdaus and Shaher, 2021). To improve patient outcomes, policymakers and professionals rely on research to evaluate the quality and safety of care (van de Glind et al., 2016). However, trauma care research in Saudi Arabia is limited due to the absence of a trauma registry (Alferdaus and Shaher, 2021). This was consistent when some participants reported that Saudi Arabia lacks research on prehospital geriatric trauma care they require to enrich and implement their knowledge. Therefore, it is not surprising that there are no geriatric care protocols, training courses, or robust and nationwide trauma care system since there is no formal and

unified trauma registry in Saudi Arabia to rely on. Alferdaus and Shaher (2021) argued that improving the trauma system in Saudi Arabia involves identifying gaps and reviewing the system by using the ACS criteria. This can also include the need for a nationwide trauma networking, trauma registry to all Saudi regions, and building level 1 trauma centres in large cities rather that only in Riyadh that my research identified as deficiencies can contribute to improvements in the system.

Additional issues were also identified that are difficulties in developing geriatric specific guidelines and forming training courses. The poor prediction of mortality in older people in the quantitative study and the lack of relevant research in Saudi Arabia, as reported by the qualitative study's participants, might reflect these issues. Also, there are no unified trauma registries and there are two trauma registries working separately in one city. These identified deficiencies can be associated with the lack of relevant research to inform guidelines and training compared to the Trauma Audit and Research Network TARN database, which collects data from different MTCs in the UK and has produced recent high-quality research. I experienced a problem when I decided to conduct a multi-centre retrospective study and collect data from the KAMC and KSMC trauma centres due to their small data sizes. The KAMC MTC registry manager refused to allow this without a valid reason, so I conducted my retrospective study using data from the KSMC MTC registry. As shown in a Saudi study, collecting multi-centre data is challenging due to logistical challenges such as comparability, completeness of datasets, some organisations' need for manual data collection and screening (Alharbi et al., 2022). Developing guidelines and forming training courses should be based on evidence as I did in the quantitative and qualitative studies. Hence, developing training addressing the knowledge and skills gaps as I identified from the interviews with Saudi paramedics and EMTs would be feasible. I specifically asked each interviewee how they acquired and applied their knowledge to older trauma patients, and what skills they were confident or unconfident in applying. These reflect the importance of research in exploring paramedics' needs in knowledge and skills and identifying gaps in guidelines prior as I did in this PhD research to form training courses and develop robust guidelines, followed by subsequent evaluation research. However, these can be challenging until having reliable and sufficient data collected from a unified nationwide registry, as applied in the UK, the US, and Australia countries.

An unstructured literature review was undertaken to identify Saudi relevant research to be compared with the findings of this research. I found that Saudi research has been focused on younger trauma

patients rather than focusing only on geriatric patients. The identified literature suggested that the current Saudi trauma system has been organised based on evidence around the needs of younger people with severe injuries. Frailty and comorbidities were not considered, and it is still unknown whether this evidence is applicable to older victims and whether trauma centres can benefit them. This would explain why centralised models of trauma care may not be appropriate for older people and why research into geriatric trauma care is needed in Saudi Arabia. The limited evidence around trauma care for older people makes it difficult to make recommendations about how trauma care systems, guidelines and training could be developed. Furthermore, the principles used to develop trauma care systems (to transport seriously injured patients to trauma centres to focus and develop specialist management) may not apply well to older people, for whom rehabilitation involving multidisciplinary teams close to their home may be more important.

6.3 Conclusion:

Through this chapter, I have justified the reasons for not using a specific approach to integrate the quantitative and qualitative data or findings. Instead, I have used the findings of retrospective and qualitative studies to construct a complementary narrative discussion leading to identify four current relevant research issues and ways to improve understanding and care. The issues identified were a lack of organised system towards providing better geriatric care, a lack of geriatric specific guidelines and training, and current research conducted on younger trauma patients rather than older victims. The next final chapter outlines the key findings of this research, strengths and limitations, implications for future, policy and practice as well as the conclusion of this PhD research.

Chapter

7

The Conclusion and Recommendations

(Chapter title: The Conclusion and Recommendations of the Primary PhD Research)

Chapter overview:

"This chapter outlines a summary of the key findings of previous chapters, implications for future research, policy and practice as recommendations, strengths and limitations, conclusion of the primary PhD research".

7.1 Introduction:

I have started this PhD research by describing the background of the research topic and the current situation of the trauma system in Saudi Arabia within the first chapter. The scoping review was then conducted to review international evidence on prehospital care for older injury patients. The third chapter then described the suggested methodology for this PhD research. Afterwards, the retrospective cohort study was conducted by collecting and analysing secondary data within the fourth chapter. The qualitative study was then conducted by interviewing Saudi paramedics and EMTs in the fifth chapter. After conducting both quantitative and qualitative findings, the discussion chapter explored Saudi paramedics and EMTs' understanding of ageing impacts and identified ways to improve their understanding along with improving care since they have also reported organisational, individual, and cultural barriers to implementing their knowledge. This seventh chapter summarises the key findings and future recommendations for improving understanding and care in Saudi Arabia. This chapter also discusses the strengths and limitations, implications for future research, policy, and practice and the conclusion of the primary PhD research.

7.2 A summary of the key findings

7.2.1 A summary of the narrative and scoping reviews:

The primary purpose of the PhD research was to improving understanding of prehospital care for older patients with injuries. This PhD project began with a narrative review within the first chapter, which provided an overview of the research topic, presented the impact of ageing changes on healthcare and patient outcomes, and clarified the implications for injured older patients, clinicians, and ambulance services. It explained how ambulance workers care for injured older patients and the impacts of ageing on prehospital trauma care. It then described the current status of the trauma system in Saudi Arabia. In the second chapter, the scoping review investigated the research themes and gaps regarding prehospital trauma care for older patients. Field-triage, ageing changes, decision-making, paramedic awareness, and paramedic behaviour were identified as themes with their subthemes. I identified that research gaps existed, including undertriage, overtriage, triage sensitivity, and specificity, determining paramedics' awareness of ageing impacts, examining EMS decision-making

processes, and understanding paramedics' behaviour in dealing with older patients. Training on identifying high-risk older trauma patients was also required. From the perspective of Saudi Arabia, these research gaps were taken into account in the qualitative study, except for the field-triage issues due to the lack of prehospital guidelines in Saudi Arabia, according to the first chapter's narrative review. Before that, the retrospective cohort study was also conducted due to a lack of relevant prehospital research, since describing injury characteristics through secondary data is the first step to improving care and practice.

7.2.2 A summary of the quantitative and qualitative studies:

A sequential explanatory mixed-methods approach with higher emphasis on the qualitative part was used in this PhD research. I conducted the retrospective cohort study first, followed by the qualitative study, and then considered how the retrospective study's findings could affect the qualitative study. The retrospective cohort study was conducted to describe the injury characteristics of older people with injuries in Saudi Arabia and identify predictors of in-hospital mortality among them. The qualitative study explored Saudi paramedics' and EMTs' understanding of prehospital care for older patients with injuries, how they acquire and apply knowledge, and barriers and facilitators to providing improved care. The descriptive retrospective study recruited 452 eligible older patients with injuries admitted to the KSMCS's MTC in Riyadh from 1st August 2017 to 31st October 2021 by ambulance services. The majority of older patients were admitted with extremity injuries had normal physiology due to low falls (falls below 1 meter). Most of the recruited cases admitted were minor cases without activating trauma teams (418 out of 448 cases). Factors behind this issue need further investigation since they were admitted to a MTC that typically treats major cases. There is no evidence that presenting characteristics were associated with mortality. This could be because presenting characteristics are poor predictors of mortality in older people, or it could be because the study lacked statistical power to detect such associations.

After the retrospective cohort study's findings were analysed, a qualitative study was conducted using the four primary aims, with one additional aim that emerged from the retrospective study. This aim was to explore whether the participants' perceptions of older trauma victims align with the characteristics of the retrospective study's cohort and whether they recognise the difficulty of

predicting death in older trauma victims. After that, I purposely recruited 20 Saudi paramedics and EMTs from the SRCA ambulance stations in Riyadh and Makkah cities. Based on the framework approach, I found that participants identified three categories of ageing-related challenges when responding to older trauma cases compared to younger cases, including physiological changes, polypharmacy, and communication difficulties. All wanted training and guidelines to implement their knowledge. As a result of insufficient education in geriatric care before being employed by the SRCA with a lack of training, they acquired limited knowledge of geriatric care. Consequently, this led to communication difficulties, inaccurate predictions of adverse outcomes, difficult IV cannulations, and difficulties in care provision for female patients due to cultural restrictions that need better communication skills.

The absence of guidelines regarding treating, transporting, and predicting the deterioration of older trauma patients meant that participants respond and treat them using their knowledge. Therefore, all major adult cases, including older patients, are transported to the nearest hospital, while minor cases are taken to hospitals preferred by older patients or relatives. I found that the participants' perceptions of older trauma victims aligned with the characteristics of the retrospective study's cohort, and they recognised their difficulty in predicting deterioration in older trauma victims. The participants reported a number of barriers and facilitators to providing improved care. Organisational barriers included limited equipment, ambulance clinicians who did not have access to patients' information, and unclear guidelines. Individual barriers included older patients and relatives refusing care, unawareness of the patient's medical history, noncooperative behaviours, a lack of trust in paramedics, and patient negligence. Cultural restrictions prevented care for female patients due to cultural barriers. Organisational facilitators included adequate equipment, training, and guidelines, while individual facilitators included older patients' cooperativeness, awareness of the consequences of refusing care, and a clear medical history.

7.3 Implications for the prehospital care for older patients with injuries in Saudi Arabia

7.3.1 Implications for future research:

Firstly, it was not surprising that there are no geriatric care protocols, training courses, or robust and nationwide trauma care system since there is no formal and unified trauma registry and relevant research in Saudi Arabia to rely on. These issues hinder the implementation of knowledge by ambulance clinicians, so collaborations between the educational and health sectors are necessary to address the role of research in developing trauma systems, guidelines, and training to improve geriatric trauma care through the following actions required (**see Figure 7.1**):

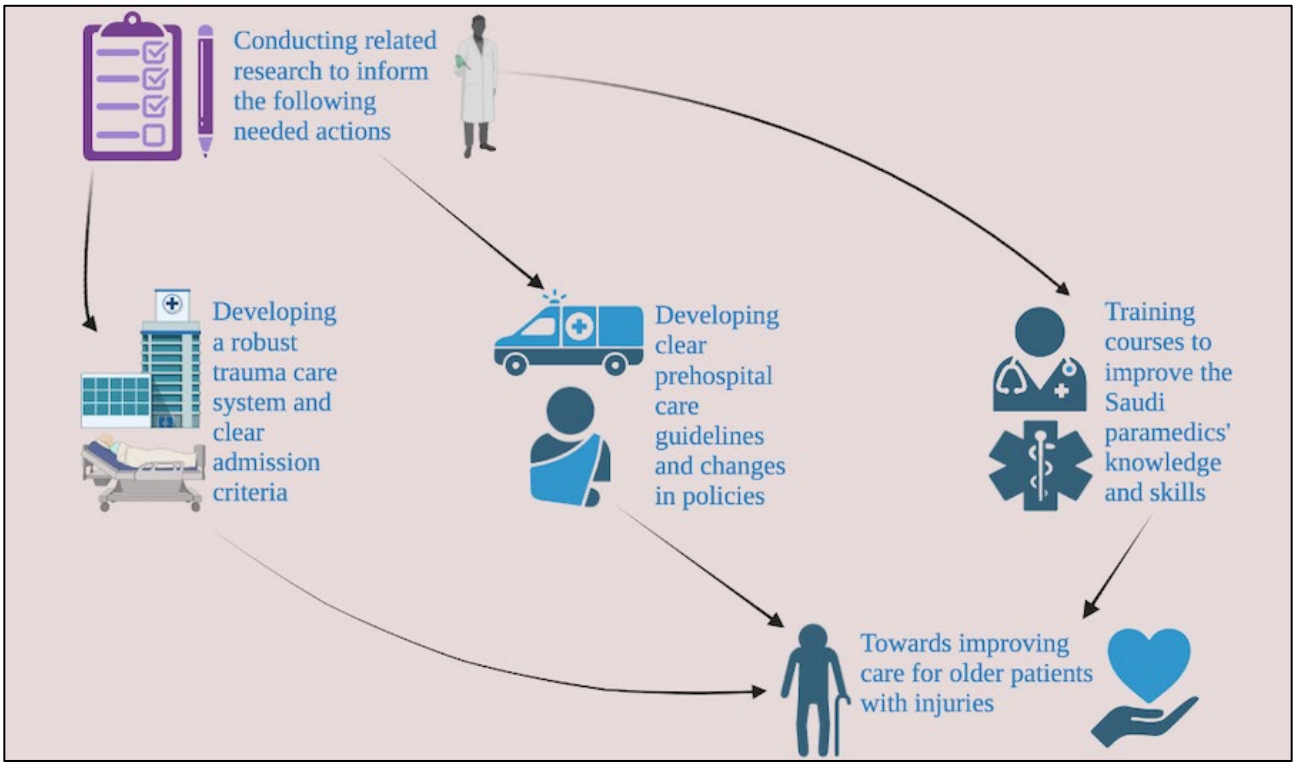


Figure 7.1: The needed actions to improve care, understanding and implementation of knowledge by future research

Second, it is required to identify what areas in the Saudi paramedics and EMTs' knowledge and skills need improvement by research, as I did to help form the contents of guidelines and training. These steps are to meet their training needs, enhance patient safety culture and give them the required skills to deal with the cultural restrictions. Third, ambulance clinicians should be informed about these improvements. A Canadian EMS project implemented to translate knowledge into practice (Jensen and Dobson, 2011) suggested that while EMS guidelines are developing, paramedics and medical directors

should understand what guidelines exist and how they are tailored to reduce knowledge-to-action gaps (Jensen and Dobson, 2011). Fourth, further research is needed to gain patients' and relatives' views on current prehospital care to identify their needs.

Fifth, more research is needed to develop field-triage, bypass, and destination tools using observational data as applied in some developed countries such as the US and the UK. Considering the insufficient findings of my quantitative study and the lack of relevant research in Saudi Arabia, more research is needed to develop trauma triage methods for older adults. Sixth, future research is required to evaluate how frailty might be effectively integrated into trauma care pathways (Carter *et al.*, 2022), with considering that MTCs treat injuries rather than frailty, trauma centre care may not be appropriate for older patients with significant frailty. Older patients who are frail could be referred to rehabilitation involving multidisciplinary teams. Seventh, future studies should aim to reduce avoidable calls and responses to older patients to save trauma care resources and reduce the unnecessary use of trauma care. Lastly, despite the findings of this study suggesting that ambulance clinicians could develop guidelines for managing older trauma patients, there is no evidence that older trauma victims benefit from trauma centre care. More research needs to be conducted on effectively caring for those victims.

7.3.2 Implications for policy and practice:

Firstly, due to the lack of evidence on trauma system, guidelines, and training towards geriatric trauma care, research is required to address the current issues before implementing any changes in policy and practice. Secondly, there is currently no organised trauma system and unified registry in Saudi Arabia, leading to difficulties in understanding patients' characteristics and outcomes following injuries (Alharbi *et al.*, 2022; Chowdhury, Mok and Leenen, 2022). Therefore, a clear national trauma system and nationwide registry are needed since only Riyadh has two MTCs and two trauma registries (Alferdaus and Shaher, 2021; Alharbi *et al.*, 2022; Chowdhury, Mok and Leenen, 2022). Further, Al-Noor specialised hospital is the primary referral centre for trauma patients in Makkah city, despite not having a dedicated trauma centre, and millions of Muslims annually visit this city (Bukhari *et al.*, 2018). Therefore, Makkah, the second largest city, needs a level 1 trauma centre to serve visitors during annual Islamic visits.

Third, this research highlights the need for EMS policymakers to improve the clinicians' understanding and their prehospital care for older trauma patients, which is a component of the trauma care system. Clinicians need to recognise that policymakers have to manage competing demands. For example, using tablets can improve access to patient information, but they may also incur costs and risks of patient confidentiality being breached. The fourth action is to increase the number of female paramedics participating in Saudi ambulance services to deal with female patients, along with health sectors' efforts to educate the public about the consequences of patient or relative refusals of care, as well as the role of paramedics. Fifth, the Saudi paramedics and EMTs should be encouraged to admit their lack of knowledge or practice and emphasis the importance of an openness culture and feedback for enhancing older patients' safety. Sixth, EMS policymakers and stakeholders could work on reducing barriers to providing improved care and offering relevant training courses and workshops to facilitate implementing knowledge. Seventh, the findings suggest building coordination between ambulance services, MTCs, and other hospitals to determine clear patient care pathways and networks based on evidence and training efforts.

Eighth, presenting the findings of this research in relevant Saudi conferences and training sessions can encourage Saudi ambulance clinicians to identify their knowledge gaps and then improve and expand their knowledge and skills. This can improve geriatric care and address barriers preventing improved care. Lastly, changes in policy and practice may include expanding EMS roles while responding to older trauma patients, such as assessing frailty to improve outcome prediction. Frailty is an independent predictor of 30-day mortality for older trauma patients (65 years and older) (Pecheva *et al.*, 2020; Rickard *et al.*, 2021). Paramedics could benefit from a simple frailty assessment tool, such as the clinical frailty scale, which was shown to be feasible, reliable, and accurate, according to O'Caoimh *et al.* (2019). However, trauma centre care is typically provided to previously healthy people who are in danger from their injuries. Older people with frailty strongly correlated with death risk may not benefit from a trauma centre. It may be better for them to receive holistic rehabilitation care with multidisciplinary teams closer to their homes.

7.4 Strengths and limitations of this PhD research:

In terms of strengths, this project is the first research in Saudi Arabia on the prehospital trauma care for older patient. A part of this research, I have conducted a scoping review in order to identify the current research gaps concerning prehospital geriatric trauma care in the world and investigate them in Saudi Arabia. This project employed a mixed-methods design to provide an in-depth understanding of relevant issues. I have used quantitative, qualitative, and data integration methods to explore the current trauma care practice for older patients with injuries. Both quantitative and qualitative studies have explored 'geriatric trauma care' as a topic in 'Saudi Arabia' as a setting that is relatively under-researched internationally and nationally. Further, trauma registries can provide unselected samples that avoid the selection biases of more rigorous designs. A sequential explanatory mixed-methods approach was used to better understand the current prehospital care for older trauma patients in Saudi Arabia to identify ways to improving understanding and knowledge. Conducting the qualitative interviews has allowed exploring in-depth perceptions from frontline ambulance staff involved in delivering trauma care. In these interviews, I ensured allowing the interviewees to speak openly and honestly, and that my data analysis accurately reflected what they reported.

In terms of limitations, for the quantitative study, I have described older patients' injury characteristics based on data from only one healthcare facility and one Saudi city, which may have affected generalisability. The retrospective study's sample size was relatively small, so it may have been under-powered to detect important associations. The qualitative study did not include any observation of paramedic practice, so the results may reflect the paramedics and EMTs' perceptions of what happens rather than what is actually happening. Further, this study did not include older patients or relatives, which may have prevented identification of important insights. The translation process in this study may result in English-speaking readers misinterpreting what the participants reported. Lastly, this PhD research used two different data sources and separate but related questions and considered the limitations of not being a true mixed methods project. I then followed the advice of Creswell and Plano Clark (2017) to writing a side-by-side narrative discussion as an alternative process relying on the findings of the quantitative and qualitative strands data to address the primary research question.

7.5 The conclusion of this PhD research:

It was initially difficult to integrate the findings of the quantitative and qualitative studies since these studies used separate but related questions and used different data sources. Therefore, I have decided to write a side-by-side complement narrative discussion that focuses on four deficiencies identified by my research, including no organised system, no geriatric-specific guidelines, training, and lack of research. In addition, I have gained a comprehensive understanding of how Saudi ambulance clinicians respond to, manage, and transport older patients with injuries to the KSMC's MTC ED. Through the retrospective and qualitative findings, I identified future needs to developing robust trauma systems, forming guidelines, training, and considering research roles in Saudi Arabia in order to improve clinicians' understanding, facilitate the implementation of knowledge, and improve care. Moreover, I have identified research gaps that could be investigated, including investigating older patients' experiences and preferences, and conducting observational studies to help develop robust triage, destination, and bypass tools.

In addition, I have explored cultural barriers to care for older female patients and identified the need for female paramedics in ambulances. Furthermore, I have discussed how these identified issues could be used in forming training and guidelines to improve the quality of care provided by Saudi ambulance clinicians. To reduce the impacts of these issues, EMS policymakers and stakeholders could work together, and government may play an important role in raising public awareness of the consequences of care refusals for cultural reasons and paramedics' responsibilities. Under the development of Saudi Arabia's trauma care system, coordination, networking, and activation of research roles between ambulance services and traumatic and non-traumatic hospitals are required to create a clear trauma care pathway, taking into account distances to hospitals and triage roles. Finally, a unified trauma registry in all Saudi regions and the reduction of increased costs are also necessary for developing and improving a national trauma care system.

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Appendices

Appendix 1: Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist:

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	Yes
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	Yes
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	Yes
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualise the review questions and/or objectives.	Yes
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Yes
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status) and provide a rationale.	Yes
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	Yes
Search	8	Present the full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Yes
Selection of sources of evidence†	9	State the process for selecting evidence sources (i.e., screening and eligibility) included in the scoping review.	Yes
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that the team has tested before their use and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	Yes
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	Yes
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	N/A
Synthesis of results	13	Describe the methods of handling and summarising the data that were charted.	Yes

RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Yes
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	Yes
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A
Results of individual sources of evidence	17	For each included source of evidence, present the charted relevant data related to the review questions and objectives.	Yes
Synthesis of results	18	Summarise and/or present the charting results as they relate to the review questions and objectives.	Yes
DISCUSSION			
Summary of evidence	19	Summarise the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider key groups' relevance.	Yes
Limitations	20	Discuss the limitations of the scoping review process.	Yes
Conclusions	21	Provide a general interpretation of the results for the review questions and objectives and potential implications and/or next steps.	Yes
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence and sources of funding for the scoping review. Describe the role of the funders of the scoping study.	N/A

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see the second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see the first footnote).

‡ The frameworks by Arksey and O'Malley and Levac and colleagues and the JBI guidance refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping study (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

Appendix 2: Searching strategy:

Database	***Search performed***	***The process performed***
Scopus	20 January 2021	1 elder* 2 olde* 3 geriatric* 4 ageing 5 aging 6 1 OR 2 OR 3 OR 4

		7 injur* 8 trauma* 9 wound* 10 6 OR 7 OR 8 11 prehospital 12 “out of hospital” 13 “emergency medical service*” 14 ambulance 15 paramedic* 16 10 OR 11 OR 12 OR 13 OR 14 17 6 AND 10 AND 16 18 Limited to Language: English, Date: 1 January 2001 to 23 January 2021 and Subject area: medicine and health professions.
CINAHL via EBSCO	24 January 2021	1 elder* 2 olde* 3 geriatric* 4 ageing 5 aging 6 1 OR 2 OR 3 OR 4 7 injur* 8 trauma* 9 wound* 10 6 OR 7 OR 8 11 prehospital 12 “out of hospital” 13 “emergency medical service*” 14 ambulance 15 paramedic* 16 10 OR 11 OR 12 OR 13 OR 14 17 6 AND 10 AND 16 18 Limited to Language: English, Date: 1 January 2001 to 23 January 2021 and Age: aged:65+ years & aged: 80 & over.
PubMed	24 January 2021	1 elder* 2 olde* 3 geriatric* 4 ageing 5 aging 6 1 OR 2 OR 3 OR 4 7 injur* 8 trauma* 9 wound* 10 6 OR 7 OR 8 11 prehospital 12 “out of hospital” 13 “emergency medical service*” 14 ambulance

		15 paramedic* 16 10 OR 11 OR 12 OR 13 OR 14 17 6 AND 10 AND 16 18 Limited to Language: English, Date: 1 January 2001 to 23 January 2021, Text availability: available full-text papers and Age: aged:65+ years & 80 & over.
Medline via Ovid	24 January 2021	1 Choosing "Multifield search" 2 elder* OR olde* OR geriatric* OR ageing OR aging 3 injur* OR trauma* OR wound* 4 prehospital OR "out of hospital" OR "emergency medical service*" OR ambulance OR paramedic* 5 2 AND 3 AND 4 6 Copying & pasting the following: ((elder* or olde* or geriatric* or aging or ageing) and (injur* or trauma* or wound*) and (prehospital or "out of hospital" or "emergency medical service*" or ambulance or paramedic*)).af. WITH limiting the search to Language: English, Date: 1 January 2001 to 23 January 2021, Text availability: available full-text papers. 7 Pressing: Search.
Cochrane library	25 January 2021	1 Choosing "advanced search" 2 elder* OR olde* OR geriatric* OR ageing OR aging AND injur* OR trauma* OR wound* AND prehospital OR "out of hospital" OR "emergency medical service*" OR ambulance OR paramedic* 3 Pressing: Search. 4 Limiting the search to Language: English and Date: 1 January 2001 to 24 January 2021

Appendix 3: The Characteristics of the Included Papers:

No.	*Authors & date*	*Country & publisher*	*Aims and objectives*	*Research designs & sample*	*Key findings*
1	(Hon *et al.*, 2020)	United States- Prehospital Emergency Care	Objective: To determine the ambulance workers' accuracy of judgment in predicting the occurrence of intracranial bleeding, as shown on initial cranial CT scan in head-injury geriatric patients & compare their judgments with other sets of field-triage criteria.	Quantitative- a prospective observational cohort study. Sample: 673 older patients.	1. Ambulance workers' judgments for intracranial haemorrhage increased, and the incidence of it also increased. 2. Applying a threshold of 1 per cent or higher scepticism, the ambulance workers' decision demonstrated equal precision relative to actual transport. 3. Results support the current field triage criteria: a) that consider the higher risk of serious injuries among elderly patients, despite low injury mechanisms, and b) that consider ambulance workers' judgment. 4.Ambulance workers do not have sufficient experience to evaluate and identify intracranial haemorrhages, leading to inaccurate clinical judgment. 5.Further work is required to identify better triage tools to evaluate older patients.
2	(Brown *et al.*, 2020)	Australia- Australasian Journal of Paramedicine	Objective: to determine whether geriatric cases with major injuries are more likely than their younger patients to be transported to MTCs by paramedics.	Systematic review.	1.The age variable is correlated with a reduced likelihood of ambulance transport of high-risk injured patients to MTCs compared to younger patients. 2.Making sure that geriatric cases have access to appropriate healthcare facilities by using strategies to reduce the under-triage and focus on prolonged prehospital care training for complex high-risk older cases.
3	(Cull *et al.*, 2019)	United States- The American Surgeon	Objective: to analyse the impact of prehospital vital signs on the severity of the injury and triaging level in order to develop a predictive model when evaluating older patients with falls and penetrating injuries.	Quantitative- a retrospective study. Sample: 92,780 older patients (65 years and older).	1.There were two explanations of under-triage with older patients: a) geriatric cases are not correctly triaged by ambulance workers who did not receive adequate training, are unfamiliar with triage guidelines and age bias. b) The second point is that comorbidities with geriatric patients need more intensive management than younger cases. 2. Accurate prehospital scores of vital signs & GCS criteria in the triage can help reduce the impacts of UT & OT in transporting older patients with injuries.

4	(Brown *et al.*, 2019)	Australia-Emergency Medicine Australasia	Objectives: to compare older patients' characteristics and outcomes with minor injuries (65 years of age) with younger patients (16 to 64 years of age); and to determine whether older age is linked to reduced transports to MTCs and in-hospital mortality.	Quantitative- a retrospective cohort analysis. Sample: 1625 cases (≥65 years patients vs 16-64 years old patients).	1.Advanced age was correlated with a significantly reduced likelihood of transports to MTCs. 2.Geriatric patients who were not transported to the MTCs had increased odds of deaths in hospitals. 3.The most common mechanism of major injuries was falls. 4. Developing specific out of hospital triage protocols to enable identifications of high-risk geriatric patients is important.
5	(Newgard *et al.*, 2019)	United States-Journal of Trauma, Acute Care Surgery	Objectives: This study evaluates the process of adding illnesses, anticoagulants, and physiologic geriatric criteria to triage tools to improve sensitivity for the detection of major trauma in older patients in prehospital settings and to evaluate how new criteria can work alongside the existing triage tool.	Quantitative- a retrospective cohort study. Sample: 5021 patients (65 years old and over)	1.Authors confirmed the low sensitivity of current triaging practices for determining major trauma older patients. 2.Adding any abnormal scores in GCS, vital signs, along with comorbidities, improved the sensitivity of the triage tool at the expense of specificity. These show that the high sensitivity of prehospital identification of major trauma older patients is possible. 3.Compared to current triage protocols, specific physiologic geriatric criteria, and comorbidities, the anticoagulant variable was not appropriate for determining major trauma patients. 4.Age bias can influence the provider's decision making, which can lead to reducing triage sensitivity.
6	(Meyers *et al.*, 2019)	United States-Prehospital & Disaster Medicine	Objective: To investigate the impact of implemented statewide Trauma Triage Destination Plans (TTDPs) in North Carolina, US, on EMS triage of older patients with injuries meeting physiologic criteria of major injuries, essentially based on whether these cases were transported to the MTCs.	Quantitative- a retrospective cohort study. Sample: 5345 older patients (50 years and older).	1.The under-triage issue is confirmed for geriatric patients, despite using specific physiologic markers of injury severity; (low BP, bradypnea, tachypnea, or a GCS lower than 13). 2.Occurrence of under-triage in patients for whom the injury happens less than 60 minutes from an MTC and is a much more significant issue among those living more than 60 minutes from an MTC. 3.Under-triage rates occur higher among the oldest patients. 4.Future work is required to identify the causes of undertriage among the oldest patients with injuries. 5.Any new changes in triage tools require integrating with educational programmes and feedback systems for prehospital decision-making.

					6. EMS decision-making and external factors such as personnel choice of hospitals should be examined further to determine the efficacy of the current triaging tool.
7	(Amoako *et al.*, 2019)	United States- Academic Emergency Medicine	Objective: To identify factors associated with older patients' transport with injuries, meeting geriatric triaging criteria to an MTC.	Quantitative- a retrospective observational cohort study. Sample: 10,411 older patients (≥ 70 years).	1.Several identified factors that were independently correlated with failures to transport geriatric patients to MTCs, such as older age and unavailability of MTCs in areas of residence. 2.Further investigation is needed for prehospital care systems and their processes, transport behaviours, and patterns during the initial triage to improve care for older cases with injuries. 3.Further studies are needed for the undertriage issue, factors that contribute to the problem and lack of transport by EMS providers.
8	(Benjamin *et al.*, 2018)	United States- The Journal of Emergency Medicine	Objective: To analyse characteristics of the potentially undertriage patients, including the elderly, to ease earlier determination of the high-risk trauma patients to improve triage and enhance patient safety.	Quantitative- prospective analysis. Sample: 1,003,350 patients (16 years and older).	1.Age is determined as an essential risk factor for early death, along with specific comorbidities such as CHF or CVA. 2.These results support using the age factor in the trauma centre triage and trauma team activation. Also, they indicate considering comorbidities as additional triaging criteria. 3.Older patients fail to produce tachycardiac and hypotensive responses to injury events due to physiologic changes or polypharmacy. The use of beta-blockers can affect the compensatory mechanism in heart rate in terms of shock, which can lead to undertriage of injury and delay optimal care. 4. Older patients are less tolerant of blood loss, severe pain, rapid fluid shifts, and changes in respiratory mechanisms as a result of minor injuries. 5.Identification of risk factors must start by paramedics. 6. Further prospective studies are needed to identify at-risk patients.
9	(Nishijima, S. Gaona, *et al.*, 2017)	United States- Prehospital Emergency Care	Objective: to assess prehospital medication ascertainment of the pre-injury uses of anticoagulant and antiplatelet in head-injury geriatric patients.	Quantitative- a retrospective study Sample: 2110 patients (55 years and older).	1.Pre-injury antiplatelet or anticoagulant medication use in head-injury geriatric cases is common. Hospital clinicians reported that over 28% of those cases used these agents. 2.Only prehospital ascertainment for pre-injury warfarin use had a reasonable level of agreement with ED and hospital clinicians. 3. Because ambulance workers are more aware of the haemorrhage risks associated with warfarin use than antiplatelet agents, pre-hospital

					medication assessment is more appropriate in patients who used warfarin before injury. 4.Education and training regarding the polypharmacy of older patients with head injuries are required for EMS providers.
10	(Nishijima, S. D. Gaona, *et al.*, 2017)	United States- Annals of Emergency Medicine	Objective: to evaluate the characteristics and outcomes of geriatric head injury patients transported by ambulance, specifically those who did not meet physiologic, anatomic, or mechanism of injury criteria but were administered anticoagulants.	Quantitative- a retrospective study. Sample: 2110 patients (55 years and older).	1.Few patients met the triage criteria of 1st to 3rd steps. For cases that did not meet the criteria of 1st to 3rd steps, about 30 per cent used anticoagulant or antiplatelet agents, with only around half of them being triaged to an MTC. The use of first to third steps of triage criteria alone is not adequate to identify intracranial haemorrhage and mortality or neurosurgery in those patients. Adding the anticoagulant or antiplatelet use criteria in triaging tool improves the triage sensitivity. 2. EMS providers should increase awareness about preinjury antiplatelet and anticoagulant use of older pts with head injuries.
11	(Simpson *et al.*, 2017)	Australia- BMC Health Services Research	Objective: To identify the process of making a decision by ambulance workers when managing geriatric fallers.	Qualitative- semi-structured interviews and focus groups. Sample: 33 paramedics.	1. EMS decision-making during care for older fallers is influenced by role identity and the cultural and organisational constructs of actual work. 2. The lack of preparedness to manage older fallers as a result of inadequate training and education and constant work pressure prevents providing care. 3. Paramedics struggle to assess older patients with low-acuity injuries due to repeated attendances.
12	(Garwe *et al.*, 2017)	United States- Prehospital Emergency Care	Objective: to identify distance and confounder adjusted odds of care at a tertiary trauma centre for injured geriatric patients compared to younger cases, patients transported from the injury scene and those transferred from a non-tertiary TC.	Quantitative- a retrospective study. Sample: 84,930; 44,925 patients (lower than 55 years old) & 33,566 patients (55 years old and over).	1.Older patients with injuries are undertriaged to tertiary TCs from the injury scene and inter-facility scene transfer. 2. Authors indicated that considering age bias rather than distances to tertiary TCs contributes to undertriage among injured geriatric patients. 3. Efforts should be focused not only on improving scene triage and transfer criteria, but also on improving ambulance and hospital staff training. 4.The causes of undertriage is multifactorial (proximity to tertiary trauma centres, patient preference and ineffective triage tool). 5. Prehospital triage tools are unreliable for elderly patients with injuries caused by beta-blocker use or cardiovascular diseases that reduce tachycardia and hypotension.

13	(Newgard *et al.*, 2016)	United States- Injury	Objectives: 1. to define the major trauma older patients based on predictive differences that correlate with different patterns of injury. 2.To develop alternative triage guidelines for trauma patients that are compatible with current triage guidelines to improve the identification of high-risk geriatric cases.	Quantitative- a multi-site retrospective cohort study. Sample: 33,298 older patients (65 years and older).	1.There is a possibility to enhance identifying high-risk geriatric patients in the prehospital settings. However, over-triage might occur with changes to prehospital triage guidelines. 2.Any new geriatric-specific triage protocols can be implemented effectively to older patients only after educating and training ambulance providers to reduce undertriage in older patients with injuries. However, overtriage and MTCs roles should be considered. 3.The ability to better determine major trauma geriatric patients shortly after an injury is an important initial step in providing effective and comprehensive care for this population. 4.Undertriage of injured older patients are incompletely understood.
14	(Oberkircher *et al.*, 2016)	Germany- Pain Practice	Aim: To determine whether trauma cases received sufficient analgesics when exposed to injuries commonly associated with high pain levels in out-of-hospital settings.	Quantitative- a prospective study. Sample: 153 older patients (60 years and older).	1.The researchers observed high pain levels at the time of the injury, resulting in high complications. Pelvic fractures may also increase the risk of these complications when they are immobilising. 2.Only a few cases with pelvic fractures received out of hospital analgesics, despite this type of fracture, are correlated with high pain levels. 3. Paramedics should use analgesia more frequently without waiting for a prehospital physician to act, which will reduce the need for prehospital physicians, transport time, and repetitive use of pain medications.
15	(Ichwan *et al.*, 2015)	United States- Annals of Emergency Medicine	Aim: To assess the sensitivity of using Ohio's geriatric criteria with the adult triage criteria in identifying high-risk geriatric patients who need MTCs.	Quantitative- a retrospective observational study. Sample: 101,577 patients (16 years and older). 33,379 were older patients.	1.Applying Ohio's prehospital geriatric triage protocols to the geriatric patients led to improve sensitivity in determining geriatric patients who needed transports to MTCs. 2.Standard adult triage tools have a low sensitivity in geriatric patients. 3.Using the geriatric triage tool with younger patients can lead to increased sensitivity and reduced specificity for patient outcomes.
16	(Newgard *et al.*, 2014)	United States- Prehospital Emergency Care	Objective: to assess the possibility of prehospital physiologic measures to predict major injuries among geriatric patients and reduce the	Quantitative- a multisite retrospective cohort study.	1.Changing the GCS score from ≤13 to ≤14 would reduce undertriage with increased overtriage. Respiratory status was the second most important prehospital physiologic triage measure after the GCS. 2. The effects of beta-blackers use on elderly patients and blunted haemodynamic responses to injuries make hemodynamic measures (such as

			undertriage in the major trauma geriatric patients to non-trauma centres.	Sample: 44,890 older patients (55 years and older).	SBP, pulse rate, and shock index) poor predictors of major injuries among geriatric patients. These physiologic criteria reduced undertriage slightly. 3. Modifying physiologic criteria in triaging tools can have serious implications, involving overtriaging issues and improving ambulance transport patterns. 4. Age-specific physiologic criteria can complicate the triaging process by EMS providers. Therefore, EMS education can be helpful to them.
17	(Wasserman *et al.*, 2014)	United States-Prehospital Emergency Care	Objective: to determine a neurologic scale or set of scales that optimise identifying high-risk geriatric patients with traumatic brain injury who require transports MTCs and are feasible for use in out-of-hospital settings.	Mixed methods- used a consensus panel of experts.	1.After the development and validation of a new scale (consisted of 15 scales including GCS). The expert panel determined scales were inadequate to determine traumatic brain injury with high-risk geriatric patients in the prehospital settings. 2.Developing and validating a new scale that evaluates the mental status and ability to follow motor commands are necessary. 3. Research is needed to determine whether prehospital triage tools are sensitive, specific, and reliable given the effects of undertriage and overtriage.
18	(Cox *et al.*, 2014)	Australia-Injury	Objective: To describe the association for adult trauma patients between advancing age, pre-hospital triaging compliance, and patient outcomes.	Quantitative- a retrospective descriptive study. Sample: adult patients= 3054 patients (older than 55 years) & 4407 patients (55 years and lower).	1.Older patients with injuries repetitively experience falls and poorer outcomes compared to younger counterparts. 2.Authors indicated that despite effective triage criteria used in the data, identified both geriatric and younger patients with injures; their use by ambulance workers does not match their clinical services. 3.Research should focus on the current EMS trauma triage measures to see whether these measures are for geriatric patients with injuries. 4.Paramedics can play an essential role in triage decision-making and provide optimal management for older patients with injuries.
19	(Staudenmayer *et al.*, 2013)	United States-Journal of the American College of Surgeons	Objective: To evaluate the correlations between triage patterns and outcomes in terms of a population perspective.	Quantitative- a population-based retrospective study. Sample: 6015 older patients (55 years and older).	1. Researchers reported high rates of undertriage that are not correlated with higher risks of deaths but are correlated with higher healthcare costs. 2.Further research is needed to concentrate on investigating how to enhance patient outcomes. 3.Further research is needed to investigate the patterns of injuries and older patients' outcomes and how to manage them.

20	(Nakamura *et al.*, 2012)	United States- Annals of Emergency Medicine	Objectives: to evaluate undertriage in multiple age groups and the correlation between age and high injury severity (ISS = 16 or higher), considering other triaging criteria in order to select an appropriate triage criterion & confounders, as well as the impact of a mandatory age criterion.	Quantitative- a multisite retrospective cohort study. Sample: 260,027 injured patients (including children, adults and older patients).	1.Advancing age is correlated with an increased likelihood of major injuries. 2.Under-triage increases among victims over 60 years old. 3.Despite the probability of injury severity to increase among triaged patients negatively with advancing age, the age criterion seems ineffective for improving the triaging process. 4.Causes of undertriage are poorly understood. 5.The implications of overtriage and its impacts on MTCs are poorly understood. 6.Using only age in the triage tool can minimise undertriage and increase the overtriage issue.
21	(Caterino, Raubenolt and Cudnik, 2011)	United States- Academic Emergency Medicine	Objective: to check if the prehospital score of GCS "14" is a suitable cutoff to transport older patients with injuries to MTCs.	Quantitative- a retrospective and observational analysis. Sample: 52,412 patients (16 years and older).	1. Sensitivity is increased in the GCS cutoff from 13 to 14 for older people. 2.Older patients with a GCS score of "14" have higher odds of deaths (OR = 4.68) and traumatic brain injury (OR = 1.84) than younger patients with GCS 13. This suggests that transporting older patients directly to MTCs.
22	(Werman *et al.*, 2011)	United States- Prehospital & Disaster Medicine	Aim: To describe developing a field destination tool with geriatric criteria for the state of Ohio, United States.	Quantitative- a retrospective study. Sample: 90,597 patients to compare older patients (>70 years) with patients (16 to 69 years).	1. Ohio has developed an evidence-based destination tool with geriatric criteria by analysing the unique characteristics and responses of the geriatric population. 2. These criteria (GCS, SBP, mechanism of injury, falls with head, chest, abdomen, and spinal injuries, multiple illnesses, and MVCs with one or more long bone fractures) need to be analysed to determine their impact on older patient outcomes and their improvement for triage. 3.Further efforts to improve the trauma system by linking the EMS records with the MTC trauma registries.
23	(Scheetz, 2010)	United States- Injury	Objective: to discuss published evidence, reviews, and practical guidelines related to prehospital factors associated	Literature review	1. Geriatric patients with cardiac illness who are taking anticoagulants and antiplatelet medications are predisposed to severe bleedings, which can go undetected due to lack of hemodynamic response. 2. It is required to work for more robust evidence to improve the prehospital clinical practice for triaging geriatric cases with injuries.

			with severe injuries in geriatric patients.		3. The rates of undertriage are higher in geriatric patients than in other ages. 4. It is critical to provide reliable evidence of prehospital factors correlated with major injuries so that EMS can make informed decisions to reduce avoidable deaths and morbidities.
24	(Chang *et al.*, 2008)	United States-Archives of Surgery	Objective: To investigate if age bias contributes to the injured older patients' undertriage to the trauma centre.	Quantitative- a retrospective study. Sample: 26,565 patients: 22975 patients (lower than 56 years) & 3590 older patients (65 years and older.	1. Shortages of geriatric care-specific training was the most common issue leading to undertriage. 2. Unfamiliarity with triaging guidelines and considering that it was not worth transporting to a trauma centre can lead to the undertriage. 3. Some paramedics feel they are unwelcome when delivering geriatric patients to the ED at the receiving trauma centre. 4. Shortages of geriatric care training and lack of protocol information may allow unconscious bias, impacting on EMS transport decisions. 5.Focusing on re-training clinicians regarding the application of triage guidelines might be adequate.
25	(Scheetz, 2003)	United States-Journal of Emergency Nursing	Objective: To determine the sensitivity and specificity of an out-of-hospital trauma triage tool for adults in one state, with a specific focus on triaging for geriatric cases.	Quantitative- a retrospective database study. Sample: 2063 patients (25 years and older).	1. Undertriage and overtriage are caused by noncompliance with protocols and a lack of knowledge among ambulance workers about age-related physiologic changes . 2. Research is needed to investigate EMS triage tools' sensitivity and specificity, focusing on age, sex, and pre-existing illnesses (i.e., geriatric patients), and also to determine when under- and overtriage occurs. 3.There is a lack of knowledge with ambulance workers regarding the physiologic changes that may occur with ageing and prehospital evaluation.

Appendix 4: The Interview Schedule, Information Sheet and Consent Form:

(The Interview Schedule)

The qualitative questions:

1.How do Saudi paramedics and EMTs understand the impacts of ageing changes on geriatric trauma care and how they acquire and apply their knowledge?

(Do they treat older people differently? Are they aware that they treat older people differently? Do they understand that they treat older people differently? Do they have good knowledge of how to treat older people?)

2. What are the facilitators and barriers to providing improved care?

(What are the facilitators to providing improved care? What are the barriers to providing improved care?)

Guide questions	*Comments*
How do Saudi paramedics and EMTs understand the impacts of ageing changes on geriatric trauma care and how they acquire and apply their knowledge? 1.Could you give me a brief summary of your career as an ambulance worker to date? *(Work position, job level, length of experience).* 2. Could you tell me about your experience during responding to older patients with injuries? *(Challenges or barriers during stages of prehospital care: by arrival at scene, primary, secondary survey or ongoing stage, and patient delivery).* 3. How do you feel when you attend older patients with injuries? *(Do you feel lack of confidence or negative perceptions during assessing and managing injured older patients? Why?)* 4. I would like you to think back to a recent case you have attended involving an older patient with injuries: *a. Description of the circumstances of the case.* *b. Patient was male or female? What was the case? Was the patient alone?* *c. What assessment process did you apply?* *d. Patient was transported? And Where (MTC or hospital) and why? If not transported, why?* *e. Would you have treated the patient differently if they were younger? Why?* 5. Could you describe the process by which you decide whether or not older patients with injuries need to be transported to MTC? *(When will you transport older patients to trauma centre or trauma units? Do you use specific guidelines or your knowledge? If by your knowledge, why?)* 6. How do you think the care you provide (or should provide) for older people differs? *(Does it differ from the care you provide to younger people? If no, why?)*	The 1st question.

7. Have you acquire appropriate or adequate knowledge regarding prehospital geriatric care? How you acquire this knowledge? *(Were there challenges to take education or trainings courses? How many times did you take courses during service? From private or public organisations? Were they useful? Why? could you apply this knowledge? If not, why?).*	
What are the facilitators and barriers to providing improved care? 8. What difference do you think age and the care provided to older people makes to outcomes in trauma? *(Do you think that prehospital care is more effective or less effective in older people? if less effective, why?)* 9. What factors or circumstances influence your ability to provide improved care for older patients with injuries? *(Are you able to provide improved care for injured older patients? if you are unable, why? What are the factors or circumstances?* 10. What factors facilitate providing improved care for older patients with injuries (optimal care)? Are there factors can facilitate providing improved care for older patients? if no, why? 11. Are there any differences or barriers to providing improved care for male and female older patients with injuries? *(if there are differences? Can you explain why?)* 12. How confident are you in assessing and managing older patients with injuries? *(if you are unconfident, can you explain why?* 13. Can you suggest any changes or strategies that would help you provide improved care and make proper decisions or improve your ability to care for older patients with injuries?	The 2nd qualitative question.
14. Is there anything else you would you to share with me about, or that you think I should know about, that would help us understand how Saudi paramedics or EMTs respond, assess and care for older patients with injuries?	This is for additional questions that can emerge

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(Information Sheet)

Title of the research: The Pre-Hospital Trauma Assessment and Management of Older Patient and their Association with Patient Outcomes: Challenges and Barriers

Name of Researcher: Naif Harthi

You are being invited to participate in the above study. Understanding why the study is being done and what it will involve is an important step to help you decide whether you would like to participate or not. Therefore, please read the information below carefully and ask questions if anything is unclear or you would like more clarifications before deciding to participate in this study. You may want to discuss it with others, but it is up to you to choose whether or not to participate. If you are happy to take part, I will ask you to sign a consent form.

About the research & researcher:

I am a PhD student in the School of Health & Related Research at the University of Sheffield, the UK, under the supervision of Prof Steve Goodacre (my 1st supervisor) and Dr Fiona Sampson (my 2nd supervisor) (my PhD supervisory team). This qualitative study represents a part of mixed-methods research to explore ageing-related impacts on prehospital trauma care for older patients and patient outcomes. In this qualitative study, I aim to explore how Saudi paramedics and EMTs acquire their knowledge regarding the impacts of ageing changes on prehospital trauma care for older patients, identify how they acquire and apply their knowledge, and explore the facilitators and barriers to providing improved care for older patients with injuries. The objectives of this qualitative study are to be addressed by interviewing Saudi paramedics and EMTs. There is less attention paid by Saudi ambulance workers regarding the impacts of ageing changes on their prehospital care and patient outcomes, leading to adverse patient outcomes.

As a student who received a scholarship and financially funded by the Jazan University in Saudi Arabia, the researcher hopes to contribute to increasing the understanding and knowledge of Saudi paramedics and EMTs regarding the impacts of ageing changes on the prehospital trauma care for older patients and patient outcomes. Additionally, I hope this study will help improve Saudi paramedics and EMTs' understanding and knowledge regarding the ageing impacts on the prehospital trauma care for older patients and patient outcomes.

Contact details for my PhD supervisors:

-The 1st supervisor:

Prof Steve Goodacre

Email: s.goodacre@sheffield.ac.uk, Phone number: +44 114 222 0842

-The 2nd supervisor:

Dr Fiona Sampson

Email: f.c.sampson@sheffield.ac.uk, Phone number: +44 114 222 0687

1. **What is the study's purpose?**

To explore how Saudi paramedics & EMTs acquire their knowledge regarding the impacts of ageing changes on the prehospital trauma care for older patients, how they

apply their knowledge and identify the facilitators and barriers to providing improved care for older patients with injuries.

2. Why have I been invited?

You have been chosen because you encounter impacts of ageing changes when responding, assessing and caring for older patients with injuries and have relevant experience in caring for injured older patients. It will be useful to share your experiences regarding this issue.

3. Do I have to take part?

It is up to you to decide whether or not to participate. If you chose to participate, I would give you this information sheet to keep (and ask you to give consent for your data to be used), and you can still withdraw at any time without providing any reason. If you choose to withdraw within seven days of the interview, then I will delete all of your data and exclude any responses you give from my analysis. If you wish to withdraw, contact Naif Harthi at: nharthi1@sheffield.ac.uk or +966 55 768 4253.

4. What will happen to me if I take part?

You will be invited to participate in a face-to-face interview. The interview will be quite informal and in a private room in the ambulance station. Additionally, the interview has an option to undertake the interview via online, in case there are difficulties undertaking face-to-face interviews. The interview is estimated to take between 40-60 minutes.

5. What do I have to do?

If you are happy to take part, please contact: nharthi1@sheffield.ac.uk or +966 55 768 4253. Then, you will be invited to participate in an interview, which will be scheduled at a mutually convenient time.

6. Will the interview be recorded?

Yes, if you agree. You will be asked for permission for me to audio record the interview. I will transcribe and analyse the interview. It will be kept strictly confidential, and the audio records will be stored securely. You will not be identifiable in any reports.

7. What are the possible disadvantages and risks of taking part?

The risks of taking part are low, but you should consider the following risks. Suppose you reveal evidence of poor knowledge or poor care that represents a significant risk to patient safety. In that case, I will be obliged to inform the relevant responsible individual at your employing institution. You may be upset when reflecting on the experience of facing serious events of older patients with injuries, and distress may occur from remembering unpleasant memories and feelings of older patients you met previously. If you experience such distress, I will stop the interview and give you time to reduce your

distress. If you feel able to carry on, the interview/discussion will be resumed, but the interview will be discontinued if you do not wish to carry on. If you are distressed by the interview, I will offer advice on where to seek help.

8. What are the possible benefits of taking part?

There would be no personal benefits to you if you decided to participate in this research. However, you have the opportunity to join an online presentation and discussion of my results at the end of the project. Further, the outcomes that I gain from this research will help inform the clinical practice of Saudi ambulance workers when caring for older patients with injuries and future research to improve ambulance workers' understanding regarding the ageing impacts.

9. Will my taking part in this study be kept confidential?

Yes. All information that will be collected/ recorded about you during the research will be kept strictly confidential. All documents related to the study (e.g., consent form) will be kept securely as scanned electronic files in a drive. The electronic files will be stored on a password-protected computer. The documents will be destroyed after the end of the study. As the data deletion will be compatible with my student status and access to shared drive. Further, you will not be identifiable in any reports or publications. But anonymised quotations may be used in journal articles.

10. What will happen if I don't want to carry on with the study?

You are free to withdraw from the study at any time.

11. What will happen to the results of the research study?

The data will be analysed by me as a PhD student, with support from my PhD supervisors: Prof Steve Goodacre (the lead supervisor) and Dr Fiona Sampson (the 2nd supervisor), reports of the results will include quotes from the interviews, but the participants will not be identifiable from the quotes. The study results will be published in peer-reviewed journals and presented at relevant conferences. Then the research findings will be used to inform future clinical practices and decisions. You can receive a summary of the results if you are interested.

12. Who is sponsoring the study?

This study is a part of my PhD study, and the sponsor of this study is the University of Sheffield, United Kingdom.

13. Who has ethically reviewed this study?

This study is ethically reviewed and approved by the ethics committee, Ministry of Health, Saudi Arabia.

14. Contact for further information

For further information about the study, including anything else you might need to know before deciding whether to take part, please contact:

Mr Naif Harthi (a PhD student, University of Sheffield)
Email: nharthi1@sheffield.ac.uk OR phone number: +966 55 768 4253.

Please keep a copy of this information sheet, and thank you for considering taking part in my research.

……

(Consent form)

Title of the research: The Pre-Hospital Trauma Assessment and Management of Older Patient and their Association with Patient Outcomes: Challenges and Barriers

Please tick the appropriate boxes	**Yes**	**No**
Taking Part in the Project		
I have read and understood the project information sheet, or the project has been fully explained to me. I have been given the opportunity to ask questions about the project. (If you answer No to this question, please do not proceed with this consent form until you are fully aware of what your participation in the project will mean.)	☐	☐
I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason.	☐	☐
I agree to take part in the project. I understand that taking part in the project will involve taking part in a face-to-face interview and have an option to undertake the interview via online, if there are difficulties undertaking face-to-face interviews.	☐	☐
I understand that the interview will be undertaken by Arabic, translated into English and then transferred to the University of Sheffield.	☐	☐
I understand that the information I provide will be securely stored and that access will be restricted to the researchers working on this project. I understand I will not be identifiable in the report(s) that result from this research.	☐	☐
I understand that direct quotations which are anonymous will be used in research reports. I consent for the publication of direct quotes.	☐	☐
I consent to being audio recorded	☐	☐
How my information will be used during and after the project		
I understand that my responses will be kept strictly confidential by the researcher and my personal details such as name, phone number, address and email address etc. will not be shared outside the study.	☐	☐
I wish to be informed about the study results (Optional).	☐	☐

Name of participant [printed] Signature Date

Name of Researcher [printed] Signature Date

Project contact details for further information:

Mr. Naif Mohammed M Harthi
Email: nharthi1@sheffield.ac.uk
Telephone: +447 93 956 2204 & +966 55 768 4253

Address: School of Health and Related Research, 30 Regent Street, Sheffield S1 4DA

When completed, 1 for the participant and 1 (original) for the researcher.

Appendix 5: The First Version of Interview Schedule:

Guide questions	*Comments*
How do Saudi paramedics and EMTs understand the impacts of ageing changes on geriatric trauma care and how they acquire and apply their knowledge? 1.Could you give me a brief summary of your career as an ambulance worker to date? *(Work position, job level, length of experience).* 2. Could you tell me about your experience during responding to older patients with injuries? *(Challenges or barriers during stages of prehospital care: by arrival at scene, primary, secondary survey or ongoing stage, and patient delivery).* 3. How do you feel when you attend older patients with injuries? *(Do you feel lack of confidence or negative perceptions during assessing and managing injured older patients? Why?)* 4. I would like you to think back to a recent case you have attended involving an older patient with injuries: *a. Description of the circumstances of the case.* *b. Patient was male or female? What was the case? Was the patient alone?* *c. What assessment process did you apply?* *d. Patient was transported? And Where (MTC or hospital) and why? If not transported, why?* *e. Would you have treated the patient differently if they were younger? Why?* 5. Could you describe the process by which you decide whether or not older patients with injuries need to be transported to MTC? *(When will you transport older patients to trauma centre or trauma units? Do you use specific guidelines or your knowledge? If by your knowledge, why?)*	The 1st qualitative question.

6. How do you think the care you provide (or should provide) for older people differs? *(Does it differ from the care you provide to younger people? If no, why?)* 7. Have you acquire appropriate or adequate knowledge regarding prehospital geriatric care? How you acquire this knowledge? *(Were there challenges to take education or trainings courses? How many times did you take courses during service? From private or public organisations? Were they useful? Why? could you apply this knowledge? If not, why?).*	
What are the facilitators and barriers to providing improved care? 8. What difference do you think age and the care provided to older people makes to outcomes in trauma? *(Do you think that prehospital care is more effective or less effective in older people? if less effective, why?)* 9. What factors or circumstances influence your ability to provide improved care for older patients with injuries? *(Are you able to provide improved care for injured older patients? if you are unable, why? What are the factors or circumstances?* 10. What factors facilitate providing improved care for older patients with injuries (optimal care)? Are there factors can facilitate providing improved care for older patients? if no, why? 11. Are there any differences or barriers to providing improved care for male and female older patients with injuries? *(if there are differences? Can you explain why?)* 12. How confident are you in assessing and managing older patients with injuries? *(if you are unconfident, can you explain why?* 13. Can you suggest any changes or strategies that would help you provide improved care and make proper decisions or improve your ability to care for older patients with injuries?	The 2nd qualitative question.
14. Is there anything else you would you to share with me about, or that you think I should know about, that would help us understand how Saudi paramedics or EMTs respond, assess and care for older patients with injuries?	

Appendix 6: The Second Version of Interview Schedule:

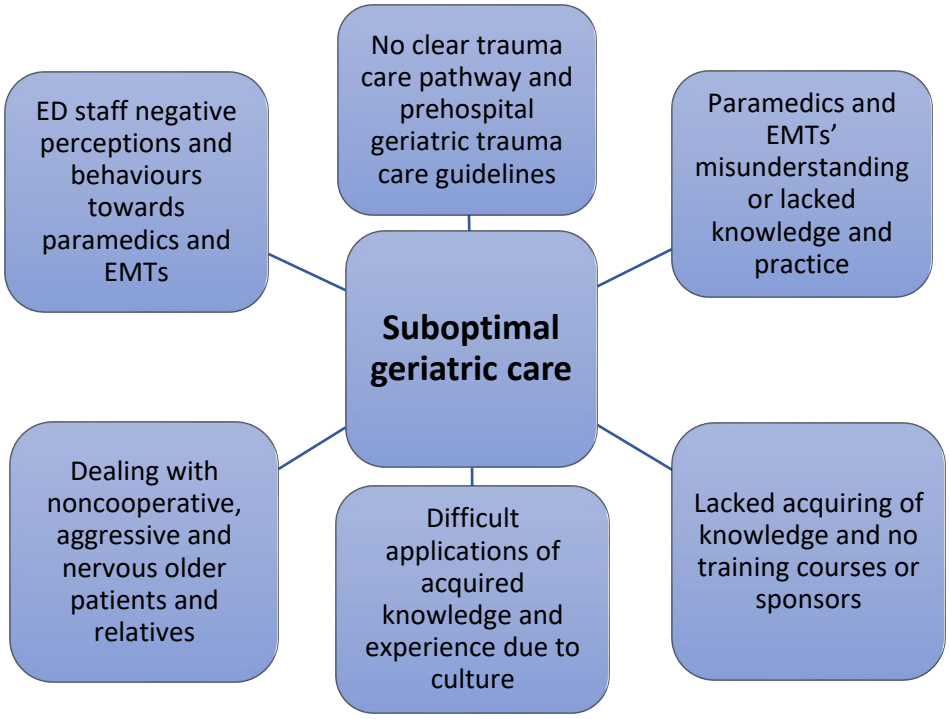
Guide questions	***Comments***
How do Saudi paramedics and EMTs understand the impacts of ageing changes on geriatric trauma care and how they acquire and apply their knowledge? 1.Could you give me a brief summary of your career as an ambulance worker to date? *(Work position, job level, length of experience).*	The 1st qualitative question.

2. Could you tell me about your experience during responding to older patients with injuries? What are the most important challenges? Why? *(Challenges during responding to and caring for older patients with injuries).* 3. How do you feel when you attend older patients with injuries? *(How confident do you feel when assessing and managing injured older patients? if you feel unconfident, explain why?)* 4. I would like you to think back to a recent case you have attended involving an older patient with injuries: *a. Description of the circumstances of the case.* *b. Patient was male or female? What was the case? Was the patient alone?* *c. What assessment process did you apply?* *d. Patient was transported? And where (MTC or hospital) and why? If not transported, why?* *e. How did you help the patient? How did you address the problems you identified?* *f. Would you have treated the patient differently if they were younger? Why?* *g. Do you think this case is typical of older patients with trauma? If not, how it differs from typical cases?* (I can then contrast the case interviewees describe and their perceptions of a typical case with the characteristics of cases in the quantitative study) 5. Could you describe the process by which you decide whether or not older patients with injuries need to be transported to MTC? *(When will you transport older patients to trauma centre or trauma units? Do you use specific guidelines or your knowledge? If by your knowledge, why?)* 6. How do you think the care you provide (or should provide) for older people differs? *(Does it differ from the care you provide to younger people? If no, why?)* 7. Have you acquire appropriate or adequate knowledge regarding prehospital geriatric care? How you acquire this knowledge? *(Were there challenges to take education or trainings courses? How many times did you take courses during service? From private or public organisations? Were they useful? Why? could you apply this knowledge? If not, why?).*	
What are the facilitators and barriers to providing improved care? 8. Do you think that prehospital care is more effective or less effective in older people? if less effective, why? 9. What factors or circumstances influence your ability to provide improved care for older patients with injuries? What are the most important factors or circumstances? Why? *(Are you able to provide improved care for injured older patients? if you are unable, why? What are the factors or circumstances?* 10. What factors facilitate providing improved care for older patients with injuries (optimal care)? What are the most important facilitators? Why? *(Are there factors can facilitate providing improved care for older patients? if no, why?)*	The 2nd qualitative question.

11. Are there any differences or barriers to providing improved care for male and female older patients with injuries? *(if there are differences? Can you explain why?)* 12. Can you suggest any changes or strategies that would help you provide improved care and make proper decisions or improve your ability to care for older patients with injuries?	
13. Is there anything else you would you to share with me about, or that you think I should know about, that would help us understand how Saudi paramedics or EMTs respond, assess, and care for older patients with injuries?	

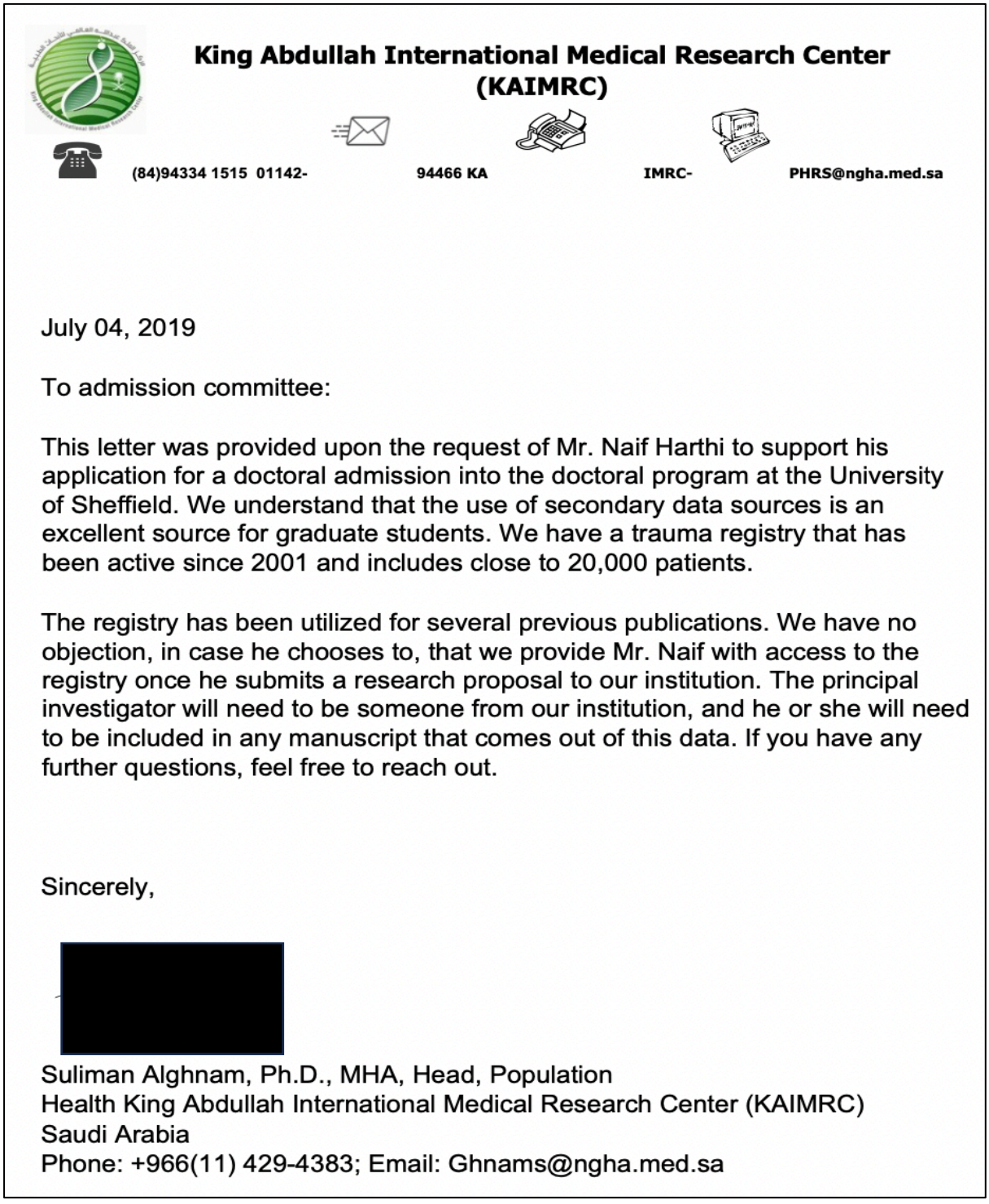
Appendix 7: The Third Version of Interview Schedule:

Guide questions	***Comments***
How do Saudi paramedics and EMTs understand the impacts of ageing changes on geriatric trauma care and how they acquire and apply their knowledge? 1.Could you give me a brief summary of your career as an ambulance worker to date? *(Work position, job level, length of experience).* 2. Could you tell me about your experience during responding to older patients with injuries? What are the most important challenges? Why? *(Challenges during responding to and caring for older patients with injuries).* 3. How do you feel when you attend older patients with injuries? *(How confident do you feel when assessing and managing injured older patients? if you feel unconfident, explain why?)* 4. I would like you to think back to a recent case you have attended involving an older patient with injuries: *a. Description of the circumstances of the case.* *b. Patient was male or female? Was the patient alone?* *c. What assessment process did you apply?* *d. Patient was transported? And where (MTC or hospital) and why? If not transported, why?* *e. How did you help the patient? How did you address the problems you identified?* *f. Do you think this case is typical of older patients with trauma? If not, how it differs from typical cases?* (I can then contrast the case interviewees describe and their perceptions of a typical case with the characteristics of cases in the quantitative study) 5. How do you think the care you provide (or should provide) for older people differs? *(Does it differ from the care you provide to younger people? If no, why?)* 6. Have you acquire appropriate or adequate knowledge regarding prehospital geriatric care? How you acquire this knowledge?	For the 1st qualitative question.

(Were there challenges to take education or trainings courses? How many times did you take courses during service? From private or public organisations? Were they useful? Why? could you apply this knowledge? If not, why?).	
What are the facilitators and barriers to providing improved care? 7. What factors or circumstances influence your ability to provide improved care for older patients with injuries? What are the most important factors or circumstances? *(Are you able to provide improved care for injured older patients? if you are unable, why? What are the factors or circumstances?* 8. What factors facilitate providing improved care for older patients with injuries (optimal care)? What are the most important facilitators? Why? *(Are there factors can facilitate providing improved care for older patients? if no, why?)* 9. Are there any differences or barriers to providing improved care for male and female older patients with injuries? *(if there are differences? Can you explain why?)*	For the 2nd qualitative question.
The following three questions will be asked to the remining participants (after the 16th interview) after displaying the following diagram which shows the key findings of the study: 10. Do you think all these diagram's elements are important to improving care? 11. What are the more important elements than others? Why? 12. Are there any other important elements to improving care?  	After showing the below figure to the participant to respond for the three relevant questions

13. Can you suggest any changes or strategies that would help you provide improved care and make proper decisions or improve your ability to care for older patients with injuries? 14. Is there anything else you would you to share with me about, or that you think I should know about, that would help us understand how Saudi paramedics or EMTs respond, assess, and care for older patients with injuries?	

Appendix 8: The Previous Conditional Letter for Collecting Data from the KAMC Trauma Registry:



King Abdullah International Medical Research Center (KAIMRC)

(84)94334 1515 01142- 94466 KA IMRC- PHRS@ngha.med.sa

July 04, 2019

To admission committee:

This letter was provided upon the request of Mr. Naif Harthi to support his application for a doctoral admission into the doctoral program at the University of Sheffield. We understand that the use of secondary data sources is an excellent source for graduate students. We have a trauma registry that has been active since 2001 and includes close to 20,000 patients.

The registry has been utilized for several previous publications. We have no objection, in case he chooses to, that we provide Mr. Naif with access to the registry once he submits a research proposal to our institution. The principal investigator will need to be someone from our institution, and he or she will need to be included in any manuscript that comes out of this data. If you have any further questions, feel free to reach out.

Sincerely,

[redacted]

Suliman Alghnam, Ph.D., MHA, Head, Population
Health King Abdullah International Medical Research Center (KAIMRC)
Saudi Arabia
Phone: +966(11) 429-4383; Email: Ghnams@ngha.med.sa

Appendix 9: The KAIMRC's Ethical Approval Letter for the Quantitative Study:

Kingdom of Saudi Arabia
Ministry of National Guard - Health Affairs

المملكة العربية السعودية
وزارة الحرس الوطني - الشؤون الصحية

King Abdullah International Medical Research Center (KAIMRC)

IRB NCBE Registration No.: H-01-R-005

(84) 94456 1515 94466 irb@ngha.med.sa

IRB Office Memo Ref.No. IRBC/1670/21 E-CTS Ref. No. RYD-21-419812-116691

Study Number: **NRC21R/320/06**
Study Title: **What are the characteristics of major trauma older patients in Saudi Arabia and predictors of in-hospital mortality among them?**
Study Sponsor: **Non Grant**
IRB Approval Date: **18 August 2021**
IRB Review Type: ■ **Expedited Review** ☐ **Full Board**
Study site(s): **Central Region**

Dear **Dr. Suliman Alghnam**
Research Scientist, KAIMRC
Ministry of National Guard – Health Affairs

Sub-investigator/s – Fiona Sampson, Naif Mohammad Harthi and Steve Goodacre

After reviewing your submitted research proposal/protocol and related documents, the **IRB has APPROVED** the submission. The approval includes the following related documents:

Document/Title	Version	Date
Research Proposal	01	18 August 2021
Data Collection Form	01	18 August 2021

The approval of the research study is valid for **one year** from the above approval to expiration date.

Terms of Approval:

- **Annual Reports:** An Annual report must be submitted for approval to avoid termination/suspension of your research.
- **Financial report:** If your study is funded project, details financial report should be submitted with the scientific report.
- **Final Report:** After completion of the study, a final report must be forwarded to the IRB.
- **Retention of original data:** The PI is responsible for the storage and retention of original data pertaining to the project for a minimum of five years.
- **Reporting of adverse events or unanticipated problems:** The PI is responsible to report any serious or unexpected adverse events or unanticipated problems, which could involve any risk to participants or others, or any event on incidents that may have impact on the research or participants.
- **Biological samples:** No biological samples to be shipped out of the Kingdom of Saudi Arabia without prior IRB approval.
- **Participant incentives:** No financial compensation or gifts to be given to participants without prior IRB approval.
- **Storage of biological samples:** All biological samples collected for the purpose of this research must be stored in the KAIMRC related repository.
- You will need to resubmit the proposal to the IRB for review and re-approval before implementing any changes to the approved proposal.
- It is possible that the IRB may decide that the proposed new changes may exclude the proposal from being accepted for exempt review.
- It is your responsibility to safely store the data collected.
- Please note that phone based surveys are not permitted.
- If your approved proposal requires access to Bestcare, please write to the IRB informing them of the name of the designated data collector and exactly define the period requested for collecting data. Do not start the data collection until an approval memo is issued from the IRB giving permission to that collector to start accessing Bestcare for the duration of the project and after signing a confidentiality agreement.
  To submit a copy of your manuscript to the IRB.

[redacted]

Prof. Hamdan AL Jahdali
A/Chairman, Institutional Review Board (IRB)
Ministry of National Guard - Health Affairs

HJ/AJ

P.O. Box 22490, Riyadh 11426
Tel. 8011111
Telex : 403450 NGRMED SJ
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Appendix 10: The ScHARR's University Research Ethics Committee-approved Self-declaration Letter for the Quantitative Study:

Downloaded: 04/09/2021
Approved: 03/09/2021

Naif Harthi
Registration number: 200222138
School of Health and Related Research
Programme: PhD Health & Related Research

Dear Naif

PROJECT TITLE: Pre-Hospital Trauma Assessment and Management of Older Patients and their Association with Patient Outcomes: Challenges and Barriers
APPLICATION: Reference Number 043352

This letter confirms that you have signed a University Research Ethics Committee-approved self-declaration to confirm that your research will involve only existing research, clinical or other data that has been robustly anonymised. You have judged it to be unlikely that this project would cause offence to those who originally provided the data, should they become aware of it.

As such, on behalf of the University Research Ethics Committee, I can confirm that your project can go ahead on the basis of this self-declaration.

If during the course of the project you need to deviate significantly from the above-approved documentation please inform me since full ethical review may be required.

Yours sincerely

Email Scharr Rec
Departmental Ethics Administrator

Appendix 11: The KSMC's Ethical Approval Letter for the Quantitative Study:

Kingdom of Saudi Arabia
Ministry of Health
King Saud Medical City

مدينة الملك سعود الطبية
KING SAUD MEDICAL CITY

المـملكة العـربية السـعوديـة
وزارة الـصحة
مدينة الملك سـعود الطبية

IRB Registration Number with KACST, KSA: H-01-R-053
IRB Registration Number U.S. Department of HHS IORG #: IORG0010374

- Memorandum -

Date: November 23, 2021

Proposal Reference No.	: H1RI-21-Nov21-01
Proposal Title	: "Injury characteristics and in-hospital mortality predictors for elderly trauma patients in Saudi Arabia: a multicentre retrospective study"
PI	: Dr. Sharfuddin Chowdhury
Co-Investigators	: Mr. Naif Mohammad M Harthi
Type of Review	: Initial
Category of Approval	: Exempt
Date of IRB Approval-Expiration (Validity)	: 23/11/2021 22/11/2022 (12 months)

Dear Dr. Sharfuddin Chowdhury,

We are pleased to inform you that the above-referenced research proposal has been reviewed and was approved. The Institutional Review Board (IRB) committee found that the research met the applicability criteria and was eligible for exempt review. However, to commence the collection of data a permission letter must be issued from the Director of the Research Center first.

This approval is valid for **12 months** from the date of IRB review when approval is granted. The approval will no longer be in effect on the date listed above as the IRB expiration date. Please note that you are obligated to submit the following to IRB committee:

1. progress/final report on the **12 months (23-Nov-2022)** (or earlier in the case the study has completed)
2. any manuscript resulting from this research for approval by IRB before submission to journals for publication.

The approval of the conduct of this proposal will be automatically suspended after 12 months, in the case the Progress Report (or Final Report, if relevant) is pending acceptance. You also need to notify the Research Centre as soon as possible in case of:

1. any amendments to the proposal;
2. termination of the study;
3. any serious or unexpected adverse events;
4. any event or new information that may affect the benefit/risk ratio of the proposal.

All records relating to the research including consent form must be retained and available for audit for at least 3 years after the research has ended.

We wish you every success in your research endeavors.

[redacted]
Dr. Faisal Almazroua
Chairman, Institutional Review Board (IRB)
King Saud Medical City Riyadh, KSA

وزارة الصحة المملكة العربية السعودية
مدينة الملك سعود الطبية
King Saud Medical City
لجنة أخلاقيات البحوث (IRB)

☎435-5555 Ext. 2345 irb@ksmc.med.sa

Appendix 12: The Previous Conditional Letter for Collecting the Qualitative Data in the SRCA:

بسم الله الرحمن الرحيم

Kingdom of Saudi Arabia
Saudi Red Crescent Authority
Head Quarter
(259)

المملكة العربية السعودية
هيئة الهلال الأحمر السعودي
الإدارة العامة
(٢٥٩)

Conditional Acceptance letter of research

Dear Mr. Niaf Mohammad Harthi,

Warm Greeting from Saudi Red Crescent Authority (SRCA),

This letter is to inform that your proposed research paper entitled "The Pre-Hospital Trauma Assessment and Management of Older Patient and their Association with Patient Outcomes: Challenges and Barriers", has been conditionally* accepted. The SRCA wishes you success in your future educational and appreciate your interest.

*Eligibility for Full Acceptance

Researchers are eligible to be fully accepted once they have provided to the Saudi Red Crescent Authority the following:

- *Receiving/providing a confirmation letter from a well-known university stating that you are a university student who wish to conduct a research in Saudi Red Crescent Authority.*

With Regards

Dr. Mohamed Al.Suwayeh
[redacted]
General Director of Training
25/7/2019

Kingdom Of Saudi Arabia
Saudi Red Crescent Authority
General Directorate Of Training

Enclosures: ..... المشفوعات: Date : / / التاريخ: No: ..... الرقم:

سنترال: ٠١١ ٢٨٠٥٥٥٥ - فاكس: ٠١١ ٢٨٠٦٦٦٦ - الرمز البريدي ١١١٢٩ - الرياض

Appendix 13: The Ministry of Health's Ethical Approval Letter for the Qualitative Study:

Kingdom of Saudi Arabia
Ministry of Health
Central IRB
GDRS

المملكة العربية السعودية
وزارة الصحة
اللجنة المركزية لأخلاقيات البحوث
الإدارة العامة للبحوث والدراسات

اللجنة المركزية لأخلاقيات البحوث بوزارة الصحة

Central Institutional Review Board

National Registration Number with NCBE-KACST, KSA: (H-01-R-009)

Approval Letter

Date: 2/8/2021

Central IRB log No: 21- 73E

Category of Approval: Expedited

Dear: Mr. Naif Mohd Harthi

The Central IRB pleased to inform you that your study mentioned below has been reviewed and approved. This letter gives you an ethical clearance to implement your study according to the approved documents and you still need to obtain administrative approval from the site/s where the study will be conducted.

Protocol Title	The Pre-Hospital Trauma Assessment and Management of Older Patient and their Association with Patient Outcomes: Challenges and Barriers
Principal Investigator	Mr. Naif Mohd Harthi
Affiliation	Jazan University
PI e-mail	Nharthi1@sheffield.ac.uk
Documents Reviewed	IRB form, CV, Ethics certificate, consent form, study survey and data sharing agreement.

Approval Conditions:

1. Approval is valid for **one year** from the date of this letter.
2. If the research is not completed within the validation period, PI will be required to apply for an extension from the IRB, one month before the expiry of the approval.
3. Abide by the rules and regulations of the Government of Saudi Arabia, NCBE, MOH and the IHC-GCP guidelines.
4. The research team should follow the IRB approved study documents, unless amendment(s) are requested and approved by the IRB.
5. All researchers are required to have valid research ethics certificate on Protecting Human Research Participants.
6. The research team are not allowed to disclose personally identifiable data to any other party.
7. The PI is required to keep the study data securely for at least five years after completion of the study.

e-mail: gdrs-irb@moh.gov.sa

Kingdom of Saudi Arabia
Ministry of Health
Central IRB
GDRS

المملكة العربية السعودية
وزارة الصحة
اللجنة المركزية لأخلاقيات البحوث
الإدارة العامة للبحوث والدراسات

8. The collected data should only be used for this research.
9. It is required to collect three copies of informed consent forms (unless waived) as follow:
   I. one copy to be kept with the PI
   II. one copy to be kept with the study participant
   III. one copy for the IRB committee OR to be kept in the participant file in case of clinical research
10. The PI is required to submit a progress report **every six months**
11. the PI must ensure adequate close-out of the study.
12. Publication by any means is not allowed except after getting an approval letter from the IRB and MOH research department.

Sincerely yours,

[redacted]

Dr. Hussain A. Darraj, MBBS, MSc, MD

Chairman of the Central IRB, MOH, KSA.

المملكة العربية السعودية
وزارة الصحة
Ministry of Health
Approved
اللجنة المركزية لأخلاقيات البحوث
Central Institutional Review Board

e-mail: gdrs-irb@moh.gov.sa

Appendix 14: The Process of Checking and Cleaning the Chosen Variables' Missing Data:

The variable	*Variable classification in the SPSS*	*The variable domains in the SPSS*	*Missing data rates (before data cleaning)*	*The credibility of variables ranges*	*Actions taken*
Patient ages	Categorical	Four age subgroups: (55-64, 65-74, 75-84 and 85 and older)	Valid= 452 Missing data=0	Checked and no issues were identified.	No further actions required to clean the variable
Sex	Categorical	Two domains: (male or female)	Valid= 452 Missing data=0	Checked and no issues were identified.	No further actions required to clean the variable
Direct and indirect transport times to MTC	Categorical	Two domains: (<60 min VS ≥60 min)	Valid= 452 Missing data=0	-This variable data was collected and calculated by: (ambulance departure time and date – MTC arrival date or time= time to MTC). -Initially, this variable has two calculated variables: 1) Ambulance departure date or time (this first variable has 48 cases with missing data) despite these cases being transported from the scene to the MTC. 2) MTC arrival time (without missing data).	-After that, I have decided to assume which cases were transported to the MTC by (<60 min VS ≥60 min), using the following variables: a) Checking no. of prior facilities (0, 1, or 2). As if a patient has (0), they will be considered transported to MTC by (<60 min) and vice versa for other cases. b) If cases were transported to the MTC from a scene (outside the Riyadh city), cases will be sorted under (≥60 min transport to the MTC) and vice versa for other cases. I have taken this assumption because Saudi paramedics ideally transport all cases to the nearest hospital regardless of the care level provided by health care facilities based on the current Saudi EMS guidelines.
Injury cause (mechanism of injury)	Categorical	8 domains: fall (more than 1 metre), fall (same level or lower than 1 metre), fire, flames or smoke, cutting or piercing object, motor vehicle accidents, motorcycle, pedestrians, struck by or collision with person or object)	Valid= 452 Missing data=0	Checked and no issues were identified.	11 domains were identified and then merged into 8 domains to reduce limited cases in some domains and decrease the number of the variable domains. The merging domains were motor vehicle passengers and motor vehicle drivers under motor vehicle accidents,

					machinery domain with cutting & piercing objects, and finally merging struck by or collision with person domain with struck by or collision with a person.
Affected body parts	Categorical	8 domains: (head, neck, thorax, abdomen, lower back, lumbar spine or pelvis, hip or thigh, extremities, burns to external body surfaces or injuries to multiple body areas)	Valid= 451 Missing data=1	Checked and no issues were identified.	12 domains were identified and then merged into 8 domains to reduce limited cases in some domains and decrease the number of the variable domains. The following domains were merged: injuries to the ankle and foot, injuries to the elbow and forearm, injuries to the knee and lower leg, injuries to the shoulder and upper arm, and injuries to wrist and hand to be under extremities injuries. The missing data patterns were then investigated in the next sections to decide which approach to use with the missing data.
First systolic BP at scene: (mmHg)	Continuous	N/A	Valid= 375 Missing data=77 cases (17%) Mean=137.17 Median=135.00 Mode=120 Max=244 & Min=52	Checked and no issues were identified as ranges were credible.	The missing data patterns were then investigated in the next sections to decide which approach to use with the missing data.
First heart rate at scene: (b/m)	Continuous	N/A	Valid= 377 Missing data=75 cases (16.6%) Mean=89.20 Median=88.00 Mode=80 Max=170 & Min=42	Checked and no issues were identified as ranges were credible.	The missing data patterns were then investigated in the next sections to decide which approach to use with the missing data.

First respiratory rate at scene: (b/m)	Continuous	N/A	Valid= 379 Missing data=73 cases (16.2%) Mean=17.38 Median=18.00 Mode=18 Max=30 & Min=10	Checked and no issues were identified. As ranges were credible.	The missing data patterns were then investigated in the next sections to decide which approach to use with the missing data.
Mental status at scene (AVPU acronym):	Categorical	5 domains: Alert, Verbal (response to voice only), Painful (response to pain), Unresponsive, or Unknown or not collected).	Valid= 385 Missing data=67 cases (14.8% = unknown or not collected data)	Checked and no issues were identified. As ranges were credible.	The missing data patterns were then investigated in the next sections to decide which approach to use with the missing data.
Number of prior facilities	Categorical	Three domains: (No prior facilities, one prior facility, or two prior facilities)	Valid= 452 Missing data=0	Checked and no issues were identified.	No further actions required to clean the variable
Hospital destinations	Categorical	Two domains: (Direct to the major trauma centre or indirect to major trauma centre)	Valid= 452 Missing data=0	Checked and no issues were identified.	No further actions required to clean the variable
Mode of arrival to MTC	Categorical	Four domains: (Red Crescent ambulance, government ambulance, private ambulance, or unknown or not documented).	Valid= 452 Missing data=0	Checked and no issues were identified.	I found two cases with “unknown or not documented” data. After that, I found them transported by the red crescent ambulances according to the “prehospital ambulance arrival date and time” variable. Therefore, I merged these limited cases with the “Red Crescent ambulance” domain.
Trauma team activation	Categorical	Two domains: (yes or no)	Valid= 451 Missing data=1	Checked and no issues were identified.	The missing data patterns were then investigated in the next sections to decide which approach to use with the missing data.
ED- first systolic BP: (mmHg)	Continuous	N/A	Valid= 441 Missing data=11 cases (2.4%) Mean=142.15	Checked and no issues were identified. As ranges were credible.	The missing data were then investigated in the next sections to decide which approach to use with the missing data.

			Median=139.00 Mode=140 Max=237 & Min=37		
ED- first heart rate: (b/m)	Continuous	N/A	Valid= 443 Missing data=9 cases (2 %) Mean=89.26 Median=88.00 Mode=90 Max=160 & Min=21	Checked and no issues were identified. As ranges were credible.	The missing data patterns were then investigated in the next sections to decide which approach to use with the missing data.
ED- first respiratory rate: (b/m)	Continuous	N/A	Valid= 447 Missing data=5 cases (1.1 %) Mean=19.40 Median=19.00 Mode=20 Max=36 & Min=13	Checked and no issues were identified. As ranges were credible.	The missing data patterns were then investigated in the next sections to decide which approach to use with the missing data.
ED- first GCS score (total)	Categorical	Four domains: (15, 14, 13 or < 13)	Valid= 400 Missing data=52 (11.5%) 15 score= 368 cases 14 score= 7 cases 13 score= 2 cases < 13 score= 23 cases	The GCS ranges from 3 to 15. Also, I found only one older case who had a non-credible GCS score, such as “44”. I changed the “44” score of this case into “4” as I believed that the person who collected this score meant “4” GCS score.	Regarding the missing data, patterns of missing data were then investigated in the next sections to decide which approach to use with the missing data.
Injury severity score	Categorical	Three domains: (0-8 minor, 9-15 moderate, ≥16 serious)	Valid= 452 & missing data=0 0-8 minor=153 cases 9-15 moderate=235 cases ≥16 serious= 64 cases	Checked and no issues were identified.	No further actions required to clean the variable.
In-hospital mortality	Categorical	Two domains:(Yes, No- because discharged to home, discharged against medical advice, transferred to another hospital for rehab/convalescence,	Valid= 451 Missing data=1 Yes: 26 cases. No: 425 cases.	Checked and no issues were identified. The 425 cases were discharged to home, discharged against medical advice, transferred to another hospital for rehab/convalescence, transferred to	Regarding the missing data, patterns of missing data were then investigated in the next sections to decide which approach to use with the missing data.

		transferred to another hospital for ongoing acute care, or absconded).		another hospital for ongoing acute care, or absconded.	
Length of stay in hospital: (days)	Continuous	N/A	Valid= 452 Missing data=0	Checked and no issues were identified.	No further actions required to clean the variable.

Appendix 15: The Results of Investigating the Patterns of Missing Data in Each Case and Variable:

The eleven variables that have missing data were:
a) Six continuous and two categorical variables (including four prehospital & four in-hospital physiological variables), and
b) Three categorical variables: affected body areas, trauma team activations, and in-hospital mortality data.

Cases with missing data (by cases' designed IDs)	*Systolic BP at scene*	*Heart rate at scene*	*Respiratory rate at scene*	*Mental status AVPU at scene*	*GCS score at ED*	*Systolic BP at ED*	*Heart rate at ED*	*Respiratory rate at ED*	*Affected body parts*	*Trauma team activation*	*In-hospital mortality*	*Numbers of missing data in each case*
80	1	1	1	1								4
308	1	1	1	1								4
353	1	1	1	1								4
383	1	1	1	1								4
611	1	1	1	1								4
623	1	1	1	1								4
748	1	1	1	1								4
754	1	1	1	1								4
785	1	1	1	1								4
819	1	1	1	1								4
831	1	1	1		1							4
849	1	1	1	1								4

890	1	1	1	1								4
895	1	1	1	1								4
918	1	1	1	1								4
947	1	1	1	1								4
948	1	1	1	1								4
949	1	1	1	1								4
952	1	1	1	1								4
989	1	1	1	1								4
1017	1	1	1	1								4
1019	1	1	1	1								4
1026	1	1	1	1								4
1033	1	1	1	1								4
1045	1	1	1	1								4
1047	1	1	1	1								4
1061	1	1	1	1								4
1063	1	1	1	1								4
1070	1	1	1	1								4
1072	1	1	1	1								4
1076	1	1	1	1								4
1083	1	1	1	1								4
1096	1	1	1	1								4
1102	1	1	1	1								4
1105	1	1	1	1								4
1143	1	1	1	1								4
1191	1	1	1	1								4
1194	1	1	1	1								4
1205	1	1	1	1								4
1223	1	1	1	1								4
1259	1	1	1	1								4
1262	1	1	1	1								4
1283	1	1	1	1								4
1284	1	1	1	1								4

1287	1	1	1	1								4
1295	1	1	1	1								4
1297	1	1	1	1								4
1300	1	1	1	1								4
1319	1	1	1	1								4
1328	1	1	1	1								4
1330	1	1	1	1								4
1110					1	1	1	1				4
173	1											1
985	1											1
291		1										1
1100		1										1
758			1									1
75				1								1
421				1								1
993				1								1
1056				1								1
1217				1								1
151					1							1
158					1							1
202					1							1
316					1							1
366					1							1
380					1							1
437					1							1
453					1							1
478					1							1
482					1							1
519					1							1
520					1							1
541					1							1
542					1							1

568					1							1
711					1							1
738					1							1
774					1							1
775					1							1
781					1							1
854					1							1
856					1							1
865					1							1
871					1							1
876					1							1
887					1							1
936					1							1
937					1							1
943					1							1
977					1							1
1000					1							1
1005					1							1
1068					1							1
1085					1							1
1236					1							1
630						1						1
684						1						1
798						1						1
1034						1						1
1195						1						1
58							1					1
740							1					1
1345									1			1
359										1		1
70											1	1
269	1	1	1	1	1							5

601	1	1	1	1			1					5
632	1	1	1	1	1							5
957	1	1	1	1	1							5
971	1	1	1	1	1							5
1255	1	1	1	1		1						5
1281	1	1	1	1	1							5
436	1		1	1								3
676	1	1	1									3
691	1	1	1									3
885	1	1	1									3
1139	1	1	1									3
1229	1	1	1									3
610		1	1		1							3
489	1	1										2
585	1				1							2
615	1	1										2
626	1				1							2
655	1	1										2
659	1		1									2
719	1				1							2
688		1			1							2
694		1	1									2
562			1		1							2
551					1		1					2
1133		1			1							2
605	1	1	1	1	1	1	1	1				8
761	1	1	1	1	1	1	1	1				8
792	1	1	1	1		1	1	1				7
1031	1	1	1	1		1	1	1				7

Appendix 16: Repeated Multivariable Analysis for the Scene SBP, Heart Rate, and Respiratory Rate Variables with In-hospital Mortality under Each Age Strata:

Covariates	*Categories*	*Frequency*	*Adjusted odds ratio*	*95% confidence intervals*		*P-value*
				Lower	*Upper*	
Scene SBP	<90 mmHg	4	5.85	0.56	60.92	0.14
	≥90 mmHg (Ref)	214	1.00			
Scene heart rate	<60 or >120 b/min	9	0.00	0	.	0.999
	60-120 b/m (Ref)	209	1.00			
Scene respiratory rate	<10 or >29 b/min	1	0.00	0	.	1.000
	10–29 b/min (Ref)	217	1.00			
Constant			0.06			<.001
a.Age subgroups = 55-64 b.Variable(s) entered on step 1: Scene SBP, Scene heart rate, Scene respiratory rate						
Covariates	*Categories*	*Frequency*	*Adjusted odds ratio*	*95% confidence intervals*		*P-value*
				Lower	*Upper*	
Scene SBP	<90 mmHg	2	0.00	0.00	.	0.999
	≥90 mmHg (Ref)	102	1.00			
Scene heart rate	<60 or >120 b/min	6	3.00	0.30	29.94	0.349
	60-120 b/m (Ref)	98	1.00			
Scene respiratory rate	<10 or >29 b/min	0				
	10–29 b/min (Ref)	0				
Constant			0.07			<.001
a.Age subgroups = 65-74 b.Variable(s) entered on step 1: Scene SBP, Scene heart rate.						
Covariates	*Categories*	*Frequency*	*Adjusted odds ratio*	*95% confidence intervals*		*P-value*
				Lower	*Upper*	
Scene SBP	<90 mmHg	1	0.00	0.00	.	1.000
	≥90 mmHg (Ref)	78	1.00			
Scene heart rate	<60 or >120 b/min	3	0.00	0.00	.	0.999
	60-120 b/m (Ref)	76	1.00			
Scene respiratory rate	<10 or >29 b/min	0				
	10–29 b/min (Ref)	0				

Constant			0.07			<.001
a.Age subgroups = 75 and 84 b.Variable(s) entered on step 1: Scene SBP, Scene heart rate.						
Covariates	***Categories***	***Frequency***	***Adjusted odds ratio***	***95% confidence intervals***		***P-value***
				Lower	***Upper***	
Scene SBP	<90 mmHg ≥90 mmHg (Ref)	0 0				
Scene heart rate	<60 or >120 b/min 60-120 b/m (Ref)	1 46	0.00 1.00	0.00	.	1.000
Scene respiratory rate	<10 or >29 b/min 10–29 b/min (Ref)	0 0				
Constant			0.05			<.001
a.Age subgroups = 85 and older b.Variable(s) entered on step 1: Scene heart rate.						

Appendix 17: Five Matrices of Each Study Objectives of the Qualitative Study:

Matrix 1: The first study objective: Saudi paramedics and EMTs understanding of impacts of ageing changes on care and patient outcomes:

Domains for each objective	***Themes (with interviewees' IDs)***	***After examining data for quotes and responses that identify the importance of themes and subthemes.***
1. Age-related changes in the individual patient's anatomy and physiology	*The physiological changes impacts: responding to severe injuries caused by medical conditions or low mechanism of injuries and difficult procedures to older trauma patients* A11, A10, A8, A12, A18, A22, A14, A15, A9, A17, A19, A20	A11: "older patients can have a serious injury with no severe pain, while younger patients can have severe pains…" A10: "there were no clues of a neck femur fracture with him. As the patient location has no clues and no clear mechanism of injuries. The fracture happened during changing clothes due to osteoporosis caused by malnutrition…". "Older patients with low mechanisms of injuries have higher injuries… *Complications* in older patients happen higher than in younger patients. We see many of this issue in the *field*. So, dealing with older people is usually *tough*" and "deteriorations in older people are higher than in others". "it is difficult to cannulate older patients… This will make a difference in the *quality of care*". A8: "sometimes, we respond to *traumas* caused by *medical conditions.* In these situations, our focus on the case only as *traumas*, not as *medical*. Maybe that case was suffering from diabetes or myocardial infarction before the accident". "Always, older people have osteoporosis as simple injury can cause fractures... This is also a challenge". Again, "Always, older people have osteoporosis as simple injury can cause fractures. When we put the patients on a *backboard*, the *backboard* will be painful for them more than younger patients. this is also a challenge". "sometimes, we do not know older cases' *complaints*. They do not have a degree of *pain* like *younger adult patients.* Older cases have lower pains". "Sometimes they have an *unclear degree of pain*". A12: "their injuries are more severe than in younger patients that may happen due to an *underline cause such as stroke, MI or a shock* which happened due to an accident… This is an important point because we *should extract information* for an issue in older patients in detail because in hospitals, we should describe how injuries happened with the patient… injuries may happen due to *hypoglycemia*, so in the hospital, ED staff will treat essentially *the underlaying cause* of this issue. These small details can make difference in hospitals' care *as a definitive care* and also, during providing care during transporting patients". "they are different. As younger patients *can compensate for a longer time*. But for older patients, *compensations* are lower, and they can deteriorate rapidly. Because older patients have *comorbidities. They may have previous surgery, chest pains, MI, or congestive heart failure*". A18: "most of older cases had low falls in homes, not high falls. These low falls can lead to risky injuries. Most of these injuries were minor and some of them were critical. Some minor injuries lead to death…". "the most difficult procedure in my training was *cannulations* of older patients because for me, *cannulations* for them can fail once or twice until applying it successfully". A22: "when *stabilising* the patient with suspected back injury, we should provide *doubled care for geriatric patients* compared to *adult* younger patients. Also, when *transferring* them, we should take more care during ambulance moving to avoid further injuries in the older patients. *Any simple movement could be life-threatening*". "Their *veins are different* from younger *adults*. *You can find veins or not*. This is one of the difficulties we face with the *geriatric* patients… if we needed to use a medication and no IV, this will be problematic, and the case can then deteriorate". A14: "*lifting and moving* older patients is difficult. Because sometimes we deal with *heavyweight* older patients. So, *we lift and move* them from their beds into stretchers and from the stretcher to the *ambulance*".

		A15: “older patients differ from younger patients because older patients usually have osteoporosis. The second reason is any movement to older patients can cause another or complicated injury. In contrast, I can move younger patients and apply *log rolls* for them easily”. A9: “The third challenge is that I face is *inserting cannulas* in older patients. I always face this issue. In this situation, I am working on the *emotional* and psychological aspects in the patient more than only *healthcare* to intervene… Because a lot of older patients refuse *cannulations*”. A17: “We have *equipment* but it is difficult to lift and move them into the ground floor because the building have no *lifts* or have *lifts* that do not accommodate *the board size* completely... So, we will be forced to stabilise them by any appropriate way and move them. In these situations, I cannot provide the needed care… I have another point which is that when you have an older patient with *hemorrhage*, and you must give him *fluids* and you have only one *solution* which is *opening an IV*. But *opening the IV* can be unsuccessful and difficult due to unclear or tortuous *veins*. Also, the *IO* route is inappropriate due to the *osteoporosis*. So, based on the *protocol*, we will try to transport him directly to the hospital… we cannot deal with older people easily because they have pains during movements…”. A19: “challenge that I face is uncontrolled bleeding in older people and level of consciousness decreases and becomes *weak* rapidly in them compared to younger patients… they use medications such as *aspirin* or have *cardiac or diabetic histories*. So, controlling bleeding in *young* patients is *easier* than in *geriatric* patients”. A20: “Usually, there are difficulties in *IV cannulations*. For example, we responded to an older case. When I held his hand, there were no clear veins except one vein. This is one of difficulties we face during opening veins… one of issues we face is responding to some older patients who live in second or third floors. So, the access to them will be difficult especially if we want to transport them to hospitals. We can enter the building, but we cannot move them from their bed to the ambulance… Sometimes, the difficulties in their weights and their buildings’ ladders are narrow... Sometimes there are no *lifts*”.
	Difficult communications with older patients due to hearing issues and mental conditions. A11, A6, A8, A15, A1, A18, A14	A11: “the issue of loss of hearing in older people is one of common issues that we should be aware of because he should give older patients different care compared to younger patients that then will give him positive reflections from the older patients”. A6: “*dealing* with older patients’ needs to be *emotional,* and honestly. We need communication skills”. “some older cases have mental conditions. So, we take prolonged time durations with these cases in *taking histories, assessments* and identifying the complaints due to the difficulty in communication with them”. A8: “the level of fears in older people are higher than others. This is the biggest challenge. Because they become a highly nervous in the field. So, it will be difficult to communicate and examine them”. “These always happen. I suggest using a *system of tags* in Saudi Arabia. Using *tags for diabetes and DNR*. For example, every older person has *a tag or ID* showing that he is *diabetic* and his medical information”. A18: “asking a lot of questions by paramedics bother older people. Sometimes older people will not answer them, and they can then say that it is not your business and only transport me. I think these may happened due to *side effects of medications* they use. This can prevent me providing help to them if they did respond to my questions”. “Due to the ageing impacts that occur in older people such weak hearing, I will need to be closer to their ears and speak loudly to hear me. This is one of circumstances that I encounter in the scene that can impact on *taking medical history*. If I could not take the *medical history* clearly, this will impact on the care provision for older people. Unclear *medical history* can prevent using medications to treat them and then influence providing the service… *Courses for the communication skills* are necessary and very important skills to deal with the older people and enable us to obtain what we need”. A15: “For the communication with the patient, most of geriatric patients more than 70 years old. They have CVA or old stroke. They cannot talk with you. There is no direct communication with them. You cannot explain the procedure to them. So, you must have one of the family members who can talk with them and explain to them the procedures. The communication is a big challenge with them”. “You should try and talk with older patients using the same of their language *accent*… Because you cannot predict their behaviours and they may hit you”.

		A1: "some older patients have *chronic diseases* such *CVA*, and they can be *comatose* in homes. So, we will have difficulty in *communication*. Also, their relatives are unaware of their patients' medical issues, *medications*, or any information". A14: "I respond to *bedridden older patients* who are unable to talk. For an example, relatives say their patient has a fever but in fact that patient has not a fever. *I then check for vital signs and take an ECG using the monitor.* I then will find the patient with *unclear* issue. The *chief complaints* in older patients are *unclear*".
	Difficult predictions of adverse outcomes in older trauma patients A11, A6, A10, A5, A8, A18, A24	A11: "when I deal with an older trauma patient, the blood volume is not similar to the younger patients' blood volumes. Also, *the medical histories and medications* are very important. Particularly, if older patients use medications for hypertension, BP cannot be a good indicator. Sometimes, *heart rate* also cannot be a good indicator due to *beta blockers*. So, we should deal with older patients differently from younger patients who have better health conditions". A6: "sometimes, we cannot recognise *any signs of shock in fall-down cases,* although they can *have internal bleeding*… you cannot then *diagnose or predict* issue". A10: "Older persons with shock can have unclear signs of shock because the use beta-agonist, calcium channel blockers, antihypertensives in general. So, the tachycardia can be unclear with them". A5: "For cases with *shock*, as we know that *the first sign of shock is the tachycardia*. For *geriatric patients*, most of them use specific *medications* such as *beta blockers* and these cardiac medications mask the *heart rate*. This will make a difference in *internal bleedings or signs of shock*. So, these signs will be unclear. In this situation, I will not depend on *the vital signs* completely during the *shock*. I will depend on *the general impression* of the patient and *amount of bleeding loss*. I will depend in my *examination* completely more than depending on the *vital signs* especially the *tachycardia*". A8: "Sometimes older patients use *medications* that make *the shock* difficulty to be identified clearly. Some patients use *aspirin* that can make the *bleeding* higher. Some of them use *beta blockers or calcium channel blockers* and this can lead to unclear *vital signs* such as inaccurate *blood pressures or heart rates*". A18: "we have responded to an older case in *a car accident*. The main cause for the accident was the *hypoglycemia*. We have taken *vital signs, first and secondary surveys,* and loaded him in the ambulance as *a critical patient*. His blood pressure was low (*hypotension*), and *heart rate was normal*, *65* b/m. Here was the difficulty and I then became *confused*. After *13 minutes*, when reached to the hospital, we discovered that the patient uses *beta-blockers* that was a reason for *a compensated response with normal pulse rate*. Because it is supposed to be *tachycardia* due the *hypovolemic shock*, not normal heart rate. This is the difficulty in dealing with older patients… it is unreasonable that the patient was having *a hypovolemic shock and his heart rate was normal*. So, I have taken long time to diagnose *his hypovolemic shock*. But the adult younger patient has a *normal physiology*. As he will be *compensated* and I will then identify his *hypovolemic shock*, directly *open vein, and give him fluids*" A24: "if the older case use cardiac medications and he has *a shock*. We cannot determine his *shock* and his blood pressure is normal due to use of cardiac medications and in the fact that the patient needs fluids, and the patient then can deteriorate rapidly or in minutes. This is one of the most important issues".

Matrix 2: The second study objective: How Saudi paramedics and EMTs acquire and apply their knowledge when attending to scene:

Domains for each objective	***Themes (with interviewees' IDs)***	***After examining data for quotes and responses that identify the importance of themes and subthemes.***

2. Knowledge gaps	*Acquiring insufficient knowledge from multiple sources before and after employment.* A11, A9, A13, A10, A5, A12, A18, A17, A19, A20, A21, A22	A11: "they have difficulties in dealing with *geriatric patients* rapidly. They have *less knowledge, are* not well-trained, have no *continuing education*, do not take *short courses*, and other factors. Also, they might work in an area that does not have *geriatric patients"*. "We take relevant *knowledge* from the school, but *clinical practice and skills* need working in the field". A9: "Honestly, I like looking for any knowledge to benefit myself more and more. I see that I have acquired the relevant *knowledge* from the *textbooks, research, internet* and learning from *experienced* colleagues but still insufficient". A13: "the *knowledge* is insufficient. I acquired my *knowledge* from *university study, internship year, work experience and guidelines*". "no one can say my knowledge is sufficient. Anyone always needs develop his experience, skills and knowledge and use different sources of knowledge". A10: "the *ITLS* provides the relevant knowledge better than the *PHTLS course* because the *ITLS* has section for *geriatric care* and the *PHTLS* has a section for *special considerations* including *geriatric and paediatric patients".* A5: "*the geriatric care knowledge* in my university study was insufficient. It did not have a specific *module* like *pediatric and gynecology patients* that have specific *modules*. We were studying limited *geriatric care*… I am satisfied with my current *knowledge* to deal with older patients. I acquired this *knowledge by reading books*". A12: "Incorrect and every day I learn new things regarding the *knowledge* from reading and learning from research and experience. Each case differs from another case. We learn from different cases everyday essentially from the Red Crescent Authority's *protocols*". "Regarding the university study, the study did not essentially focus on geriatric patients. It was general and focused on *middle-aged group*s of patients, not on *elderly or pediatrics*. It focused on only *the most common* cases". A18: "the Red Crescent Authority started providing *courses* for *the prehospital care*. They collect *the top ten most common cases* of the special considerations' cases in Saudi Arabia... They give *courses* about only *the most common top ten cases* that occurred repetitively in the scene with us. These *courses* were given if the *medical directors* noticed weakness among *paramedics* of a specific ambulance station regarding the *geriatric care*…". "These courses were insufficient because they covered only *the most common* cases". A17: "Not yet. Because every day we learn new information. Especially about the older people who use a lot of *medications* that have a lot of side effects. These *medications* can cause reading *normal vital signs* with older patients… I responded to an older patient who has constipation due to specific *medications*. After identifying these *medications*, I will then take *medications'* names and read about them. because if I responded to another similar case who has similar *medications*, I will be familiar about the medications… also my experience that I gained regarding the differences about *the vital* signs in older and adult younger patients". A19: "I see it is still insufficient. *I can deal with the patient but in a specific period*… unfortunately, the university study did not cover the *geriatric* comprehensively. *The sections of geriatric and pediatric* have not been *covered well*". A20: "But regarding *the knowledge*, I did reach to a sufficient level of knowledge yet. Some patients give me *medications* that I did not know or hear about them yet. But I have a small booklet I use it and has information of *all medications*. I use it". When I asked him about the applicability of his current knowledge, his response: "Yes I can apply it in the reality, and I don't have any issue about that". A21: "I can say that I acquired it when I started working in this area that have older patients as most cases. After that I felt that I need developing myself in the geriatric care. I obtained an experience in dealing with them. Sometimes, I receive thirteen calls per day for older people… there are *medications* they use I do not know about them… I hope to see specialised *courses* in this in the future". A22: "Usually, *geriatric patients have medical histories*… if an older patient has a specific disease, after finishing caring for them, I will read about his disease… because I will later respond to older patients with the same disease and have information about it".

	No related courses available and organisations provide such courses. A6, A7, A10, A5, A8, A15, A14, A1, A12, A11, A18, A21	A6: "Honestly, no *courses* available. I have never seen *courses* focusing on *geriatric care in prehospital settings*. I did not hear about that before". A7: "in Saudi Arabia, no *courses* available for *geriatric* care. Unlike to *paediatric* patients, there are courses specific for them. I have never heard about or seen any courses for caring for *geriatric* patients". A10: "I did not see *courses* specific for *older trauma patients.* I have seen only a part of a book, but it only covers t*he medical cases*". "no *sponsors* or *organisation* provide that knowledge for the *healthcare professionals and public* to raise the *awareness*". A5: "no *courses* available for *geriatric care*. This is important point for me because honestly, I did not find" and "We have a lack of courses for geriatric care". A8: "it is difficult to find relevant *courses*. I don't remember any relevant *courses and conferences* about". A15: "unfortunately, the *prehospital care* has *a shortage of courses*. When we take a course in trauma, we find it covers *pediatric, adult, and geriatric patient*s together. No courses special for geriatric patients. There is a shortage. These courses always have *geriatric patients within the adult patients".* A14: "I have taken *the PHTLS course* and know *the ITLS course* that have sections for the *geriatric care*. But I do not know any *course* special for *geriatric patients*". A1: "I have never seen a specific course for them". A12: "I remember there was only one *workshop* that introduced by *SASEM* organisation. It covered the *special considerations* in geriatric patients. It lasted one or two days and has been held only once with providing us a reference to read it. But there are no *courses* specific for geriatric patients held regularly and annually". "we need *courses* specific for *geriatric care* either *trauma or medical care*. I see this is very important for paramedics to have high *knowledge or awareness*, then apply them in real cases and have *experience* based on the knowledge". A11: "we do not take courses *special* for only *geriatric patients"*. "These *courses* at the end focus on *geriatric, paediatric and pregnant patients* as *special considerations".* Again, A18: "currently, the Red Crescent Authority started providing *courses* for *the prehospital care*. They collect *the top ten most common cases* of the special considerations' cases in Saudi Arabia… They give *courses* about only *the most common top ten cases* that occurred repetitively in the scene with us. These *courses* were given if the *medical directors* noticed weakness among *paramedics* of a specific ambulance station regarding the *geriatric care*… Honestly, there are challenges in finding *courses*. These *courses* are special *designed* for only *hospitals' cases*. Our issue is that the centres that provide *prehospital care*-related *courses* are so limited. Additionally, regarding the *budget* and funds, we cannot compare the Ministry of Health or military hospitals' funds with the Red Crescent Authority's funds. Because providing these *courses* is cost-effective". "Also, *courses for the communication skills* are necessary and very important skills to deal with the older people and enable us to obtain what we need… I see the *communication skills* with older people should be high-leveled and very important for paramedics to know how to deal with older people and their mentality, learn about *medications* that influence on their behaviours as side effects and understand them". "These *courses* are special *designed* for only *hospitals' cases*". A6: "We need more training because we use only our current knowledge". A21: "there is a lack of *training*. For example, in the *bachelor study*, unfortunately, the focus on the *geriatric* care was limited despite older people represent higher rates of patients. In my working area, the older cases represent more than 90% of the received calls and it is rare to respond to younger *adult and pediatric* cases… Even after the *bachelor* study, there is a limited focus on the *geriatric* care in the *training courses*. Especially the shortages of information of the common diseases and *morbidities*".

	A lack of prehospital geriatric trauma care research in Saudi Arabia. A10, A18	A10: "there is no research about your topic in Saudi Arabia. I did notice any *study or research* regarding the injuries in older people in the *prehospital care*". "I wish your *research* contributes to improve the *quality of care*". A18: "Honestly, we have a weakness in *the EMS research* that focus on *elderly patients*. if you want to improve this, we should have *a research centre, research administration or research team* working on *the geriatric care in EMS*. If you want to do that, you need *data*, and the *data* is available… We need a research department and *teams* specialised in *the geriatric care*".
3. Applicability of the current knowledge when responding to older trauma patients	*Difficult application of knowledge when responding to and caring for female cases due to the local culture.* A10, A12, A18, A19 A1, A8, A14, A17, A9, A21, A22	A10: "the *ITLS* provides the relevant knowledge better than the *PHTLS course* because the *ITLS* has section for *geriatric care* and the *PHTLS* has a section for *special considerations* including *geriatric and paediatric patients" and "*The above two *courses* are *applicable*. The *applicability* of *ITLS* in Saudi Arabia is higher than the *PHTLS* regarding the *prehospital geriatric care".* A12: "the current acquired knowledge is *applicable* but not with all cases. Because each case in the *prehospital* setting differs from another, meaning that with some cases, I should be *creative* by any way in dealing with". A18: "honestly, *Mosby and Nancy Caroline* textbooks were helpful. Because it is difficult that *paramedics* talk *to medical directions* or colleagues and say to them that I have lacked knowledge. But not everything in these North American textbooks we can apply in our society. Because these textbooks deal with all males and females equally" … For the skills, I have requested a training in hospital on learning for *cannulating* older patients. Regarding other skills and *advanced procedures*, I have learnt them from *simulations* that have become available for us… Yes. This knowledge was *applicable* and effective… if I have acquired *knowledge* about that *beta blockers* impact on *compensatory mechanisms* in older people, this is *applicable* in real cases. I can see these in the scene. Another example, if we responded to a simple car accident and found the patient has *severe chest pain*. We can say that the patient has *MI*. Because we learnt that we may respond to *a trauma* case with *a medical background"*. "I face only one challenge which is *physical examinations with females*. It is difficult to examine the *chest and connect the 12 leads ECG*. I see this is a simple challenge because with a good *communication*, these procedures will be easier… *courses for the communication skills* are necessary and very important skills to deal with the older people and enable us to obtain what we need. Again, A19: "I see it is still insufficient. *I can deal with the patient but in a specific period*". When I asked A19 about his university study, his response: "unfortunately, the university study did not cover the *geriatric* comprehensively. *The sections of geriatric and pediatric* have not been *covered well*". A1: "I have acquired the current *knowledge* from university study, *protocols*, sometimes responding to *interesting cases* and then *reading* about those cases to gain *knowledge*… This knowledge is difficult to be applicable because some older patients socially do not accept our care, depends on the *culture*… I responded to a *female* older patient who has 70 years old with *a chest pain, hypertension, and diabetes*. We decided to apply *ECG* for her, but her relatives refused. She also refused and she was aware of that… Also, relatives refuse the physical examination especially, when we want to check for any injuries, *infections*, or anything else". "raising awareness among patients' relatives. This should be a task of *paramedics'* tasks. Because *paramedic* should not only provide care for older patients, but also raising *awareness* of *relatives* about that how should they care for their patients, how they deal with their patients, if hypoglycemic, what will they do? How they will give *medications* for under the patient's tongue if he has *a cardiac history or weakness* and *relatives* should not put their patients in *supine position*". Again, A8: "female patients have higher fears to examine her. She does not want to touch er or uncover her clothes to examine her due to the *culture*. This is a difficult issue".

		Again, A14: "We feel that there is a *distance* between us and female patients. We face difficulties due to the *culture* in *applying ECGs, checking vital signs and clinical examination.* Sometimes, it is impossible to apply a *12-lead ECG and physical examination*". Again, A17: "Patients' relatives must have sufficient knowledge about us in the Red Crescent Authority. They must know that we are qualified as I do not need to say to them that I am qualified. Originally, it is not the relatives' responsibility, but it is the responsibility of the Red Crescent Authority or the organisation that provide the care. The Red Crescent Authority should start working on the media, distribute educational courses and leaflets everywhere for public". Again, A9: "there are difficulties in uncovering the *female patients*' faces, examine *chest or abdomens*. I see this is a social and cultural issue that we cannot change it. But we can reduce this issue by using a *polite* way of *approaching* to the patients or way of convincing them *professionally*… I see this is my solution to this issue". A21: "*females* are more difficult due to a culture matter… For example, examinations and assessment are difficult with them. They refuse the assessment on chest and abdomen that are difficult with them". A22: "due to *the culture*, if the patient is *female*, I will be unable to apply *12-lead ECG*. But *the contact with the patient* can play important role… I don't always encounter this issue because it will depend on the paramedic himself. How to contact with *relatives*, convince them?".
	Confidence or nonconfidence in applying specific skills when responding to older trauma patients. A7, A9, A5, A8, A6, A11, A13, A15, A14, A1, A12, A18, A17, A19, A20, A21, A24	A6: "I see that *trauma* cases are easier to deal with than *medical* cases. As in *trauma* cases, we can see the injuries and identify the *mechanism of injuries" and "*issues in trauma cases are clearer while medical cases are complicated". A7: "I am highly confident as I try to provide my care with showing my confidence to the patients to make them relax. If they refused my care or transports, I could then advise and convince them to be transported to the doctor to receive better assessment". A9: I feel confident when I care for older patients. Because older patients have the same treatments of *the adult and pediatric patients*, except that when we face only the issues of giving *advance interventions* or *medications* to the older patients, refusals of our instructions, nervousness or saying bad things by the older patients. In these situations, we try to calm them". A5: "I feel confident. Because I have my mother who has hypertension and diabetes and I always care for her. Also, my grandmother who passed away a while ago. I was caring for her when I always was a university student. So, I never feel unconfident when I care for them. I feel I have a previous experience in dealing with them especially with my family that facilitated dealing with older people. It is correct that I face difficulties sometimes regarding the non-cooperativeness with some patients, but everything goes fine". A8: "I feel more confident, and I acquired this confidence from the experience by responding to a lot of calls. Also, I was caring for my parents. Therefore, I have acquired better communication skills". A13: "I feel confident in caring for geriatric patient because my study level, capability and work *experience*. By these, you will gain confidence. The most important point is being *calm* when caring for them. this action will make me able to arrange my ideas and think to undertake correct steps. Always, I make the debate with the patient, not with relatives to try to control the debate. I try to talk with the patient on the same level of eyes and make sure the patient understands what I say". A15: "I feel confident because I see four years of work is enough, even for an individual who feels less confident. Because in *Riyadh*, you will respond to a lot of different cases such as *multi-trauma, geriatric patients, and all cases* until gaining an experience that will help you to manage and deal with any case in the future". "You should try and talk with older patients using the same of their language *accent*. You should explain to them. Because you cannot predict their behaviours and they may hit you. I see these your actions will facilitate all next actions of care".

		A14: “I don’t feel less confidence. As I found my previous experience in the *ICU* useful that has taught me a lot. Because I have dealt with different *specialties* such as *cardiologist* who deals with cardiac issues and *geriatricians* who deal with older patients. for example, there *was a heart failure patient* who had increased blood pressure. I was unable to give him *fluid* that can lead to further issues. So, in this situation, I will search for a better care possible for the older patients lead to my experience that I have learnt in the *ICU* along with my university *study* and work *experience*”. A1: “I gained my confidence from university study and searching for any new updates in my specialty especially for this group of population that we find in every home… Also, I benefited from my experience and making relationships with hospitals’ care professionals after delivering cases ask them about cases we delivered; what happened with our cases, what procedures you will do for them and what are their treatment plans... etc”. “I feel confident in providing *medications* for *life savin*g with cautions because we afraid from any *complications* my occur in older people, doing *CPR*, *decision of transports to choose the suitable facility, cannulation, suctioning patients*, and the most important thing that we face is changing the *patient position*. Paramedics do not deal with only patients, but also with *relatives*. As *paramedics* can raise relatives’ *awareness*”. A12: “I do not have non-confidence as I deal with them as any patients with considering their age that differ from others. So, I give them more considerations more *than middle-aged patients*. I work in an area have a lot of older patients either *medical or trauma* cases that led to obtain more experience in dealing with them more than others and this including dealing with my parents and the grandfather in the home. I have obtained experience in the *tracheostomy, NG tube*, and dealing with older patients compared to *the middle-aged patients*”. A18: “at the beginning of my profession, I was unconfident… I needed more time for my skills as I remember that I have requested a special *training* on *cannulations* of older patients in a hospital which has a department of internal medicine caring for the older people. It is correct that I was feeling fears and non-confidence but with the experience, I have become better after spending one to two years to become capable in my skills while for my *knowledge*, I have spent around five years”. “The most procedures that I am confident in applying them are *chest compressions, ventilations by bag valve masks, and intubations.* But the most difficult procedure in my training was *cannulations* of older patients because for me, *cannulations* for them can fail once or twice until applying it successfully”. A17: “my confidence is high. When responding to older people, I assure them based on their mood. I should gain their trust before applying any procedure with them. After that all care steps will be facilitated... I see the beginning of care with them is very necessary and important to gain their trust. After that, all next procedures will be applied easily. The assurance is the key of approaching to the patient…”. “I see a lot of colleagues deal with older people inappropriately. They do not know to deal with them. I see it differs from a paramedic to another. Some of them deal with older patients like any trauma case or routine cases until completing the care”. A19: “From the beginning of my service, I noticed that there are improvements or gaining confidence in this because I deal with different medical teams that increased the confidence in dealing with patients… the care providers’ *first exposure* to patients can make them *shocked* but if the same injuries repeated, the care providers then will have experience in dealing with these injuries and become familiar to deal with any patient’s *reactions*. I see *the experience, exposure to cases, and self-learning* will improve the care”. A20: “I do not have nonconfidence. I like talking with them as sometimes I found them upset. So, I talk with them… Sometimes, I talk with them loudly to let them hear me and I can then gain information from them… I acquired this skill because I like hearing from experienced colleagues to know what the correct and wrong actions are from the experience they had. Also, I acquired this from the life experience because I deal with older people by using words they like because dealing with them is difficult... I approach to the patients and try to hear them as much as possible until obtaining needed information... For example, my colleague takes the history asking about their diseases and medications and I hear patients’ responses and then analyse about what things happened with the patients”.

		A21: "after starting to take *board certificates*, honestly, I have gained more confidence… the *experience* in the *geriatric* care was useful as I have said that 80% of the cases I responded to are older cases… Regarding the skills, I have confidence in applying them such as *history-taking and medications care* after taking *the history* completely. But regarding the skills that am unconfident in applying them, *the airway management* such the *RSI* is difficult to be applied with the *geriatric* cases". A24: "The experience has helped me because I respond to at least ten calls for older cases including responding to the pilgrims… six months for newly employed paramedics is enough to have better experience… you need to make older cases feel that you care for them... I talk with them by setting down to them at the same level of eyes… the essential skill is the good *communication*. Then, every next action will be OK… the most difficult skill is the *IV*. We try to open *IV* more than once until being successful". A11: "there is *misunderstanding* as *paramedics and EMTs* should deal with older patients differently from younger patients because of their use of polypharmacy and *physiological changes…* They have *less knowledge, are* not well-trained, have no *continuing education*, do not take *short courses*, and many other factors. Also, they might work in an area that does not have *geriatric patients*. For example, some ambulance workers work in industrial areas, and they will deal with only *younger patients*. So, those paramedics will be unfamiliar with seeing and dealing with older patients".
	Using own knowledge to make arbitrary EMS decisions due to the current guidelines that apply to all trauma patients and a lack of geriatric specific guidelines. A18, A10, A5, A13, A11, A7, A6, A1, A12, A15, A14, A8, A9, A21, A22, A23	A18: ""there is *no communication* between the prehospital and in-hospital settings. So, I can only decide which hospital is more appropriate to my older patient*…".* A10: "the patient was transported to hospital with *a trauma unit*, not to *a trauma centre*. The patient was transported to *a nearest hospital* based on the *protocol* and has *a general and orthopaedic surgeries*" and "I would deal with older and younger patients differently but based on the *protocol* and *knowledge*, they are similar". A5: "I see *trauma centers* is the best choice for the older patients. Before transporting an *older trauma patient*, the *decision* will depend on the *patient condition*, and which is the *nearest hospital*. Some hospitals do not have *orthopedics specialty.* So, I will avoid choosing these hospitals, even it is the *nearest hospital* because it does not have specialties that patient needs. So, I will consider *a nearest hospital* that offers specialties that patient needs. *A nearest and appropriate hospital*". A13: "the transport was to a nearest hospital which has a needed specialty such as *a general surgery*. According to the *guidelines*, we should consider the nearest hospital and has the required *specialties*. If we needed a *specialty* that was unavailable in the nearest hospital, we will consider another farther hospital". A11: "we depend on the following factors: 1) Does the patient need *neurosurgery*? If yes, the patient will be transported to *a trauma centre*. 2) Does the patient need *vertebral column surgery*? If yes, there is a hospital that receives such cases. 3) Does the patient need *vascular surgery*? If yes, some hospitals receive such cases. 4) Does the patient have any other injuries? If yes, go to nearest hospital". A6: "If the cases were with a *life-threatening condition*, they would be transported to *the nearest hospital*, regardless of type of facility, 'trauma centre or hospital'". A15: "We transport *life-threatening condition* patients to *a nearest hospital* and *stable* patients based on their desires". "That is the *protocol* we follow". A14: "I am talking about a *stable* case who has only a *pain*. So, the patient management was giving him the *paracetamol* in the ambulance and transport him to the *hospital* he wants. But if he was a *life-threatening condition* patient, we will transport him to a nearest hospital". A7: "We have three tags to triage the patients: red, yellow, and green tags. Red tag means a serious patient, yellow tag for moderate cases, and green tag for mild cases. If the patient has green tag, we can ask him/her which hospital they need to be transported to. If his/her tag is yellow or red, we can transport them to a nearest hospital". A1: "if the patient was with *a life-threatening condition*, the transport should be to *nearest hospital* until becoming stable by *stabilising ABC* and he then will be transported to another *hospital* that has the needed specialty by using Ministry of Health's ambulances".

		A18: "If *hospital A* is nearer than *hospital B*. But *hospital A* is unready to receive trauma cases, we will consider *hospital B*. However,if we transported the case to the *hospital A*, they will not refuse receiving our case because there are fears to be accountable legally if they refused the case. So, they will receive our case in *their ED and surgery room*, but at the end, they do not have a *trauma surgeon*… they will use their own *ambulances* to transport the patient to *a trauma centre.* So, the patient will take a longer time to be managed". A12: "my role is to assess the case. If the case is severe, I will transport him to a nearest hospital and if he is *critical*, I will transport him to *a level 1 trauma centre*. For example, I responded to case with an amputated leg. The distance to general hospital was 10 minutes and distance to *the level 1 trauma centre* was about 12 minutes. I directly then transported him to the KSMC's *trauma centre* because the patient *needed a vascular surgeon*. I do not focus on the distance to hospitals but also on the needed specialty for the patient". "Until present, nothing is clear regarding that. But it depends on the patient situation". A15: "We transport life-threatening condition patients to *a nearest hospital* and *stable* patients based on their desires". A8: "based on the current protocol, dealing with older patients does not differ from caring for younger patients. They have the same care steps. But they differ in *the communication skills and emotional care* when dealing with older patients. So, dealing with older patients differently depends on the paramedics themselves based on *the personal and scientific experience*". A9: "based on the research that I have read, I have seen that these steps that I applied are the best ways to protect the patient by taking *a general impression, then scene safety, and treatment steps* that I have mentioned. I found my steps are more effective after acquiring them from studies and research". A10: "I always inform my colleagues about that older people have *differences* compared to others… they use *medications control blood pressure,* and those patients have unclear *blood pressures* when *compensating in shocks*, they can use *medications to control the heart rate* or use *pacemaker* in their hearts. So, they can have increased pulse. The *protocol* does not show these information or differences. But we give more care for these things". "We do not have protocol for geriatric patients. The current *protocol* used for all adult patients. But we give older people more care based on their differences to others". A21: "according to the *protocol* that we use, the transports should be to a nearest hospital if the patient is *vitally unstable*. But if the patient is *vitally stable*, we will not need to transport the patient to the nearest hospital". A22: "the current *protocol* is used similarly with older and *adult* younger patients but at the end, it depends on *the paramedic* himself if he provides *doubled caring for older patients* or not. For example, when I respond to older patients, I provide *doubled caring* for them. But… some colleagues deal with them like any adult patient". A23: "firstly, if the older patients have *comorbidities*, secondly, if they have more than 65 years old, and thirdly, if they have previous injuries in the same current body part… these three criteria that led us to decide transporting the patient to a nearest hospital… No, this is not the protocol of the Saudi Red Crescent. This is based on my personal decision… honestly because *the current protocol* of transport is not clear. Therefore, it depends on the paramedic's decision".

Matrix 3: The third study objective: Barriers to providing improved care for the older trauma patients:

Domains for each objective	***Themes (with interviewees' IDs)***	***After examining data for quotes and responses that identify the importance of themes and subthemes.***

4. Organisational barriers	*Lack of necessary equipment or manpower while caring for older trauma patients.* A10, A15, A14, A17, A23	A10: "there is a lack of *supplies* and *equipment* that can improve the q*uality of care* for older people such as a*dded back boards, blankets* for older patients, *short cannulas* for older patients. Availability of these supplies will facilitate providing better care for them". A15: "we need additional *equipment*. For example, we have *splints* used for *femur fractures*. When we use them, you not then see them again because they will go with the patients to hospitals. Then, the Red Crescent Authority will not give us alternative equipment. This issue applies to all splints we have. Our organisation gives us splints to be used for one year and then they will give us alternatives. This is an important point". "Sometimes, we are a few members in the scene. For example, we are two persons, one is a driver, and another is a care provider. We have *a heavyweight geriatric patient,* and we cannot move him. I see this is difficult. If we were three people, we could provide something helpful for the patient. This is an important point". A14: "there is *a shortage of manpower*. We are only two persons in the ambulance. For example, one of us is driving and I will be busy in *splinting extremities, opening a vein, preparing fluids and painkillers.* I have only two hands". A17: "we have shortage of *equipment* such as specific sizes of *cannulas* and *nasal cannulas* that can be unavailable or limited". A23: "honestly, the resources and equipment can be insufficient such as insufficient sizes of *c-collars* especially those sizes that are used for older people that sometimes can be unavailable".
	Restricted on-scene time to caring for older patients by the SRCA while older patients need longer time. A14, A13, A6	A14: "the Red Crescent Authority restricts our time of stay in the field which each patient. They expect we stay *10 to 15 min in the field*. Spending more than that can cause some issues and lead to investigation with us by our organisation. Spending time in convincing the patient for transports, then moving them from bed to *stretchers* to ambulance from second or third levels to ambulance can take 20 to 25 min". A13: "usually I encounter the issue of time in the scene. As in the Red Crescent services, I should spend a specific duration time (10 minutes) with each patient. Normally, *assessment of patient and application of treatment plan* can take 10 to 15 minutes with any patient, but in older patients they can take longer… the number of paramedics in the scene is important. As there are some procedures that can take normally 4 to 5 minutes by one paramedic but by three paramedics, they can take 2 minutes. This point is important". Again, A6: "We take *a long time* with older cases compared to younger *adults…* We take prolonged time durations with these cases in *taking histories, assessments* and identifying the complaints due to the difficulty in communication with them".
	Lack of care guidelines. A11, A10	A11: "the current *protocols* in the *tablet* provide general information for *geriatric and paediatric patients*. For example, regarding *the fluid replacement in trauma cases*, the tablet give you steps to be followed and the required amount of *fluid* to be provided for older cases". A10: "We do not have *protocol* for *geriatric patients*. The current *protocol* used for all adult patients. but we care give older people more care based on their *differences* to others".
	No data of older patients' history shared to paramedics. A18, A21	A18: "Currently, when we go to the scene, we record our patient's report *electronically* via *an iPad application* we use… paramedics record the patient's information such *as vital signs, provided interventions* and others, and then send them to the targeted hospital… Paramedics can send this information to hospitals but cannot obtain any information about the patient… *the past medical history* is rich by information of *polypharmacy and medical events* that if we did not obtain them, it will be difficult *to assess and diagnose* cases in the prehospital setting".

		A21: “there should be a linkage of data in our devices such as information of medical histories. Especially, when we respond to older cases, and we know their information… the patient can have *Parkinson syndrome*, osteoporosis, or dealing with patient who has cardiac transplant. In these cases, dealing with medications will differ… *the assessment* will differ as well. It is important to have linked data”.
5. Individual barriers	*Refusals of paramedics’ care by older patients or relatives and difficulties in convincing them.* A8, A9, A10, A5, A13, A14, A15, A20, A21	A8: “The most difficult action is convincing older patients to be transported to the hospital. A lot of them refuse transport to the hospital. They like only transports to the hospitals that they always visit. So, they always refuse to go to a nearest hospital if they are sick and in a critical situation”. A9: “I always face that older patients refuse my instructions such as applying *the C-collar or backboard*. Most of them refuse these actions by saying they are painful or saying that you are not a doctor to give that *order*”. “she was refusing our examination as she wanted to be assured about her sons who were involved in the *accident*. She asked us to examine her sons instead of her”. “I needed to transport her to the hospital as soon as possible rather than losing the time. Because she needs examinations in the hospitals such X-rays, labs tests before she *deteriorates*, to be then intervened in the appropriate time”. “Some *relatives* hide some information. When we asked them about kind of *medications* that are used by their older patient, they refuse to give us this information and the patient himself can also refuse giving us this information”. A10: “older people’s resistance to transports are higher than in younger patients”. A5: “Sometimes I face difficulties in dealing with refusals of care by *older patients*. for example, *relatives* can call us for their older *patient*. In that time, they are worried about their patient because they noticed alterations in his situation and their patient does not want the *emergency medical ambulance services*. He refuses our care and will be noncooperative with us”. A13: “I encounter difficulties in dealing with older patient. Especially if I want to apply a *specific procedure* with them or change a current *procedure* to another better *procedure*. They can refuse do that. Then, I will need to explain to them the *procedures* calmly. For example, most of them refuse the *examination* and they may have *fractures*. At the same time, they can be in a specific body position that can complicate their injuries or lead to further injuries. They refuse to change their *position* because they have fears of *pain*. This is important point because examinations can lead to *correct treatment plan and correct applications of procedures”.* A14: “the biggest challenge is convincing older patients to *transport* to *hospitals*. They refuse the *transport* even we relied on their relatives to try convincing their patients. Older patients want to be treated in home rather than treating them in the *hospital*. They do not want *hospitals*”. A15: “*Most of geriatric patients refuse the emergency services. They don't want to go to the hospital. They don't want to do anything with them…* I always face this issue. Even they may have fractures, they say: I don’t want to go to the hospital and leave me in my home. I die in my home better than dying in the hospital… Also, moving older patients with trauma from a place to another or changing their positions that we found to another position are *challenges*. They refuse moving them because fears of increasing pains with them. Also, these happen in the ambulance during enroute to the hospitals due to circumstances of the roads. Their pains increase when moving”. A21: “the biggest challenge I always face is they do not give us information of their diseases and medications. We always suddenly then discover new things while treating them... In some cases, we should intervene rapidly, but we take long durations of time to identify this information: what are their diseases? What medications do they use? So, we will be enforced to search for this information by ourselves by opining drawers to know what the medications they use… because we need to determine their pain management”. “As I said in the beginning that there are difficulties in convincing relatives or their older patients about that we are to provide treatments for patients. Yes, it is difficult to apply what I have learned”.

		A20: “They refuse. For example, we say to them that you should go to the hospital. He replies I am OK. When we try to convince him, but he refuses. They refuse the care or transports or both”. “If we could not convince them, we cannot then do anything for them. some of them say unsuitable words. Our roles then will be that talking with their relatives because their patients refuse transports to the ED and hospitals. Sometimes, their relatives refuse transporting their patients even they should be transported. for example, their older patients always go to specific hospitals regularly, but the hospital does not receive any new patients now. So, refusals can happen here because the relatives want that hospital and they do not want to consider another hospital”.
	Older people or relatives' unawareness of the medical conditions and medications. A11, A5, A15, A18, A20	A11: “this issue can lead to difficulties in obtaining of the older patients' histories in the scene”. “in our culture, usually, older patients have their sons, daughters, grandsons, and granddaughters around them. So, it is rare to face this issue”. A5: “the most challenges that I face is responding to older patients who are *unaware* of their medical problems… I can respond to older patient who have hyperglycemia and at the same time, he has incompliance in taking his prescribed medications. This can cause issues *on his kidneys or heart* or lead to injuries in extremities. Some of them are *unaware* about these issues or are negligent. A20: “some relatives do not know the *conditions* of their older patients completely especially their *diseases and DNR* information. I have noticed a lot of these issues in some calls. But sometimes I respond to some relatives who know very thing about their patients. Once you entered the rooms of their patients, you know these families are careful with their patients”. A15: *“if there are no relatives or bystanders with older patients, it will be difficult to take the medical history”. “We will not know anything about the patient. So, taking the past medical history will be a challenge for me”. “Sometimes you can ask the geriatric patient. Most of them will be bedridden. They may have CVA they cannot talk with you. So, you can ask the relative. What happened with him? What is the difference?”.* “Taking *history* is important because I do not want to apply a procedure that can harm the patient”. A18: “sometimes, when we reach to an older patient with no relatives in home, the difficulty is in prolonged durations of time from the injury time to the call. This means that it will be prolonged time to identify the injury”.
	Responding to aggressive, nervous, fearful, or non-cooperative older patients or relatives. A7, A5, A8, A12, A17, A24, A13, A14, A19, A10, A23	A7: “Relatives prevent me to provide care for their older patients and usually they want from me to rush. This prevents me concentrating on providing the needed care for their patients”. A5: “the most difficulties that I encounter when I deal with older people is the non-cooperative older patients. That is only thing that influence on providing my ambulance and treatment services to the patient”. “I always encounter is some of older cases with Alzheimer. Those patients are noncooperative with me during taking their vital signs because in that time, they are fearful. They are unaware of my roles and services that I will provide for them”. A8: “non-cooperativeness of relatives will not help you to providing improved *geriatric care*. For example, when we respond to an older patient, his relatives can ask you why you did not come earlier and why did you come late! These behaviours can agitate their older patient rather than making their patient comfortable to facilitate the care”. “Always, we should be aware of that older people have levels of fears or nervousness higher than in younger patients. So, it is difficult to communicate with them or examine them. These are the biggest challenges”. “Always *female* older patients try to deny any injury due to fears of going to the hospital. Older people do not like hospitals. They think if they went to the hospital, they will die there, or they will not be discharged. A lot of them deny the injury. They try as much as possible to avoid transports to the hospital. In these situations, we try to convince them”. A12: “the most important thing is responding to non-cooperative older patient who prevents us to do anything to him. He only wants transports to hospitals. Here he prevents you providing the *care*. Sometimes we respond to such cases and the refusals can be usually by the patients and sometimes by relatives”.

		A17: “Patient’s relatives can shout, behave aggressively, and consider as only a transporter. They also may refuse our care. They are non-cooperative with us. Sometimes, the older patients can be nervous, and we cannot gain their trusts to deal with them. Even if we tried to convince them. We cannot control the patients’ relatives. Some of them are unaware of that we are *qualified and trained* and we can provide good service, but we need a space to serve the patients. I think the reason for this issue is that they have a previous incident with paramedics who dealt with them negatively”. A24: “in some noncooperative families, they neglect their patients and ask us: why did you come late… or ask us only carry their patients and transport them directly”. A13: “some older patients are illiterate. So, we face difficulties in caring for them by finding them noncooperative. We face this issue with them”. “I always encounter the issues of denials of pains or injuries by older patients, despite they may have severe injuries, or they are sick”. A14: “some relatives are not polite or *irritable* with us. They put us under pressure despite we want to serve the patient and we know they are worried about their patients”. A19: “I notice in older people or their relatives that they overestimate in showing older patients’ complaints or injuries and then the patients say that ‘do not do that’, ‘I cannot stand up’, ‘do not lift me or move me, leave me’. Some of the older patients do not trust us”. A10: “denials of pains, tolerance of pains in older people are higher than in younger patients”. A23: “relatives in the scene can be agitated and they can request from us to intervene rapidly or transport their patients directly because they are emotionally nervous that can prevent us providing better or high-quality care. Honestly, *the bystanders* can be barriers… So, we will be enforced to lift and move the patients and complete our care in the ambulance”. “if the patients are alone in the home and there are no bystanders or relatives around them. This is one of the difficulties that we encounter especially with older people who live alone and no one around them. Therefore, we encounter difficulties in reaching to older patients’ homes and if we arrived, it will be difficult to obtain sufficient information about the case such as *mechanisms of injuries*, how the injury happened because the patient is disoriented. So, we will suppose the worst”.
	Older patients and relatives’ lack of confidence in paramedic care. A1, A9, A19, A21	A1: “Nonconfidence of care by relatives. They do not trust *paramedic* roles. This happens with every *paramedic*. For example, when I ask relatives: let me know what happened with your patient? They reply: patient’s awareness altered. Then, I ask them: when? They reply: two hours ago. I then ask: what is his *history*? They reply: he has *diabetes, hypertension, and old CVA*. Then I say: let me see his medications. They reply: do you investigate with us? I called you to transport us to the hospital”. A9: “Always we face the issue of contempt of the *paramedic’s* roles from patient and relatives. This is important point. This issue happens when they say that you are not *doctor*, you are just transporter. This issue happens for reasons: the *paramedics* themselves who built this reputation about us. Some of them say to patients that I came to you only to transport you to hospitals, or they transported *patients* using wrong manners”. “This issue needs longer time to be solved. I see this issue is multifactorial between *patients, relatives*, or the *paramedics* themselves”. A19: “sometimes, relatives request from us only ‘load and go’ rapidly to hospitals without providing any care to their patients. The reasons for this issue can be presence of anxiety or fears for their older patients, non-confidence in the paramedic roles, or both. I blame some paramedics in the issue of non-confidence in paramedic roles. Because their *attitudes* should be better in *the scene*. They must *trust themselves* because if the *paramedic* trust himself, dealing with the patients will be better. The paramedic’s *attitude* is important”.

		A21: “the society public should trust us. Especially, if the relatives refuse the care because they do not trust us… You will then become as a transporter. The training is required because it is important to remove fears from the paramedics when dealing with older people. Because usually, the practitioners do not trust themselves when providing care especially in urgent calls”. “there is no education about the ambulance roles. Because the majority of older people have the old perception which is they think that the ambulance is only for transport… they do not realise that we are the first point of treatment, not the hospital. They do not know that we can provide treatment for them. So, they will not give us information of their diseases or medications”.
	Relatives neglect older patients' needs. A9, A5, A1	Again, A9: “Always, I face the nervousness, aggression, and patient negligence by relatives. For example, if I asked relatives about why blood sugar is decreased in their older patient, they say: this the fifth or sixth time happens through a week. If I then asked their older patient about that, he replies it is not your business. You are not my son! Then, I will say: OK. I always face these issues. Again, A5: “I can respond to older patient who have hyperglycemia and at the same time, he has incompliance in taking his prescribed medications. This can cause issues *on his kidneys or heart* or lead to injuries in extremities. Some of them are *unaware* about these issues or are negligent. A1: “most older patients that we responded to are *bedridden and careless*. I mean they are *negligent*. This happens in some districts due to their financial circumstances. Because *negligent* patients can have unclean clothes and bad odors that influence on us during *transports*. But with rich people, we can find their patients have *a nurse or two nurse*s in the home, medical mattresses, and some devices such as *ventilators and suction units*”.
	Language barriers. A5, A18	A5: “I always face the *language barrier*. Some older patients do not understand me who are from different nationalities. I have difficulties in giving information to them”, A18: “Normally, we take the *history* from the *family*, or from the patient's nurse who receives us in home and sometimes we have a language barrier with them who serve the older patient at home. In this situation, it will be difficult to take the *past medical history* which is important to decide the *patient's trauma management*”.

6. Cultural barriers	*Difficulties treating female patients.* A10, A9, A5, A8, A15, A17, A14, A1, A20, A21, A22	A9: "Regarding the *female* patients, dealing with them is a sensitive issue. They refuse our *examination* as I should provide *a clear patient report* to the *doctor*. The *female* patients and their *relatives* also refuse doing my *examination*…". "there are difficulties in uncovering the *female patients*' faces, examine *chest or abdomens*. I see this is a social and cultural issue that we cannot change it. But we can reduce this issue by using a *polite* way of *approaching* to the patients or way of convincing them *professionally*. If you did not apply these, we will not blame relatives if they *refused* the care". A8: "female patients have higher fears to examine them. They do not want to touch er or uncover their clothes to examine them due to the *culture*". A10: "Regarding the *culture* or local traditions, *female patients* accept *females' care* more than *males' care*. This can be solved by employing f*emale paramedics to deal with female geriatric patients*". A5: "there are clear barriers when caring for *female patients*. These always happen with me. Some of them accept after many times of trying to convince them and some refuse… Usually, they refuse *treatment and interventions*" and "this is one of issues that I mostly face regarding the gender. Some relatives are strict, even if I tried to convince them. If I want to take ECG, he says no, take her to the hospital for a female nurse to take ECG from my female patient". A15: "Some female older patients do not accept anything from us. They want *females* to provide services for them. They refuse *the physical examination and taking an ECG*. For example, they refuse examining fractures and leg injuries…". "The solution for this issue is employing female paramedics". A14: "We feel that there is a *distance* between us and female patients. We face difficulties due to the *culture* in *applying ECGs, checking vital signs and clinical examination.* Sometimes, it is impossible to apply a *12-lead ECG and physical examination*". A1: "I responded to a *female* older patient who has 70 years old with *a chest pain, hypertension, and diabetes*. We decided to apply *ECG* for her, but her relatives refused. She also refused and she was aware of that. She said: no, I do not want. Because the issue of different genders. Also, relatives refuse the physical examination especially, when we want to check for any injuries, *infections*, or anything else". A20: "In our society, relatives try to cover female older patients' faces during examining her. For example, I have done *CPR* for an *arrested older female patient* has 80 years old. Her relatives were covering her head during the resuscitation because she was outside the home". "This delays the care. You can see the male older patients' faces but in females, we may have delays in see their faces". A21: "*females* are more difficult due to a culture matter… For example, examinations and assessment are difficult with them. They refuse the assessment on chest and abdomen that are difficult with them". Again, A22: "due to *the culture*, if the patient is *female*, I will be unable to apply *12-lead ECG*. But *the contact with the patient* can play important role… I don't always encounter this issue because it will depend on the paramedic himself". A17: "Originally, it is not the relatives' responsibility, but it is the responsibility of the Red Crescent Authority or the organisation that provide the care. The Red Crescent Authority should start working on the media, distribute educational courses and leaflets everywhere for public".

Matrix 4: The fourth study objective: Facilitators to providing improved care for the older trauma patients:

Domains for each objective	***Themes (with interviewees' IDs)***	***After examining data for quotes and responses that identify the importance of themes and subthemes.***

7. Organisational facilitators	*Developing geriatric-specific care protocols.* A10, A22	A10: "it is possible to add a part in the current *protocol* specific for *medical and trauma older patients* in order to improve the service". A22: "I think that adding international *protocols* specific for treating the older people will facilitate the care. This is very excellent and important thing for trauma and *medical* patients".
	Availability of adequate equipment and manpower. A12, A19	A12: "Presence of *the right equipment* to provide *a high quality of patient care*. For example, I need *vacuum mattresses* to facilitate lifting and moving the patient especially if the patients in first or second levels. At the beginning, I need *manpower* to move the patient safely towards the ground floor and then use the *vacuum mattress* to move the patient to the *ambulance*". A19: "as I have said, *the self-preparation*. *You have to be prepared to deal with any patient* by equipment that facilitate providing the care such as ready bags, stretcher, *equipment*. Also, *the team* should be ready".
	Raising older patients and relatives' awareness of consequences of care refusals and roles of paramedics. A5, A1, A12	A5: "The awareness is a thing that can facilitate providing care for older people. Educating older people and their relatives is important. Because some relatives refuse the patient care. Sometimes, older patients themselves refuse *the treatments and interventions*". A1: "raising awareness among patients' relatives. This should be a task of *paramedics'* tasks. Because *paramedic* should not only provide care for older patients, but also raising *awareness* of *relatives* about that how should they care for their patients, how they deal with their patients, if hypoglycemic, what will they do? How they will give *medications* for under the patient's tongue if he has *a cardiac history or weakness* and *relatives* should not put their patients in *supine position*. This is the most important point to raise the awareness for patients' relatives or nurses". A17: "Patients' relatives must have sufficient knowledge about us in the Red Crescent Authority. They must know that we are qualified as I do not need to say to them that I am qualified. Originally, it is not the relatives' responsibility, but it is the responsibility of the Red Crescent Authority or the organisation that provide the care. The Red Crescent Authority should start working on the media, distribute educational courses and leaflets everywhere for public".
8. Individual facilitators	*Improved communication skills.* A6, A10, A9, A15, A24	A6: "older cases seek *emotional and social* care more than *healthcare*. This is the most important challenge we deal with". "I always try to build links with them before starting the *assessment,* which will facilitate giving us *important information*, become cooperative with us, and make it easier *to deal* with them". A10: "I feel kind and emotional with them more than just healthcare, giving them respect and care more than others". "So, their acceptance to the care will be higher". A9: "my intervention to her was *emotional* more than a healthcare because she was refusing our examination as she wanted to be assured about her sons who were involved in the *accident*. She asked us to examine her sons instead of her. So, after we tried to convince her, we have taken her sons with us in the ambulance, despite this action is not acceptable!! We try to the patient satisfied and at least we provide humanitarian and healthcare service". A15: "You should try and talk with older patients using the same of their language *accent*. You should explain to them. I see these actions will facilitate all next actions of care". A24: "Older cases need better care and respect. I deal with them emotionally".
	Working in partnership with cooperative older	A15: "the most important point in the care is *relatives*. Because they facilitate explaining the *procedure* to the patient and take the medical history as well. These will then facilitate the care".

	patients and relatives to facilitate providing improved care. A1, A9, A13, A15, A20, A22	A1: "Aware and cooperative relatives when we respond to their patients, and they trust our care. They should be aware of their patients' situation. Also, they approve what procedures that I want to do for their patients. for example, if I discovered the patient's *hypoglycemia*, they would let me provide *D50* for their patient because they are aware and cooperative". A9: "if *relatives* and their older patients were cooperative, this will give me a high confidence and facilitate providing my care especially if they gave me accurate correct information". A13: "some older patients have clear information of their *complaint* and *mechanism of injury*. Because if I have clear information about the *mechanism of injury*, I will directly identify injured parts and shorten the time and intervene directly". A20: "When I respond to case, enter the home, find his *printed report shows his conditions and medications* completely and read it *directly*. Honestly, I find this in each home and given by hospitals that older people visit. I found a lot of them have similar *reports*. This facilitates providing their care… I see the point of report is the most important because it will show you that when the patient has visited the hospital and why he has been discharged". A22: "if the patients are *oriented*, not *confused*, I will ask them to get more information by taking *the SAMPLE history*. Because asking questions will lead to identify their exact issues".
	Relatives' awareness of patients' conditions. A6, A21	A6: "if relatives know the patient's medical conditions and *medications*. For example, if the patient has an injury, they could see the patient's *mechanism of injury*… because this is the most important point… As *relatives* facilitate our care for their patients". A21: "when we respond to patients who have educated relatives. For example, they can provide a paper which has the patient's *medical history and medications* that patient uses with their doses too. This facilitates our care because they are aware that we will provide emergency care and they don't interfere in our care. Also, they are aware of all information about their patient such as diseases and medications used… educated relatives is one of the most important things".
	Sufficient training and knowledge. A8, A10, A11	A8: "*Well-training* with sufficient experience will facilitate providing improved *geriatric care* because anyone who has no experience, he will deal with older patients like any patient. This is a mistake because older patients are different". A10: "by the continuing education to raise the *awareness* among *healthcare professionals* and others". A11: "we should *update or refresh our knowledge"*.

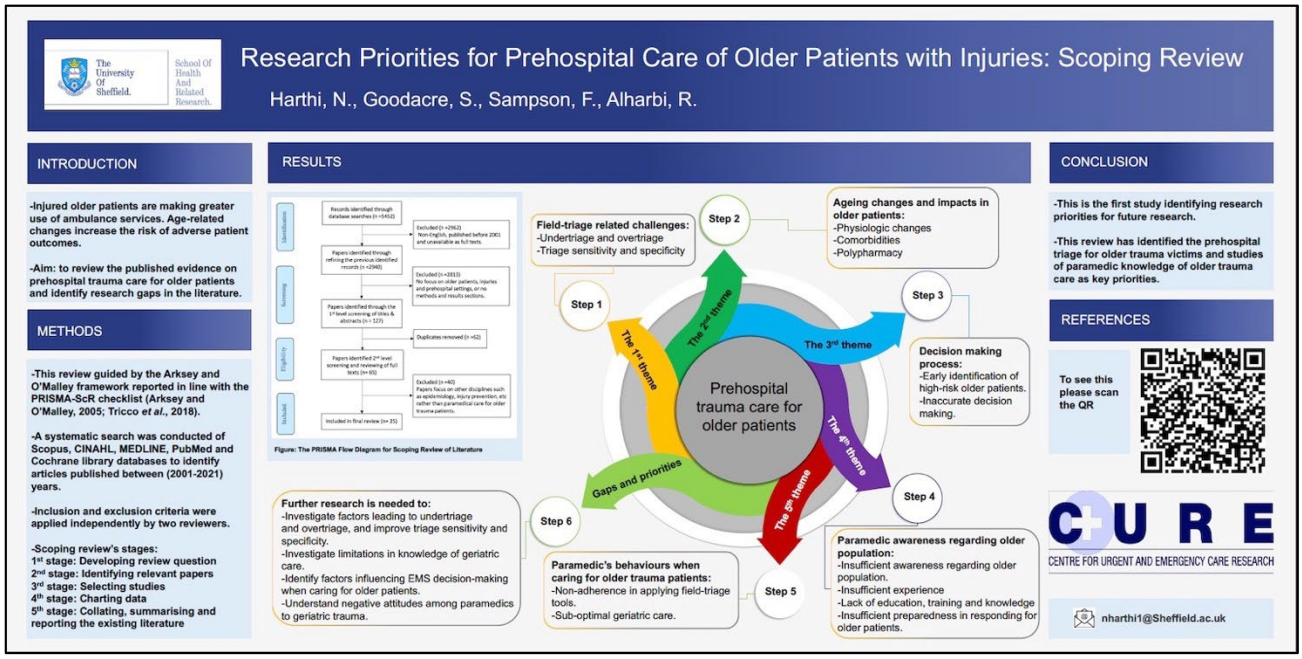
Matrix 5: The fifth study objective: Exploration of whether Saudi paramedics and EMTs' perceptions of older trauma victims align with the characteristics of the retrospective study' cohort and whether they recognise the difficulty of predicting death in older trauma victims:

Domains for each objective	***Themes (with interviewees' IDs)***	***After examining data for quotes and responses that identify the importance of themes and subthemes.***
9. The consistency of Saudi paramedics and EMTs'	*Prevalent low falls due to medical conditions, normal physiology, head, pelvic, and*	A6: "The majority of older patients I encounter are *fall-down patients* and have *normal vital signs,* although the patient can have *distress* without giving us *an indicator* of a specific *complaint*… We faced older cases, usually, they were *bedridden* with medical issues". A11: "Any older case with *altered mental status* I respond to, directly I will think he has *diabetes*. Because older patients can be exposed to *traumas* due to *diabetes* (*hypoglycemia*), this happens a lot in my *shifts*. Only this point can represent the majority of geriatric *trauma* patients. The majority of older cases have similar *medical histories*".

perceptions of older trauma cases with the retrospective cohort's injury characteristics.	*extremities injuries (consistent).* A11, A6, A5, A8, A15, A1, A12, A18, A17, A19, A21	A5: "I heard from my colleagues that most of older cases are fallers in home that usually have resulted in fractures due to the osteoporosis… Definitely, these happened by medical conditions such as *neural deficits or stroke*". "Usually, those cases are hypertensive. Their *oxygen saturation* can be low due to reduced lung capacity. I deal with them based on their traumas that happened with them. For example, in increased heart rate or hypertension with use of polypharmacy, I don't depend on these vital signs, but I depend on my *physical examination*. This is my opinion, also, I depend on the mechanism of injury". A8: "Honestly, *fall down* cases are most common. We always see with them *hip dislocations, neck of femur, mid-thigh fractures, head injuries and contusions*". "Usually, they have *abnormal vital signs such as hypertensions and tachycardias*". After asking A15 about his recent fall down case. He reported that "this case is similar to a lot of cases I responded to. I became familiar with these cases. Once I receive any calls for older patients with fall downs, I will directly expect presence of hip fractures because I have gained experience due to a lot of cases I encountered before. For vital signs, it differs from a patient to another but most of them have *stable* vitals". A1: "Yes. *Neck of femur fractures are most common. Also, fall down in older cases are most common* especially they mostly fall down in late nights or early morning when they wake up and go to baths. As they lift their legs to baths and then *traumas* occur. Regarding the *vital signs*, most of them have *normal* signs if they do not have *history*... Usually, older cases with *history* are *hypertensive*". A12: "the most cases we responded to are *fall-downs* due to loss of consciousness. For impacted body parts, *head contusions, neck pains, and shoulder dislocations* are common. Also, *pelvic fractures* happen in *females* who have 70 years old and over due to the *osteoporosis*". "Usually, older patients are *most likely to be vitally stable except the critical cases in RTAs*". A18: "From my experience, most of older cases were low falls in homes, not high falls. These low falls can lead to risky injuries. Most of these injuries were minor and some of them were critical. Some minor injuries lead to death… In general, most of older cases had *shoulder dislocation or leg's shaft fractures*". A17: "For the *mechanisms of injury* in older cases, injuries always happen at morning or late night. As these times correspond to time of entering baths. *Neck of femur fractures* is a commonest injury happens with them. Always, when we receive a call for an older case due to falls, we will directly think about *the neck of femur fracture* because it is *common*. Also, *humerus fractures*. As in some older cases, when they fall down, the most body part impacted first is the hand. These injuries that I always encounter". A19: "usually they have *hip and thigh fractures* caused by *sliding* that happen during washing or they are on bed. Regarding the *vital signs*, usually they are *vitally stable* even their *heart rate* is slightly tachycardic". A21: "fractures in thigh are very popular in older cases that I responded to and caused by falls. The first bone that I would think about directly is the femur if I responded to falls especially in cases with osteoporosis. Regarding the vital signs, usually they are *unstable*".
	Most geriatric patients are car accidents victims, abnormal physiology, and pelvic and lower extremities' injuries (inconsistent). A9	After asking A9 how typical older trauma patients differ from others? His response: "Honestly, I do not respond to a lot of older trauma cases. But I responded to a case two weeks ago in a car accident. The patient was having a hallucination and speaking understandable words. He was hypertensive and refusing our care and transports". After he reported that car accidents are the most mechanism of injuries he responds to with older cases. Also, he reported that "honestly, usually I respond to cases with *back and lower extremities injuries* and usually they have *abnormal vital signs* such as *hypertensions or diabetes* in car accidents' cases".

10. Difficult predictions of adverse outcomes in older trauma patients	*Difficult identification of severe injuries in older people due to their decreased pain sensitivity.* A11, A6	A11: "older patients can have a serious injury with no severe pain, while younger patients can have severe pains". A6: "sometimes, we do not know older cases' *complaints*. They do not have a degree of *pain* like *younger adult patients.* Older cases have lower pains". and "Sometimes they have an *unclear degree of pain".*
	Unpredictable abnormal physiology in older trauma patients due to polypharmacy. A6, A11, A10, A5, A8, A18, A24	A6: "sometimes, we cannot recognise *any signs of shock in fall-down cases,* although they can *have internal bleeding*. That is *one of the issues* we encounter" and "because you cannot then *diagnose or predict* the issue". A11: "*the medical histories and medications* are very important. Particularly, if older patients use medications for hypertension, BP cannot be a good indicator. Sometimes, *heart rate* also cannot be a good indicator due to *beta blockers*. So, we should deal with older patients differently from younger patients who have better health conditions". A10: "Older persons with shock can have unclear signs of shock because the use beta-agonist, calcium channel blockers, hypertensive in general. So, the tachycardia can be unclear with them". A5: "For *geriatric patients*, most of them use specific *medications* such as *beta blockers* and these cardiac medications mask the *heart rate*. This will make a difference in *internal bleedings or signs of shock*. So, these signs will be unclear. In this situation, I will not depend on *the vital signs* completely during the *shock*. I will depend on *the general impression* of the patient and *amount of bleeding loss*. I will depend in my *examination* completely more than depending on the *vital signs* especially the *tachycardia*". A8: "Sometimes older patients use *medications* that make *the shock* difficulty to be identified clearly. Some patients use *aspirin* that can make the *bleeding* higher. Some of them use *beta blockers or calcium channel blockers* and this can lead to unclear *vital signs* such as inaccurate *blood pressures or heart rates*". A18: "we have responded to an older case in *a car accident*. The main cause for the accident was the *hypoglycemia*. We have taken *vital signs, first and secondary surveys,* and loaded him in the ambulance as *a critical patient*. His blood pressure was low and *heart rate was normal*, *65* b/m. Here was the difficulty and I then became *confused*. After *13 minutes*, when reached to the hospital, we discovered that the patient uses *beta-blockers* that was a reason for *a compensated response with normal pulse rate*. Because it is supposed to be *tachycardia* due the *hypovolemic shock*, not normal heart rate. This is the difficulty in dealing with older patients and in *taking their past medical histories*". "I have taken a long time to understand what happened with him. Because it is unreasonable that the patient was having *a hypovolemic shock and his heart rate was normal*. So, I have taken long time to diagnose *his hypovolemic shock*". A24: "if the older case use cardiac medications and he has *a shock*. We cannot determine his *shock* and his blood pressure is normal due to use of cardiac medications and in the fact that the patient needs fluids, and the patient then can deteriorate rapidly or in minutes. This is one of the most important issues".

Appendix 18: The Poster for the Scoping Review:



Appendix 19: The Poster for the Qualitative Study: