Describing the Demographic and Clinical Characteristics of Patients who Present to the Scottish Ambulance Service with Non-Traumatic Back Pain

A retrospective observational study

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Abstract

Background

Non-traumatic back pain (NTBP) is regarded as a prevalent, low-acuity condition in ambulance services within the United Kingdom. Recent evidence suggests that NTBP (dorsalgia) may be safely treated outside of the hospital, thereby avoiding the Emergency Department. There is limited published evidence on this population's demographic and clinical characteristics, which is required for developing future clinical practice. This study sought to: i) establish the characteristics of patients presenting to SAS with back pain, the demographics for NTBP; ii) determine the positive predictive value (PPV) for ambulance clinicians' diagnosis of true NTBP (dorsalgia); and iii) identify common pain relief measures used to treat these patients.

Methodology

This research comprised a retrospective observational study that used quantitative data situated within a positivist paradigm. The data were based on emergency calls made to the Scottish Ambulance Service (SAS) diagnosed as 05 NTBP by ambulance clinicians in 2018–2019. Quantitative methods were used to collect and analyse the data to address four research questions.

Aims: i) to establish the patient demographic for NTBP 999 calls, including socioeconomic status (SIMD) with associated NEWS; ii) to analyse the positive predictive value (PPV) for ambulance clinicians' diagnoses of true NTBP and whether this differed by dispatch priority; iii) to determine the sensitivity and specificity, positive predictive value (PPV) and negative predictive value (NPV) of aMPDS on objective acuity measured by NEWS for ambulance clinician coded 05 NTBP; and iv) To explore what pre-hospital clinical interventions were used by ambulance clinicians to treat these patients.

Methods: A retrospective observational study was conducted to describe demographic and clinical characteristics over a 12-month period. Data extracted were age, gender, deprivation category, immediate outcome (home or hospital), recorded baseline

observations, National Early Warning Scores (NEWS), pain scores, all recorded pharmacological treatments and final emergency department diagnosis.

Findings: There were 8824 patients included in this study. More women (55.8%, 4927) made calls for NTBP than men (44.2%, 3897). Men made more calls for NTBP than women in only one age category 50-59 years. The median age of all patients was 60 years (range 43–77). Ten percent (882) of patients made more than one call for NTBP within the same 12-month period. Ten percent of people investigated from the SAS data made more than one 999 call for NTBP over one year. Fifty percent of patients (4303) lived in the most deprived areas of Scotland (SIMD 1 and 2). NTBP was determined to be more common amongst people living in SIMD 1. Clinically, 8542 patients had a complete first NEWS recorded: 49% (4215) with a score of 0, 35% (2940) NEWS of 1–6, and 16% (1403) with a NEWS ≥ 7. This indicated that NTBP could not always be considered a low acuity condition. The SAS data demonstrated that there were no significant differences in SIMD status and NEWS scores. This suggested that people living in higher areas of deprivation were just as likely to be unwell with NTBP as found in people living in more affluent areas. The final ED diagnosis confirmed that patients were more often recorded being symptomatic of NTBP rather than having true back pain (dorsalgia). This indicated that the 628 presentations of NTBP were small scale and were not common presentations in prehospital care. The aMPDS was demonstrated as not being effective at identifying NTBP, which is thought to be a low risk condition. The aMPDS high specificity of 97.6% suggested that patients who were triaged to be low clinical risk were true of low clinical risk (NEWS <7). The PPV for ambulance clinicians' diagnosis of dorsalgia was 20.4%. Commonly recorded pain relief methods included Entonox 54% (2409), morphine 24% (1055), paracetamol 13% (568), and ibuprofen 6% (286). Over the counter medications used in combination (ibuprofen and paracetamol) may have been effective for some people with NTBP. Being in pain was not found to be a predictor for ambulance transport to ED. The findings suggested that there were other factors that determined conveyance requiring analysis of individual cases.

Conclusion: Calls for NTBP span all age groups in the adult population, proportionately more women required SAS support. Medium to high clinical risk was reported in one-third of patients, suggesting not all NTBP were low acuity. In this study, ambulance

clinicians' ability to diagnose true NTBP (dorsalgia) was determined. This identified some priority areas for further research.

Dedication

Mum

Margaret Christine Aitchison 30th June 1948 – 11th of December 2016

This is for you.

Acknowledgements

This project would not have been possible without the guidance, wisdom, and emotional and practical support received from so many people. A clinical doctorate is not the measure of oneself. It is a quest that is only achievable with the help, love, and support of others. Understanding that it is the journey not the merit or the award, is what only truly counts.

I would like to sincerely thank everyone who has helped me. Without you all this project would not have been possible.

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Thank you.

Chris

Declaration

I hereby declare that this thesis embodies the results of my own research and that I am the author of this thesis, except where otherwise stated. To the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made.

Signature: _____

Date: _____

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Personal Statement

> Courage isn't having the strength to go on … it's going on when you don't have the strength. *(Napoleon Bonaparte n.d.)*

I graduated from the University of Newcastle Upon Tyne with an Honour's degree in history on the 16th of July 1994. With a recession and few graduate jobs available, I returned home to Peebles, where I worked in a gym, volunteered for community work, and completed my first aid training with the British Red Cross. I decided I wanted a career where I could help people and contribute to society and, being honest, had my heart set on joining the fire service. A friend of our family who worked for the CSA told me all about a career I never imagined, the Scottish Ambulance Service (SAS).

On the 15th of June 1997, I went to Barony Castle, the Scottish Ambulance College in Eddleston, to start my basic training and career with SAS. Three weeks later, and as a probation ambulance care assistant (ACA), I reported to Edinburgh North Station, Brunswick Street, Edinburgh. The ambulance depot was in the middle of a tenement block of flats, accessed by a tunnel in the middle of the building. I never looked back. Keen to move on and with only one goal to one day become a paramedic, I kept my head down and was always seeking opportunities to progress. I took up my first accident and emergency posting at Biggar, where I worked as an ambulance technician, commencing my training at Barony in November 1998 until fully qualifying in 2000. During this time, I met my future wife, Alison, a radiographer at the old Law Hospital. Next, I went to Glasgow East, where I successfully progressed to paramedic, then to Hamilton, to Helimed 5, where I realised a dream role, being a helicopter paramedic. In 2005 I returned to Higher Education to complete a BSc Emergency Practitioner Degree, studied at St Martin's College (later the University of Cumbria) and awarded by Lancaster University, where I graduated in 2008. I studied this degree as I wanted to move into the newly developed community paramedic programme working with the GP out-of-hours services across Lanarkshire. Although I enjoyed working in the community, an exciting opportunity arose in Special Operations. This provided me with the chance to explore rescue, multi-agency major incident training, working with the police, fire and military; a whole world of astonishing opportunities that did not disappoint. During this time, I became a Chemical Biological Radiological Nuclear (CBRN) trainer, and a team leader, and in the process found I enjoyed teaching. In 2011

I saw an advert on the service vacancies website for an associate lecturer for pathophysiology at the Scottish Ambulance Academy, Glasgow Caledonian University (GCU). To my astonishment I got the job and, after a challenging beginning, had the privilege of working with a wonderful team of people. During this time, and following graduation with my university teaching qualifications, I was presented with an exciting opportunity to enrol in a clinical doctorate programme, now accepting paramedics, at the University of Stirling. I often marvel that I almost went to Stirling University to read history in 1991 and reflect that it is funny how life can take you to the same place but in a different direction.

This project has been an incredible journey. The greatest gift is how it changes one's perception and how it has changed how I now see and think about things in general. I hope that, whatever the outcomes are, I can share these perspectives and in a small way contribute to the growing body of evidence and knowledge for ambulance care.

Chris Aitchison

Chapter 1: Introduction and overview of the study

1.1 Overview of the chapter

General George S. Patton famously stated, "*Never tell people how to do things. Tell them what to do and they will surprise you with their ingenuity*" (Patton, 1947, p. 357). Although the origins of this citation are anecdotal, the observation has some merit. It is only possible to deal with a problem if a problem is understood. Once the scale of the problem is defined, a basis of knowledge can be established, enabling people to find ingenious solutions to address the challenge. Non-traumatic back pain (NTBP) is frequently cited as being a major global health problem without a single obvious cause or solution for healthcare providers (GBD 2021; Buchbinder et al. 2018). From an ambulance perspective NTBP is perceived to be an example of a minor health condition that results in unnecessary transfers to hospital. Anecdotal discussions with colleagues in the SAS often highlighted that back pain was a challenging condition for ACs to manage. Although this consensus appeared consistent amongst many colleagues there was no hard evidence to support these sentiments. This made NTBP an interesting topic for investigation and why it was selected for my thesis. It is hoped that by discovering this population the study will contribute to understanding an example of minor health problems that impact on modern paramedicine.

Although unlikely to be life-threatening, NTBP has been suggested to be a common reason for people to call an emergency ambulance (Capsey et al. 2022). Whether NTBP is a common condition that significantly contributes to the increasing workloads of the Scottish Ambulance Service (SAS) is unknown. Without an understanding of who the people are, their main demographic and clinical characteristics, how they are call triaged by the SAS and how they are managed and treated by ambulance clinicians, it is difficult to inform practice guidelines and educational curricula. This need to understand the people who are most likely to call an emergency ambulance and to determine whether they differed from those who presented to the documented primary health care sources, or whether they were a unique population, generated this study. The purpose of this study was to describe the demographic and clinical characteristics of these people, whilst aiming to contribute to developing a further understanding of this global health problem from an ambulance service perspective. Understanding how NTBP was triaged, treated, and transported to Emergency Departments (EDs) by SAS may help to inform

care pathways and identify the associated risks for the pre-hospital management of this condition. As shall be discussed, NTBP was found to be a complex condition with multi-factorial causes. The results of this research reflect a pre-Covid population, one that requires a description of the context within which this study is situated.

A brief history of pre-hospital care, the Scottish Ambulance Service (SAS), and the evolution of paramedicine, from ambulance driver to pre-hospital specialist, is presented. Throughout the study ACs are responsible for analysing and grading the different levels of severity of NTBP in pre-hospital settings. It is the demographic characteristics of the patients who call the SAS that are presented in this thesis. Throughout the study, ambulance clinicians (ACs) describe the different grades of practice. The subsequent chapters will describe the demographic and clinical characteristics of this sample population for assessing and treating NTBP, by presenting the results of a scoping literature review, describing the chosen research methods, presenting the study's results and a discussion of these, in addition to the subsequent recommendations and conclusions that can be made.

1.2 Background: A brief history of Ambulances and the Scottish Ambulance Service

Archaeology has determined that ancient civilisations may have used ambulances from the earliest recordings of human history. The Roman military (27BCE to the 5th Century) used a wide range of medical and specialist techniques to treat their wounded. On Trajan's column in Rome, a capsarius (Roman military First Aider) is depicted banding a legionary's leg with a bandage with a further two of his colleagues assisting wounded comrades (Malton Museum 2021). The first recorded emergency ambulances are thought to be used during the siege of Malaga in 1487, initiated by the Catholic monarchs of Spain against the Emirate of Granada (Kuehl 2002).

The first organised ambulance service in Scotland was established in 1775 when a pair of sedan chairs were purchased in Edinburgh on behalf of the physicians at the Royal Infirmary for *the transportation of persons requiring medical attention but unable to travel thereto* (Liverpool Medical Institution n.d.). This marked the start of the ambulance service in Scotland. The modern SAS dates to 1948 when the newly formed Scottish National Health Service (NHS) contracted two voluntary organisations, the St Andrews Ambulance Association, and the British Red Cross, to jointly provide a

national ambulance provision for Scotland, then known as the St Andrews and Red Cross Scottish Ambulance Service (St Andrews First Aid 2017). In 1967, following the withdrawal of the British Red Cross, the service was renamed the St Andrews Scottish Ambulance Service (Scottish Ambulance Service 2021a). In 1974, as part of the reorganisation of the Scottish Health Services, the Scottish NHS assumed responsibility for providing ambulances in Scotland. The name was shortened to the current SAS (Scottish Office 1994; Scottish Ambulance Service 2021a). Since 1999, the SAS was constituted as part of NHS Scotland and is governed by a special health board, funded directly by the Health and Social Care Directorates of the Scottish Government (Scottish Ambulance Service 2021a).

1.3 The origins of modern ambulance clinicians

In 1946 in England and Wales, and in 1947 in Scotland, the NHS directed that:

> It shall be the duty of every local authority to make provision for securing that ambulance and other means of transport are available, where necessary, for the conveyance of persons suffering from illnesses or mental defectiveness or expectant nursing mothers from places in their area in or outside their area. (Health Services Act 1946, p. 24)

In its first inception, the role of ambulance services was to transport people to hospitals with no provision for immediate care. In 1964, the Millar Report may be viewed as the first significant influence for fostering the development of the professional role of modern ACs (The Ministry of Health, Scottish Home and Health Department 1966). The essence of the report recommended that ambulance drivers should treat as well as transport patients in their care. Since then, the professionalisation of the ambulance service has evolved into including graduate and undergraduate teaching at universities across the United Kingdom and in Scotland, with formal professional standards and education requirements in place since 2020.

1.4 The Joint Royal Colleges Ambulance Liaison Committee (JRCALC) guiding care

In April of 1989, the Association of Ambulance Chief Executives Joint Royal College Ambulance Liaison Committee (JRCALC) held its first meeting at the Royal College of Physicians in London (JRCALC 2021). Their responsibility was to provide robust clinical advice to ambulance services in the United Kingdom. This would ensure the standardisation of ambulance care across the UK. JRCALC now routinely publish updated clinical guidelines for ambulance clinicians. The guidelines are endorsed by the College of Paramedics and conform with the Health and Care Professions Council (HCPC) standards for paramedicine (HCPC 2014).

In 2018, when this study began, there were no specific guidelines for NTBP in ambulance practice (Brown et al. 2016a). Most of the guidelines focused on the management of immediate life-threatening or acute presentations, such as cardiac arrest, stroke, heart attacks and other life-threatening emergencies. The most recent addition of JRCALC now provides specific guidelines for low back pain (non-traumatic) (Brown et al. 2021). This suggests that NTBP may be becoming recognised as a more common condition, warranting its own guidance (Brown et al. 2021). With few UK research studies exploring this possibility, professional knowledge relating to the extent of this population and its defining characteristics appeared anecdotal, thereby providing the justification for this study.

JRCALC aims to provide standardisation in pre-prehospital care, also known as out-of-hospital care, and emergency medical services (EMS) as a subspeciality of prehospital emergency medicine (PHEM). NHS UK ambulance providers focus on caring for critically ill or injured patients before they reach the hospital and during emergency transfers to or between hospitals. These advances have developed ACs' professional practices to include responding to emergencies and transporting patients via ambulances, which include cars and aircraft. The development of including specific guidelines for a non-life-threatening condition demonstrates the continuing evolution of ambulance care.

1.5 Professionalisation of Paramedicine

The HCPC establishes professional education, training, and practice standards for paramedics (Scottish Ambulance Service 2021b; Health and Care Professions Council 2014). Paramedics are regulated by the HCPC and are required to satisfy proficiency pertinent to their scope of practice or the areas of their profession where they must be competent to practice safely and effectively. These standards were published for the first time on September 1st, 2014, and are now the tentpole of paramedic practice in the UK (Scottish Ambulance Service 2021b; Health and Care Professions Council 2014).

In the SAS, emergency medical technicians (EMTs) are ambulance clinicians who work alongside paramedics. Paramedics (senior ambulance clinicians) are a protected title, that is strictly regulated by the HCPC (Health and Care Professions Council 2014). In Scotland, ambulances are crewed by either paramedics, EMTs or emergency care assistants (Driver 2 (D2) trained to drive a blue light ambulance) (Scottish Ambulance Service 2021a). The EMTs of SAS are not state registered but are regulated by the Care and Quality Commission, which dictates the expected standard of care reflected in JRCALC. EMTs use JRCALC guidelines when referring to amendments that reflect their scope of practice. For the purposes of this study, all grades of ambulance staff were described as ambulance clinicians as the exact formulation of the crews who attended NTBP was not possible to identify, as these details were not recorded in the data. The administration of drugs permitted by paramedics only, for example, morphine, confirmed that most grades of staff had attended the population described in this research.

1.6 Evolution, Expectations and Demands on the SAS

The SAS provides free emergency medical care to anyone requiring treatment in the United Kingdom, regardless of immigration or visitor status. The service may be said to be at the centre of the urgent and emergency care system, with its goal being to ensure that each patient receives the finest, most appropriate response (Scottish Ambulance Service 2021a).

In 2017, the wider NHS implemented new ambulance standards to support this objective. These standards include meeting all targets, being efficient and effective, having a satisfied, cheerful, and productive workforce, being integrated into a larger and

urgent emergency care system, and being digitally fit for the future (NHS England 2017).

The SAS continues to alter its methods of operations to the expectations of modern Scottish society. This means that patients are treated by competent ambulance clinicians in the comfort of their own homes, are given advice over the phone, or are transported to a more suitable setting outside of a hospital (Scottish Ambulance Service 2021a). NHS Scotland continues to support the SAS to make improvements, including delivering a safe reduction in ambulance conveyance, and ensuring that no one arriving by ambulance should wait more than 30 minutes from arrival at hospital to a handover to a clinician. The treatment of NTBP is an example of a condition that, superficially, may be deemed safe to leave in the community. From a pre-hospital perspective, this has not previously been explored.

1.7 Evolving Ambulance care

Ambulance care predominantly focuses on managing and treating acute life-threatening presentations that are broad and diverse. These can range from managing cardiac arrest and treating heart attacks (myocardial infarctions) to treating traumatic injuries, such as road traffic accidents, serious assaults, or burns. The recognition and treatment of these conditions has evolved since 1971 in the UK to become the foundation of modern paramedicine (College of Paramedics 2023). If more primary health care conditions such as NTBP are becoming more prevalent in ambulance care, their management in that context requires careful consideration (Booker et al. 2015). Understanding why age and gender matter for effective care is necessary, as these variables are related to illness/injuries and their outcomes. From this perspective, presentations of NTBP affected men and women differently, as women have different anatomy and physiology, which can have an impact on the experience and response to managing health conditions (Ansdell et al. 2020; Rathbone et al. 2020). Until recently, in cardiology, women were found to be less likely to survive than men after acute presentations of some conditions, such as myocardial infarction (MI) (Greenwood et al. 2018). These different presentations of MI and other acute coronary symptoms (ACS) found that women were more often symptomatically atypical in their presentation of MI than men. Traditionally, clinical practices and guidelines for MI were initially devised on classic

male presentations of this condition, demonstrating why defining and understanding factors linked to age and gender are worth consideration (Bösner et al. 2011).

As modern ambulance care develops, the contribution that paramedics can make to primary and urgent care is developing (Eaton et al. 2021). If this provides more people in the community with appropriate care pathways, then understanding patient needs is essential, and age and gender are therefore relevant to presentations of NTBP. Describing these data were considered important for women, as their presentations of NTBP differ from those of men.

1.8 Scottish Index of Multiple Deprivation Status and NTBP

The Scottish Index of Multiple Deprivation Status (SIMD) is a government tool that identifies areas where interventions and targeted resources may be needed to address health inequalities and improve health outcomes in Scotland (National Records of Scotland 2023; SIMD 2020). If an area is identified as having a high level of deprivation, this can signify that people living there have a low socioeconomic status (SES), as they are likely to have lower income and fewer resources or opportunities (SIMD 2020). There is some evidence that SES may have a significant impact on the prevalence of conditions such as NTBP (Ikeda et al. 2019; Sommer et al. 2015). Some studies have noted that sociodemographic characteristics, such as income, education and employment status, are associated with health inequalities in general (Bloomberg et al. 1994; Marmot 2005; Adler and Newman 2022), however, developing an understanding of NTBP's socio-economic burden is also important, as it appears to be an area that requires more focused research (Kahere and Ginindza 2020). Katz (2006) argued that, although SES was associated with NTBP, it was not always a reliable measure for treating people with NTBP. Sommer et al. (2015) suggested that, although a low SES appeared to be more probable in increasing the odds of poor health and NTBP, the relationship could not be definitively established. This was suggested to be due to a lack of high-quality evidence, which was generalised as being of low methodological quality (Sommer et al. 2015). These studies demonstrate some of the contributing psychosocial challenges of managing NTBP, each of which are relevant to all healthcare providers.

There is some limited evidence that the relationship between SES and age could be significant. One Japanese study found significant socioeconomic inequalities in older

people affected by low back pain. (Ikeda et al. 2019). The authors noted that older people with a low SES were more likely to report to healthcare providers with NTBP. This suggests how the complex relationship between various factors, including age, gender, and possibly SIMD status, can contribute to this condition (Leboeuf-Yde et al. 2011; Hartvigsen et al. 2018; Marin et al. 2017).

1.9 SAS New Clinical Model of Care for the Future

The SAS new clinical response model (NCRM) is a system that categorises emergency calls in terms of need. Emergency calls are categorised by colour, each of which denotes a level of urgency and ensuring that those in greatest need receive an immediate ambulance (Scottish Ambulance Service 2017a). The system is modifiable and continually updated. Up to 2018, the NCRM had purple, red, amber, yellow, and green colour codes. Since 2018, the system has evolved to include teal calls, and formerly green calls have been categorised as lime (The Scottish Ambulance Service 2023a).

The NCRM for the future provides insight into how SAS intends to alter the delivery of its services to improve patient care in Scotland (Scottish Ambulance Service 2017a). All emergency calls from the public or from healthcare professionals to any of the three SAS ambulance control centres (ACC), located in Inverness, Edinburgh, or Glasgow, are triaged and directed to the most appropriate response for their requirements, as will be discussed in detail, later in the thesis.

Immediate codes, categorised as purple and red, are for life-threatening situations. Ten percent of the genuinely time-critical emergency calls, such as cardiac arrest, are represented by these calls. Urgent and amber codes are non-life-threatening emergencies requiring prompt responses, meaning an ambulance will arrive within nineteen minutes. Hear, Treat and Refer (HT&R) is an telephone triage system. An ambulance clinician working for the ACC triages patients who do not require an ambulance. After consultation, these patients are referred to either NHS 111 or a GP. See and Convey Elsewhere (S&CE) triages patients who require hospitalisation but not via ED. These elements were examined in the SAS data to determine whether the NCRM could detect high acuity patients, presenting to SAS with NTBP and to determine how effective the NCRM was at triaging NTBP.

1.9.1 Key Questions used by aMPDS for the call triage of NTBP

When it comes to call triage, carefully designed Key Questions (KQ) for NTBP serve as a script for Ambulance Controllers. These are numerically coded as 05 NTBP and will now be referred to as thus for the context of call triage by Ambulance Controllers and diagnosis of NTBP made by Ambulance Clinicians (ACs), (IAED 2018). This script enables them to identify the onset of symptoms related to this condition, thereby ensuring the caller receives an appropriate and timely ambulance response. If the cause of the back pain is reported to be a non-medical condition, for example, if the patient is not having difficulty breathing, chest pain or discomfort, and is completely alert, then they are triaged as a lower priority call. Ambulance controllers, therefore, may only select back pain as the chief complaint once these factors have been established. Alternatively, once it is clarified in the patient entry that it is not a recent event, that is to say, ≤6 hours ago, traumatic or spinal injuries may be ruled out. If this is unclear, code 30 *traumatic injury* is selected and entered into the system. If the NTBP is associated with *fainting (or near fainting) in patients ≥50* years, then they are recorded as presenting with the symptoms of a dissecting aortic aneurysm (DAA) until it is proven otherwise. It also demonstrates how some calls may be over-triaged.

The aMPDS algorithm guides ambulance controllers to detect life-threatening presentations that may be associated with back pain. The detection of a DAA was determined to be central to the KQs for ambulance controllers' triage. This condition is characterised by an abnormal ballooning or bulging of the aorta in which the inner layer of the artery splits, usually between one of the three layers of the aortic wall (Sethi et al. 1974; Brown et al. 2021). As the aorta is the main artery in the human body, a dissection that may rupture is considered a time-critical emergency. A ruptured AA (rAA) has a high level of mortality and morbidity (Sweeting et al. 2015). In other words, death or living with severe complications or adverse side effects associated with rAA may be the patient's outcome if it is not detected and diagnosed promptly (Choke et al. 2012; Sweeting et al. 2015; Powell et al. 2014). Back pain may sometimes be a symptom of a DAA, mainly in the thoracic (chest) or abdominal area. Some research suggests that DAA may be challenging to diagnose in the prehospital setting (Brown et al. 2016b).

1.9.2 Ambulance Control Staff Axioms for NTBP

Three propositions advise the ambulance controllers that the severity of a patient's pain is not related to the seriousness of the problem. This caveat informs the controller that various factors might influence the severity of NTBP. These factors are the individual's pain tolerance, psychological factors, and the specific cause of their pain.

The *aMPDS Back Protocol* is designed to detect high-acuity medical or traumatic injuries associated with back pain. If a patient reports that their back pain was not recent, a spinal cord injury would be deemed unlikely. This enables an ambulance controller to triage the call as NTBP.

1.10 Developing Evidence-Based Practice

Developing evidence-based research for the way in which SAS responds and manages NTBP was central to this project. The best available published literature was identified and considered, as it is acknowledged that adopting this process may best guide decision-making and thereby enhance the quality of patient care. The research that informed this study was clinically pertinent and suggested ways that could inform diagnosis, prognosis, treatment, and patient experience (BMJ n.d.). The findings of this study provide a unique contribution to this area of knowledge: ambulance care of NTBP.

The next chapter presents a scoping review of the literature.

Chapter 2: A Scoping Literature Review of the Patient Demographic and Clinical Characteristics of Non-Traumatic Back Pain (NTBP)

2.1 Overview of the chapter

In this chapter, a scoping literature review is presented. This review method was employed to establish a broad overview of the patient demographic and the clinical characteristics associated with NTBP. The review was achieved by utilising an established framework for scoping existing literature in a systematic search of relevant databases, grey literature, and key journals (Critical Appraisal Skills Programme (CASP) UK 2018; Arksey and O'Malley 2005). This scoping review helped to determine all the available evidence and identify knowledge gaps relating to pre-hospital presentations of NTBP. A process of data extraction and theme analysis was used to evaluate the quality of the study's research. The inclusion and exclusion criteria were specified to guarantee that the study selection satisfied the aims and objectives of the scoping review.

2.2 Introduction: What is NTBP and what causes it

For decades, patients with NTBP have presented to emergency, acute and primary care health services (Purcell and Cooper 2016). On average, 2.8 million adults in the UK seek help from GP services each year, costing the NHS approximately £12.3 billion and a loss of 31 million working days (Blackberry Clinic 2023). NTBP has been categorised as either 'benign', 'self-limited' or 'musculoskeletal' (Edlow 2015a). Symptomatically, it is a medical condition that is associated with extreme discomfort and is often accompanied by severe debilitating pain (Buchbinder et al. 2018; Purcell and Cooper 2016). This affects patients who suffer from these symptoms and those who care for them.

Although the supporting literature is limited and the evidence of patient outcomes vague, Robinson et al. (2004) found that most of these patients are discharged from the ED within two hours of admission, receiving minimal interventions such as simple analgesia and advice (RCGP 2015; Stafford et al. 2014). With a complete dearth of evidence acknowledging that NTBP is a problem for ambulance services with unnecessary conveyance to EDs, the view that NTBP could be treated in the community

by ambulance clinicians requires further investigation (Robinson et al. 2004). It is, therefore, possible that a proportion of patients presenting with this condition may receive more appropriate care in an alternative setting, avoiding unnecessary conveyance to the ED. These objectives are strategic priorities for the Scottish Government (Scottish Ambulance Service 2023b).

Within the context of prehospital care, NTBP is a frequently attended condition. In 2015, SAS responded to 600,000 emergency calls, of which 0.75% (*n*=4483) were recorded as NTBP by ACs. This is a similar proportion to that found in the study by Robinson et al. (2004); 1.02% (*n*=1684 (1.02%) during the 2004/2005 period (NHS Digital 2005). If these proportions were representative of other UK ambulance services, as has been demonstrated in UK-wide studies on other conditions (Duncan and Fitzpatrick 2016), then UK wide NTBP could account for between 39,200 to 60,000 emergency calls per annum (SAS 2018 and NHS Digital 2005). On review of this limited research, a scoping review of the broader literature guided my investigation.

The existing literature on acute presentations of NTBP to ambulance services is discussed in this scoping review. This literature review aimed to identify existing research and knowledge gaps relating to this condition. As evidence-based research for prehospital care is gradually being developed at this time, few ambulance studies were available for this review. In this chapter, the typology, process evaluation, and methodology of the review are discussed. This review examined existing research, thereby identifying knowledge gaps for NTBP that have informed the focus of this study.

There is a growing consensus in academia on the definition and benefits of scoping reviews, and they are evolving to inform policy and practice guidelines (Peters et al. 2021; Pollock et al. 2021; Tricco et al. 2016). According to Grant and Booth (2009), scoping reviews are a preliminary assessment of the potential size and scope of the available research literature. The review may be best termed as one that aims to map and summarise the existing literature on a specific research question or topic (Peters et al. 2021; Pollock et al. 2021; Tricco et al. 2016).

Arksey and O'Malley's (2005) seminal work on scoping reviews was used as the methodological framework for this review. These authors determined that there are four

essential steps to this process. These are to *map*, *determine, summarise, and identify literature*. In summary, they enable the researcher to map the breadth of research on a given subject (Arksey and O'Malley 2005). Following this process then helps to ascertain whether a comprehensive systematic review is required. Finally, they permit a researcher to present a summary of existing findings and identify any omissions or gaps in knowledge that require further study (Arksey and O'Malley 2005). A preliminary search revealed that few studies exist that focus on prehospital presentations of NTBP to ambulance services. Therefore, a limitation that arose from this review was a lack of sufficient studies for inclusion.

2.2.1 The Review Aims

In preparing to map the existing literature, three review aims were formulated:

1) To investigate the available literature for any emergency calls for NTBP to ambulance providers.
2) To review the epidemiological, demographic, and clinical presentations of people affected by NTBP who present to acute and primary health care providers.
3) To examine how NTBP is diagnosed and managed by ambulance clinicians, doctors and other healthcare specialists who may routinely encounter patients with NTBP.

2.3 Discovering the Literature

Searching for and synthesising the literature on this topic was challenging. One positive outcome with identifying fewer papers was it offered the opportunity to distinguish those that represented a robust research approach. When this project commenced, there were no NTBP guidelines in JRCALC. These only became available in 2021, and their addition required a review and re-evaluation of some aspects of the clinical discussion presented in this thesis. Although the literature was reviewed in a systematic manner, it was established that a systematic review was beyond the requirements of this clinical doctorate thesis. The rationale for this was the time constraints of working in a full time clinical role versus the resources required to conduct a high quality systematic review (Munn et al. 2018). Thus, a scoping review was selected as the most appropriate method. Both methods address specified objectives by reviewing questions that regard

essential ideas, theories, data, and evidence gaps. The scoping review focused on the nature, volume and characteristics of studies or knowledge gaps rather than on the synthesis of published data this distinguishes from a systematic review (Arksey and O'Malley 2005; Peters et al. 2021; Tricco et al. 2018). Three critical appraisal tools used for systematic reviews were identified as being adaptable for scoping reviews, and these were, A Measurement Tool to Assess Systematic Reviews-2 (AMSTAR-2) (Shea et al. 2017), The Critical Appraisal Skills Programme UK (CASP UK 2018), and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Tetzlaff et al. 2020) and Scoping Reviews (ScR) (PRISMA-ScR) (Tricco et al. 2018).

2.3.1 Types of literature review and Terminology

Scoping reviews are a research method used to systematically map and summarise existing literature on a particular topic (Arksey and O'Malley 2005; Peters et al. 2021; O'Brien et al. 2016; Pham et al. 2014). They enable researchers to identify key concepts, sources of evidence and research gaps within a broad research area (Pham et al. 2014). Arksey and O'Malley (2005) produced their Framework for Scoping Reviews, acknowledging that there was not one absolute method for this purpose. Since 2005, many scoping frameworks have been developed for this purpose (Tricco et al. 2018; Shea et al. 2017; CASP UK 2023).

Three tools were used for the synthesis of this scoping review. The PRISMA-ScR (Tricco 2018) is an extension of the PRISMA guidelines (Tetzlaff 2020), which are recognised and used widely in systematic reviews and meta-analyses (Arksey and O'Malley 2005; Peters et al. 2021; Tricco et al. 2018). It was used to inform the structure of this scoping review. The second tool was the Search, Appraisal, synthesis, and Analysis (SALSA) framework (Grant and Booth 2009). The SALSA tool is designed to guide methodological accuracy, systemisation, exhaustiveness, and reproducibility to provide a methodological guide for conducting the scoping review of research methods for the review (Table 1) (Mengist et al. 2020; Grant and Booth 2009). Finally, the CASP checklist was used to evaluate the literature and identify the gaps in the knowledge (Table 2).

Table 1: Adapted from the SALSA Framework (Grant and Booth 2009)

Type of Review	**Description of review**	**Search Type**	**Appraisal**	**Synthesis**	**Analysis**
Scoping Review	This framework was selected to perform a reconnaissance of the available literature for the review. The scoping review enabled an examination of the extent, range, and nature of the available research on prehospital presentations of NTBP to ambulance services. These preliminary findings suggested that the lack of evidence would make a systematic review challenging, justifying the scoping review. Beneficially, this review enabled a summary of the research findings across a body of research, and the identification of research gaps in the literature, informing the need for future studies.	Thorough but limited in time and scope.	No formal quality evaluation.	Tabular data.	Identifies the quantity and calibre of literature, potentially using the research design and other elements – specification of variable reviews.

Table 2: Critical Appraisal Skills Programme (CASP) 10-point Checklist: Adapted for a Scoping Review (CASP UK 2018)

CASP Checklist (2018)	**Yes, Can't Tell, No**	**Hints**	**Comments**
Section A: Are the results of the review valid? Did the review address a focused question?		An issue can be focused on in terms of the population studied, and intervention given the outcome considered.	
Did the authors look for the right type of papers?		The best sort of study would: address the review question, and have an appropriate study design for papers evaluating interventions.	
Is the review worth continuing? Do you think all the relevant studies were included?		Look for which bibliographic databases were used. Follow up from reference lists. Personal contact with experts. Unpublished as well as published. Exclude studies not published in English.	
Did the review authors do enough to assess the quality of the included studies?		The authors need to consider the rigour of the studies they have identified.	
If the results of the review have been combined, was it reasonable to do so?		Consider whether the results were similar from study to study. The results of all the included studies are clearly displayed. The results of different studies are similar. Reasons for any variations in results are discussed.	
What are the results? What are the overall results of the		Consider whether you are clear about the review's bottom line	

review?		results. What these are (numerically if appropriate), how are the results expressed (NNT, odds, ratios etc.)?	
How precise are the results?		Look at the confidence intervals, if given.	
Will the results help locally? Can the results be applied to the local population?		Consider whether the patients covered by the review could be sufficiently different to your population to cause concern. Your local setting is likely to differ much from the review.	
Were all the important outcomes considered?		Consider whether there is other information you would like to have seen.	
Are the benefits worth the harms and costs?		Consider that, even if this is not addressed by the review, what do you think?	

2.3.2 The Search Process

Identifying key studies that are relevant to inclusion and exclusion criteria (see Table 3) is central to all types of literature review. Structured search procedures used key terms within defined parameters of the selected electronic databases. Grey literature refers to information not published in traditional academic or commercial channels (Adams et al. 2017; Paez 2017). The literature search included reports by the SAS, International Academies of Emergency Dispatch (IAED), conference papers, theses, dissertations, government documents, working papers, and other non-peer-reviewed studies. While these resources may not have been subject to the same rigorous processes as traditional literature, they still provided valuable information for this review and the research (Adams et al. 2017; Paez 2017).

2.3.3 Inclusion and Exclusion Criteria of the literature that is reviewed

All retrieved materials presenting demographic information, socioeconomic status, and severity levels from NTBP-based ambulance calls were included. The material was omitted if it did not include patients with NTBP who were treated by ambulance services, Emergency Department (ED) or urgent primary care services. Also excluded from the retrieved data were ambulance services that did not utilise the Medical Priority Based Dispatch System (MPDS). All clinically relevant information that was retrieved included treatments for and the management of NTBP by ambulance, ED, or other urgent medical services, such as primary care. Non-English language papers were excluded. A summary of the variables included and excluded in the review are shown in Table 3.

Table 3: Inclusion and Exclusion Criteria

Inclusion Criteria	**Exclusion Criteria**
Age and gender adult patients	
Materials published and presented in English	Non-English language sources
Scottish Index of Multiple Deprivation (SIMD) based on postcode area	Private addresses, any personal identifying details.
Non-Traumatic Back Pain or conditions suggested to be symptomatic of NTBP are reported	Traumatic Back Pain
All reported emergency, urgent, routine, or planned calls are diagnosed as 05 NTBP by ACs	
All clinical variables are reported, including baseline observations, National Early Warning Scores (NEWS) and Pain scores	

All recorded prescribed medications for NTBP by ACs, General practitioners or other health professionals are reported	

The Critical Appraisal Skills Programme (CASP UK 2018) was used to evaluate the material and this was adapted from the systematic review checklist (CASP UK 2018) (Table 2). The ten-point checklist recommended the appraisal of three main issues. These issues were whether the results of a study were valid, what the results were and would the results be useful for the clinical doctorate research (CASP UK 2018). After careful consideration, the CASP framework appeared to offer the best methodological approach for the appraisal of the known literature in this scoping review (Caldwell et al. 2011).

The CASP checklist was designed to appraise the development of understanding a scoping review. The ten questions in the CASP checklist shown in Table 2 were used systematically, enabling all of the selected papers to be screened quickly. If the first two questions of the checklist were yes, the review of the paper was continued for evaluation and possible inclusion and screening (CASP UK 2018). The CASP framework afforded an evaluation of the quality of the studies whilst providing a set of standards for judging the methodological rigour of the selected research (CASP UK 2018; Singh 2013).

2.3.4 The Synthesis of the Evidence

Synthesis in a scoping review aims to meaningfully organise and compile the results of primary studies (Flemming and Noyes 2021). The synthesis of multiple findings may explain a specific phenomenon, circumstance, or experience better than a single primary research study can (Flemming and Noyes 2021). It was acknowledged that the synthesis and interpretation of the data could not go beyond the boundaries of what was observed, making the research observational and descriptive. This determined that a positivist approach was central to the research paradigm in which this review was situated (Park et al. 2020; Blumberg and Feigl 1931).

As my study examined and described the demographic and clinical characteristics of the population with NTBP that presented to the SAS, a narrative synthesis was selected as

the best way to perform the analysis. After careful evaluation of the literature finding the best methodological approach was evaluated. This process relied on the evaluation of two methodological approaches. These were defined as being integrative and interpretive (Schick-Makaroff et al. 2016). The integrative method evaluates, critiques, and synthesises representative literature on a subject to produce new viewpoints or frameworks (Schick-Makaroff et al. 2016). This includes empirical and theoretical literature, suggesting why a positivist paradigm for finding practical or real-world solutions from the research was most relevant (Park et al. 2020; Blumberg and Feigl 1931). Interpretative research, in comparison, is a research paradigm based on the assumption that social construction is not singular or objective but is somewhat shaped by human experiences (Bhattacherjee 2012; Giorgi and Giorgi 2003). The interpretive approach entails the synthesis of findings via induction and interpretation at a higher conceptual level (Schwartz-Shea and Yanow 2013; Schwandt 1994). Methodologically, this has a closer relationship to the *constructive or pragmatic paradigms* of inquiry. These paradigms may be more relevant to future research, identified in a scoping review, that may require a qualitative or mixed methods approach.

The analysis of evidence is a key stage of the literature review process. It enables the collection and synthesis of data and findings from all available evidence-based and peer-reviewed studies (Snyder 2019). This helped determine the current state of knowledge for prehospital presentations of NTBP. This was necessary for guiding the analysis and identifying knowledge gaps to inform the research (Kraus et al. 2022; Snyder 2019).

The analysis of the available literature was explicitly linked to this scoping review's original aims determining the most appropriate methodological approach for the synthesis of evidence (CASP UK 2018). A description of the findings were obtained from the available research, grey literature, policies, documents, and guidelines. A consideration of their strengths, limitations, and recommendations was then made (Munn et al. 2018; Krupski et al. 2008). The methodology and presentation of the analysis was designed to be consistent, reflecting the data compiled from the included sources (Munn et al. 2018). The primary component of this process was the critical analysis of the available literature. In other words, the synthesis of the key findings were presented explicitly, discussing each study's strengths and limitations (Munn et al.

2018; Krupski et al. 2008). Each study's quality or weight was evaluated, especially for systematic and meta-analysis review papers, which are often used to inform policy and practice.

The SALSA framework enabled a comprehensive and systematic search strategy, providing guidelines on developing search terms, selecting appropriate databases, and conducting searches (Table 3) (Grant and Booth 2009). A strength of this framework is that it helped to identify the demographic and clinical characteristics of the population with NTBP. This informed the design of the study and provided some insight into the overall body of evidence. This framework was suitable as it is adaptable for scoping reviews, facilitating the development of recommendations that might help inform future research, policy, or practice for the SAS. The SALSA framework emphasises the significance of linking the objectives, research questions, and methodologies in each study identified in the literature (Grant and Booth 2009). Table 2 demonstrates the transparency of how the scoping review was selected and why it was appropriate.

2.3.5 The Scoping Review

The limited evidence base may have presented a challenge in the drawing of robust conclusions or the provision of comprehensive insights. It is acknowledged that this may have reduced the generalisability and reliability of the review results (Vandvik et al. 2013). Having insufficient research on an identified issue presents an opportunity to conduct new studies to fill in the knowledge gap. This may result in the production of new evidence.

The flexibility of the scoping review method afforded the integration of various types of evidence, such as quantitative, qualitative, and mixed methods, within the study (Peters et al. 2021; Pollock et al. 2021; Tricco et al. 2016). This flexibility was useful for highlighting areas where more research was required and potential areas for primary studies or systematic reviews. The heterogeneity of evidence was sometimes challenging, presenting difficulty for synthesising findings for identifying common themes or patterns described in the results. This method therefore functioned to enhance the rigour and validity of the synthesis (Peters et al. 2021; Pollock et al. 2021; Tricco et al. 2016; Ryan 2013).

In summary, scoping reviews are an increasingly prevalent approach to evidence synthesis, with a growing body of methodological guidance and resources available to support review authors (Peters et al. 2021; Pollock et al. 2021). The methodology of scoping reviews is also evolving as a policy and decision-making instrument (Peters et al. 2021). Current frameworks guide the mapping of literature regarding the primary research's quantity, nature, and characteristics. This may help to determine the value, prospective scope, and cost of conducting a comprehensive systematic review for future NTBP studies.

2.3.6 The Process

The original scoping evaluation created by Arksey, and O'Malley (2005) was modified and applied in this study (CASP UK 2018). As described by Arksey and O'Malley (2005, pp. 21–23) this evaluation can be summarised into six stages:

I. Identifying the research question: a precise formulation of the research query that specified the target population and health outcome of the interest, as well as the search strategy.
II. Identify relevant studies: the scope of the review will inform the research question and objective.
III. Study selection for inclusion: the process should involve examining the literature, refining the search strategy, and evaluating articles for inclusion. [Arksey and O'Malley (2005) suggest that two authors should be used to minimise bias, but this was not feasible for this study].
IV. Charting the data: determine which variables must be extracted to answer the research question(s). The researcher employs a consistent methodology, and the data is pertinent to the posed research question(s).
V. Collating, summarising, and reporting the results: there should be three distinct stages involved with this process. Analysis comprising a descriptive numerical summary, reporting of results, and producing the outcome that pertains to the overall purpose of the research question, and an evaluation of the significance of the findings.
VI. Consultation: where appropriate stakeholder consultation has taken place.

2.4 Identifying relevant studies

A comprehensive search strategy was used to determine all relevant subject matter, as described in the five stages presented below:

I. Google Scholar, CINHAL, Science Direct, Medline (using PubMed) using the keywords:

Non-traumatic back pain (All fields) OR low back pain (All fields) OR non-specific back pain OR dorsalgia (All fields) OR Emergency Call (All Fields) OR Emergency Department (All Fields) OR Acute Services (All Fields) OR Primary Services OR Scottish Ambulance Service OR UK Ambulance Services OR NHS Scotland OR NHS England, Wales OR Northern Ireland OR Ambulance Services Treatments OR Epidemiology (All Fields) Gender OR Age OR Scottish Index of Multiple Deprivation OR Social Deprivation OR National Early Warning Score OR Acute Medical Priority Dispatch System OR Priority Dispatch OR 999 OR 911 OR 112 Protocols OR Clawson Codes OR International Academies of Emergency Dispatch OR Management (All Fields) Entonox Or Morphine OR Paracetamol Or Ibuprofen Or Opiates Or Non-Opiates OR Non-pharmacological. Sensitivity OR Specificity OR Positive Predictive Value OR Negative Predictive Value. Identifying relevant studies was also achieved by:

II. Electronic searching of The Cochrane Library and clinicaltrials.gov using an adaption of the search terms eliminating pronouns but considering verbs and initial keywords to think of synonyms.
III. Hand-searching of clinical textbooks and essential journals:
    a. Joint Royal College Ambulance Clinical Guidelines (JRCALC)
    b. British Medical Journal; Emergency Medicine Journal; Journal of Paramedic Practice
    c. BNF Pharmacology 2021.
IV. Grey literature all available non-published material and reports available in the public domain made by the SAS, the NHS, the UK and Scottish Government Health Directorates.
V. Personal communication with Scottish Ambulance Service, Information Service Division (ISD) Scotland.

The titles and abstracts of the scoping review were retrieved from the advanced search options in the electronic databases. To address the review's aims, all of the retrieved studies were related to NTBP. There were several descriptions presented for NTBP, and these included non-specific, low back pain, low back pain (with a non-traumatic cause), and dorsalgia that required evaluation. A flow chart illustrating the process of identifying the studies, the rationale for excluding studies, and the characteristics of those studies that were included in the review, are presented below in Figure 1.

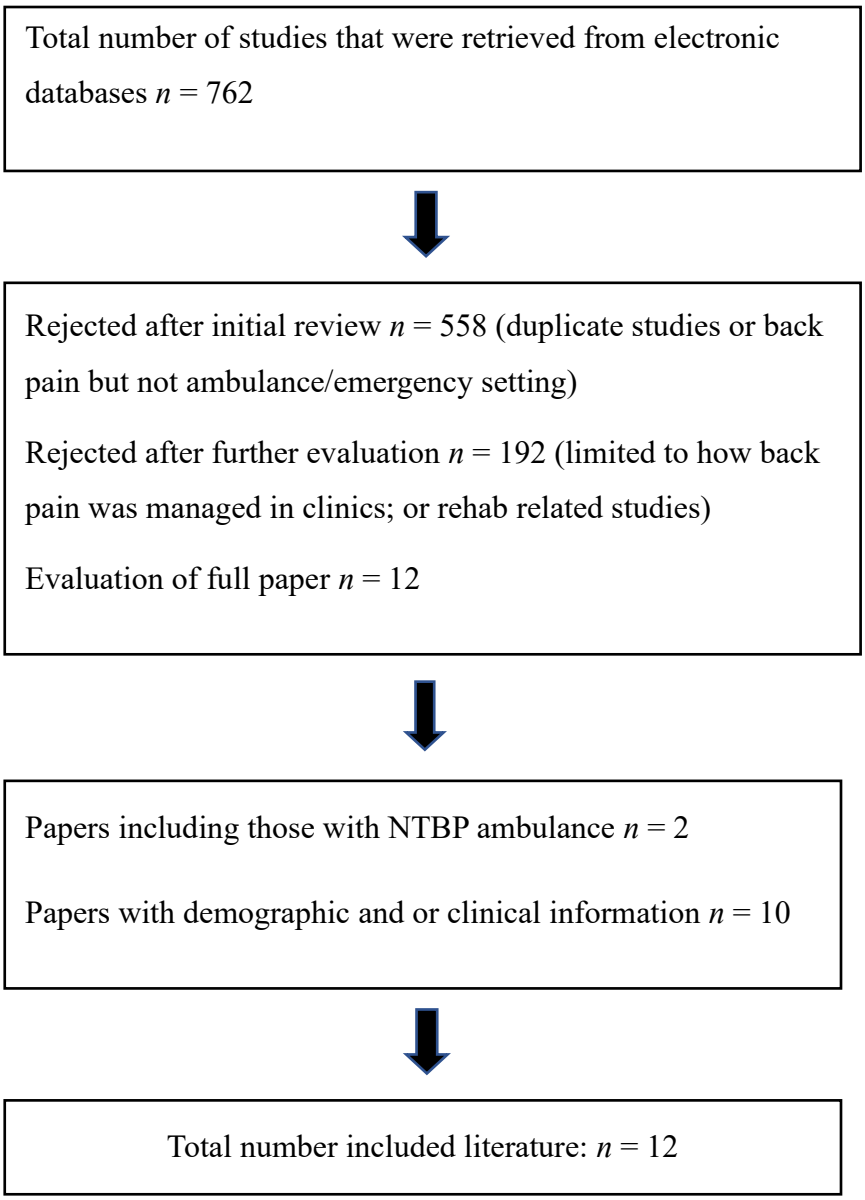


Figure 1: Flow chart of included literature determined by using the modified CASP UK Checklist

2.5 The available studies

Twelve studies were evaluated according to the CASP UK (2018) framework (Table 2) appraising whether they were valid, and reliable, for including in the review. A summary of each paper's design, characteristics, and findings, along with its strengths and limitations, is provided in Table 4 below.

Table 4: Overview of the selected papers

Author, year, and country	Description of the study	Study Design/ Patient Group and Size of the Study	Findings	Strengths and Limitations
Vella et al. (2022) Australia	Explored the usage of ambulance services and standard paramedic care for back pain. The efficacy and safety of paramedic care for back pain, and the characteristics of patients with back pain who seek care from paramedics.	Scoping review. Used descriptive retrospective data.	The top three causes for calling an ambulance are back pain. Women made more calls than men. Sixteen percent of back pain calls are transported to the hospital. Benzodiazepines, NSAIDs, opioids, nitrous oxide, and paracetamol were used in clinical treatment. Non-pharmacological care, which includes referral to alternative health providers, psychotherapy and behavioural therapies, or self-care and counselling, is under-reported. Comments on three trials that looked at the efficacy of paramedic treatments for back pain.	Provided a broad overview of the existing literature on the topic. This helped identify gaps in the research and inform future research priorities. The systematic approach found relevant studies that helped to ensure the review was comprehensive and unbiased. The comprehensiveness and accuracy of the coverage of the review were dependent on the quality and availability of existing literature. This was extremely limited for prehospital studies. The authors' interpretation of the evidence may have been influenced by their own perspectives and biases. The search strategy did not include grey literature, government documents, or conference abstracts. Studies included mixed populations for back pain, which included other presentations of musculoskeletal

				disorders. This limited some presentations of data.
Capsey et al. (2022) UK England	North East of England Ambulance Service (NEAS) emergency calls for patients with Low Back Pain (LBP). Twenty-two papers.	An observational study to investigate the extent and nature of ambulance services utilisation by patients with low back pain, using retrospective descriptive data from NEAS. Out of 484,495 calls, 3315(0.7%) were emergency calls for LBP.	3315 (0.7%) of emergency calls to Northeast Ambulance service were for low back pain. Women constituted 59% of callers. The age groups that made the most calls were 41–50 and 71–80 years. Approximately 48% of callers were categorised as having "a problem elsewhere". Analgesia was provided to 49% of callers. Entonox (24%) and morphine (13%). Most patients (69%) were transported to ED, and 28% remained in the community. Low back pain was a somewhat common reason to call an emergency ambulance. Medical emergencies and other non-spinal causes contributed to most of the calls. Further studies were recommended.	Retrospective study so no cause and effect could be determined. Limited ability for ambulance clinicians to record their working diagnosis. No final ED diagnosis. Without a final diagnosis, some conditions could not be accurately compared with low back pain. Limited to one geographic/ regional location. May not represent findings for the rest of England. Results may not be generalisable to other study settings. The study relied on retrospective analysis, which may have limitations in terms of accuracy and completeness.
Macfarlane et al. (2012)	Prevalence of low back pain across adulthood. The study was conducted in	Population-based cross-sectional study, aimed to determine the prevalence of LBP and associated disability, the	Older adults are more likely than younger persons to seek medical attention for low back pain with impairment to obtain optimum and pharmacological treatment.	Insight into how patients with NTBP were managed by GPs. Important as these are suggested referral pathways for ambulance clinicians.

UK, Scotland, and England	Aberdeen, Scotland and Cheshire County, England, UK.	frequency of consultation to general practice, and whether there were differences in management by age. 15,272 people aged 25 years and older.		Not an ambulance study. Limited to two counties so does not provide a national understanding of NTBP for England or Scotland. The study could only measure the prevalence of low back pain, but it could not determine the incidence of new cases over time. The study could not determine cause-and-effect relationships. And could only demonstrate associations between variables. The selection of participants may not have been representative of the entire population, this could have led to biased results. Participants may not have accurately recalled past exposure to outcomes, this could have led to misclassification and biased results. It was difficult to determine whether the exposure preceded the outcome or vice-versa (Wang and Cheng 2020).

Wynne-Jones et al. (2014)	To investigate the extent to which differences in setting, country, sampling procedures and methods for data collection are responsible for variation in estimates of work absence and return to work.	Systematic review and meta-analysis 45 studies, 34 were included in the meta-analysis.	Physiotherapists routinely asked patients about their job and work difficulties using a structured approach, GPs did not. There was a tension revealed between GPs' gatekeeper and patient advocacy roles, often resolved in favour of patients' needs and concerns. The workplace was a specific source of strain for patients acting as a barrier to work resumption, and over which GPs or physiotherapists could exercise limited control. At one month, one to six months, and six months and more, the pooled estimate for the proportion of adults with back pain returning to work was 68.2%, 85.6%, and 93.3%, respectively. It is estimated that 32% of persons suffering from back discomfort do not return to work within one month.	Good understanding of how patients with NTBP were managed by GP and Physiotherapists, and differences. Three independent reviewers for the study. Review was designed to identify papers that were low, medium, and high risk of bias or where a sample was poorly described. No limitations or weaknesses were described.
Corp et al. (2021) Europe	A European study of eight countries, that synthesised evidence for the management of neck and back pain,	A systematic review that reviewed clinical guidelines for recommended treatments for neck and low back pain.	There were consistent weak or moderate strength recommendations for reassurance, advice and education, manual therapy, referral for exercise/ therapy programme, oral analgesics, and topical medication,	A shared consensus for the non-pharmacological management of back pain. The study reviewed seven years of data.

	recommended options across Europe.		plus psychological therapies, or multi-disciplinary treatment for specific subgroups.	Focus on contemporary guidelines, earlier guidelines were not reviewed. Limitations with research quality (41% were high quality). Not a prehospital study. Unable to determine whether any patients were high acuity.
Deyo et al. (2014)	Low back pain in primary care. Discussed the use of lumbar spine imagery.	An article that reviewed an individual patient case study of a 71-year-old female and a male in his 40s presenting with severe land persistent low back pain. The patient had multiple comorbidities that may suggest radiology. The article offered a concise and balanced argument for the overuse of radiology based on the patient's case.	Radiology of the lumbar spine for low acuity patients is overused. Misleading findings and lack of proven patient benefits. Radiography is appropriate for patients symptomatic of cancer, fracture or other inflammatory spondylopathy. MRI scans are appropriate for neurological deficits. Patients with a history of cancer, injected medications, major trauma, and prolonged corticosteroids are important red flags for imaging. A full clinical picture should guide the ordering of lumbar images.	The article had a well-defined research question and a rigorous methodology based on two clinical case studies. The patient cases presented complex presentations that were symptomatic of NTBP. Symptomatically these were relevant to prehospital presentations. Outcomes may inform ambulance management/ referral pathways. The small size of the article may have unrepresented the requirements of a larger population and the need for radiology. Extended tests and assessments may not be transferrable to the prehospital setting.
National Institute for Health and Care	NHS National Guideline for Assessing and	National guideline 65 Back pain. A guideline for assessing and managing low back pain and	Key recommendations of the guideline are: To encourage people to keep active and	Frequently cited high-quality evidence-based guidelines.

Excellence (NICE) [NG59] (2016)	managing low back pain and Sciatica in people aged 16 and over. Outlines the physical, psychological, pharmacological, and surgical treatments.	sciatica in people aged 16 and over. Outlines the physical, psychological, pharmacological, and surgical treatments to help people manage their low back pain and sciatica in everyday life. Devised to improve a chronic patient's elf management for a better quality of life with chronic low back pain or sciatica.	continue with their normal activities as far as possible. Suggest a series of exercises including, stretching, strengthening, aerobic, and meditations as first step management in controlling pain. Consider manual therapy such as spinal manipulation, mobilisation, or soft tissue techniques such as massage, only along with exercise. Not offering acupuncture for managing low back pain.	The 2016 guidelines may not have been up to date with the latest research and evidence. May not have considered individual patient characteristics and preferences. May not have been applicable to all populations or healthcare settings. May have been influenced by conflict or bias. Ambulance providers are required to critically appraise and interpret national guidelines in the context of their patients and practice settings.
Global Burden of Disease (GBD) Low Back Pain Collaborators (2021)	The GBD is a comprehensive observational epidemiological study that provides an impressive resource to understand the changing health challenges facing people globally in the 21st century.	Systematic Review of the GBD Study 2021. Low back pain affected 619 million people in 2020 and is projected to affect 843 million by 2050. Low back pain is highly prevalent, and the main cause of years lived with disability.	The GBD evaluated a wide range of diseases and injuries from low back pain to non-communicable diseases such as cancer, malaria, tuberculosis, HIV/AIDS, diabetes, and injuries sustained in road traffic collisions and self-harm. Their study for low back pain incorporated its prevalence, risk factors and the relative harm it causes. These findings enable decision-makers to compare different health issues and their effects. These may	A large and comprehensive effort to quantify the GBD and injuries. The accuracy and completeness of the data may have varied between countries and regions. The methods used to estimate the burden of low back pain may have had limitations and may not have captured all aspects of the condition.

			be used to inform policies and practices for treating conditions such as back pain.	The study relied on assumptions and modelling, which may have introduced uncertainty into the estimates. Did not consider prehospital presentations of NTBP.
Buchbinder et al. (2018)	Low back pain: a call for action. The authors contend that low back pain and an increasingly ageing population are growing globally.	A viewpoint article that is not primary research-based and did not involve the collection of data from the participants. However, it summarises the most pressing political, public health, and healthcare challenges of low back pain and identifies actions to address them.	Buchbinder et al. (2018) argue that improvements in health and workplace policies and disability payment systems are often ineffective and wasteful. They recommend that public health programmes are required to address obesity and low levels of physical activity, which might provide a model and structure for reducing the effects of low back pain on daily living. The authors argue that the persistence of disability associated with low back pain must be recognised and that it cannot be separated from social and economic factors and personal and cultural beliefs about back pain.	An opinion piece that summarised the most pressing challenges related to low back pain and identifies actions to address them. As with any viewpoint or opinion article, the views expressed are those of the authors. They may not represent the views of all experts in that field. The article may have been limited in terms of comprehensiveness and depth of its coverage for low back pain. Did not consider prehospital presentations of NTBP.
Dionne et al. (2008)	A consensus approach towards the standardisation of back pain definitions	Delphi Population-based prevalence studies 28 experts in back pain across 12 countries. Based on 51 articles, dissected 71 articles into seven elements,	Key findings developed two definitions for low back pain. Definition one examined the site of low back pain, symptoms observed, and the time frame of the measure. Definition two	The consensus based approach gathered input from a large and diverse group of experts in the field. This approach helped to ensure that the definitions were widely

	for use in prevalence studies.	and agreed on two definitions for low back pain based on symptoms, and frequency or duration of symptoms.	examined the severity of low back pain and an optimal definition that is made from the minimal definition and add-ons. These included frequency, duration of symptoms, an additional measure of severity, sciatica, and exclusions, that may be adapted to different requirements. These definitions aimed to standardise and improve the comparison of low back pain prevalence data, by person, place, and time characteristics, to improve statistical summaries.	acceptable and applicable across different settings. The Delphi approach relied on the opinions of experts, which may not always reflect the views of all stakeholders or be based on the most up-to-date evidence. The study focused on developing standardised definitions but may not have considered other important aspects of low back pain research.
Knezevic et al. (2021)	A review article discussed the different types of pain that frequently overlap in the back.	Narrative that focused on original research articles that were reviewed and discussed by the authors of the paper.	The biopsychosocial relationship that causes NTBP. Pain classifications. Recognising high-risk populations is to help tackle healthcare costs associated with therapy and rehabilitation. A multi-modal approach to managing back pain is critical. Requirement for an interdisciplinary approach to pain management. Solitary strategies are not successful.	The article covered a broad overview of low back pain, covering a range of different aspects of the condition. As a review article, this was not a primary research study and did not have its own study design or data collection methods. One potential limitation was the article may not have provided a complete or up-to-date overview of all aspects of low back pain research. Additionally, the authors may have been influenced by their own perspectives and biases.

Feldman et al. (2006)	A retrospective study that aimed to determine the relationship between the medical priority dispatch system (MPDS) and out-of-hospital Canadian Triage and Acuity Scale (CTAS).	Obtained all emergency calls on a large urban Emergency Medical System (EMS) communication for one year. Duplicate calls, nonemergency transfers, and cancelled calls were excluded. Sensitivity and specificity to detect high acuity illnesses, positive predictive values (PPV) and negative predictive values (NPV) were calculated for protocols.	The MPDS had moderate sensitivity and specificity for detecting high acuity illness or injury from telephone triage. Recommended that a performance analysis may be used to identify target protocols for future improvements.	The study used a large sample size of emergency calls on a large urban database for one year. This enabled the authors to perform a comprehensive analysis of the performance of the MPDS. There has been no follow-up study. The study relied on data collected for other purposes and may not have been collected in a standardised manner. The study only looked at one EMS system in one urban area, so the results may not be generalisable to other EMS or geographic locations.

2.6 Appraisal and Critique of the Literature

Establishing this population's demographic and clinical characteristics was central to this review. A consistent finding in the literature was that back pain is a significant problem for healthcare providers (GBD 2021; Buchbinder et al. 2018). Capsey et al. (2022) suggested that it was a common reason for people to call ambulances. Despite this statement, the prehospital population for NTBP for UK ambulance providers was determined to be uncertain. Therefore, the Capsey et al. (2022) suggestion may be more subjective to the authors' experience of prehospital care within the North East Ambulance Service. If NTBP is indeed a widespread problem for ambulance services, it is an untested hypothesis. Therefore, this area requires more study in each country of the UK.

Vella et al. (2022) explored nine areas across Australia and New Zealand. Capsey et al. (2022) investigated four counties that collectively make up the North East of England. The Vella et al. (2022) study reviewed at least two different healthcare systems across two countries, which differed from the National Health Service investigated by Capsey et al. (2022). The management and treatment of NTBP by two semi-private healthcare providers compared to one NHS may have varied for the people who accessed these services. The patient outcomes may have resulted in varied reasons relating to why people called an emergency ambulance for NTBP (Ben-Yishay 2021). Objectively, Capsey et al. (2022) provided more comparable data with the SAS data used in this Scottish study, as both ambulance services serve the NHS.

England has twenty-seven administrative counties (Office for National Statistics (ONS) 2022). By population, the country is divided into nine regions: the North East is the ninth and the smallest (ONS 2022). In 2020, a census of the population of the North East of England revealed that this region constitutes 2.64 million people, equivalent to 4.7% of England's total population of 56,563,419 million (ONS 2022). This suggests that the study captured a small demographic impression of NTBP for England as a whole (Capsey et al. 2022). Whether the findings were consistent with the rest of England, or the UK, would require further research. This should include a NTBP study for Wales and Northern Ireland, which, like Scotland, have a devolved national ambulance service. The four countries of the UK all have their unique heritage and industries. It is possible that these may effect emergency presentations of NTBP to

different ambulance services. This suggests that a more comprehensive UK study is necessary to understand this condition's true demographic of prehospital presentations. With a UK-wide study, it would be possible to state how common emergency calls for NTBP are to UK ambulance providers. As there is no national English Ambulance Service, gaining this data would be challenging and would require input from each English service.

Age, gender, and social and economic status are relevant demographic characteristics that can affect presentations of NTBP (Campbell et al. 2001; GBD 2021; Buchbinder et al. 2018). Although there are well-reported differences in gender, age, and socioeconomic status that can affect people's experience of healthcare, no prehospital studies that incorporated these factors for NTBP were identified (Campbell et al. 2001). Each of the epidemiological systematic reviews, identified by the scoping review, focused on primary healthcare presentations of NTBP (GBD 2021; Corp et al. 2021; Wynne-Jones et al. 2014; Macfarlane et al. 2012). Excluding the ambulance papers, no evidence arose in the materials that were reviewed, that considered whether people were willing to call an emergency ambulance for NTBP (GBD 2021; Corp et al. 2021; Buchbinder et al. 2018). This demonstrated that acute presentations of NTBP were not considered to be contributing factors for this global problem.

The MacFarlane et al. (2012) study compared two populations with back pain, in Aberdeen, Scotland, and Cheshire County, England, for the prevalence of back pain. The study reviewed people aged twenty-five years and older but did not consider younger adult patients. In the other studies, back pain was more associated with older adults (Vella et al. 2022; Capsey et al. 2022; GBD 2021; Buchbinder et al. 2018). This suggested that research examining all adult calls by gender and age should be conducted, and, for Scotland, this provided a rationale for including people aged sixteen years and older. This observation ensured that including these data would make the results more generalisable and comparable with other populations for future studies.

Feldman et al. (2006) published a study that compared the Medical Priority Dispatch System (MPDS) to a prehospital acuity score analysed from thirty-two MPDS protocols. The study aimed to determine the relationship between MPDS dispatch priority and the prehospital Canadian Triage and Acuity Scale (CTAS). The Feldman et al. (2006) study determined that sixteen of the thirty-two protocols performed no better

than chance alone at identifying high-acuity patients. There are no comparable UK studies. As the SAS used the MPDS system, the study provided a valuable comparison for this review. The National Early Warning Score (NEWS) was used to supplement the CTAS for this project for SAS. Feldman et al. (2006) relied on data that were collected for other purposes and may have been collected in a non-standardised manner. The study provided valuable insight into the performance of the MPDS, which could be used to identify target protocols for future improvements of MPDS. It was noted that not all UK ambulance services use the MPDS system. The lack of research on the efficacy of MPDS ability to detect life-threatening presentations of NTBP led to the development of research questions two and three in the research presented in this thesis.

Deyo et al. (2014) discussed diagnostic imagery, namely X-rays, and their potential misuse for diagnosis of NTBP. The utilisation of these diagnostic investigations adds to the overall burden on the healthcare system. The average cost of direct access X-ray imaging is £32.73 and between £200–300 for magnetic resonance imaging (MRI) per patient (NICE 2022). The development of prehospital advice for diagnostic imagery may inform a decision to transport or not transport the patient to the hospital. Deyo et al. (2014) offer a robust discussion about the appropriateness of this procedure, their study was devised on in-hospital presentations of NTBP. The pre-hospital ambulance setting may require its own guidance that may be more relevant to ambulance clinicians and, therefore, may be more beneficial to inform their clinical decision-making for this purpose.

The severity and complexity of NTBP may require patients to seek a referral to specialists. These included orthopaedic surgeons, neurologists, and pain management specialists (NICE 2020). The NICE guidelines provided comprehensive advice for the management of NTBP for patients and healthcare providers. A review of these suggested that they would require modifications and standardisation for ambulance clinicians. Ambulance clinicians are governed by JRCALC, which enables them to work within their scope of practice (Brown et al. 2021). Determining what or if any modifications are required relied on understanding how ACs manage and treat NTBP. Capsey et al. (2022) and Vella et al. (2022) suggest that prehospital care focuses on the severity of pain that determines the analgesia of choice. Knezevic et al. (2021) describe the pathophysiology of the pain associated with NTBP, demonstrating the complexity of

its modulation and providing the rationale for administering effective drugs. These discussions demonstrated that the ambulance service manages acute symptoms. This finding revealed a requirement to explore an examination of the management of NTBP by the ACs of SAS including GP services. GPs frequently generate urgent calls from SAS in which they may administer their own medications. It was identified that GPs or other healthcare professionals who had requested an ambulance were not investigated.

Non-pharmacological treatments were not discussed for prehospital patients in any review but are recommended (NICE 2020). No studies were identified that have reviewed patient experiences or outcomes for NTBP by ambulance services. This determined another line of inquiry for the study, as these are recommended in the most recent JRCALC updates (Brown et al. 2021).

2.7 Quality of the papers

As this was a scoping review, no quality appraisal was performed because this is not typically considered part of this review procedure (Peters et al. 2021). The small number of sources that were identified by this scoping review reflects the paucity of evidence regarding prehospital presentations of NTBP. In terms of demographic and clinical characteristics, just one study undertaken in the UK described this population (Capsey et al. 2022). In the context of existing UK ambulance settings, this may have hampered the generalisability of the results. Despite the availability of demographic data, none of the studies were able to answer review aims two and three. The association between the caller's acuity and the acuity of their NTBP could not be determined. Nonetheless, in all the papers that were reviewed, enough data were available to derive useful information on NTBP management and treatment that may inform ambulance care.

2.8 Limitations

This review only included material published in English. While the literature was carefully examined and evaluated, little high-quality research was found. Demographic and clinical data were evaluated in the available sources, it was not always possible to establish a direct relationship between these and ambulance patients in particular.

2.9 Research Questions

The scoping review determined that the available literature revealed little about low back pain and how it presents to ambulance providers. The knowledge gaps identified in this review informed the development of four research questions for this study.

1) To establish the patient demographic for NTBP 999 calls, including socioeconomic status (SIMD) with associated NEWS.

2) To analyse the positive predictive value (PPV) for ambulance clinicians' diagnoses of true NTBP and determine whether this differed by dispatch priority.

3) To determine the sensitivity and specificity, positive predictive value (PPV) and negative predictive value (NPV) of aMPDS on objective acuity measured by NEWS for ambulance clinicians coded 05 NTBP.

4) To explore what pre-hospital clinical interventions were used by ambulance clinicians to treat these patients.

2.10 The quality of the available evidence

The scoping review for this study determined that pre-hospital presentations of NTBP have not yet received adequate attention and need more research. This absence of evidence presents several implications for researchers, ambulance clinicians and policymakers working for the SAS. Quality research is recognised as being vital for delivering safe, effective, and evidence-based care to patients (Worsham and Jena 2019; Luciano et al. 2019). A dearth of quality research creates challenges and uncertainties in clinical decision-making, potentially compromising patient safety and positive patient outcomes (Worsham and Jena 2019). As SAS increasingly responds to non-life-threatening presentations such as NTBP, developing quality research for these conditions is necessary.

The selected twelve studies examined the demographic and clinical characteristics of acute presentations of NTBP to healthcare providers. The studies comprised methods that included retrospective, scoping, observational, population-based, cross-sectional, Delphi-based prevalence, methods, and included a systematic review with and without meta-analysis, a national guideline, and articles. The methodological rigour varied

amongst the studies, making comparison between them challenging as the study styles varied. Despite this, some demographic consistencies were identified, such as age and gender, and clinically pharmacological and non-pharmacological interventions were consistent. The systematic reviews demonstrated high-quality research with appropriate randomisation, blinding and statistical analysis. The other studies demonstrated limitations in their small study design and potential biases. The only UK ambulance observational paper was restricted by its small sample size, which, without a proper control group, may have been susceptible to confounding factors.

The absence of quality literature on pre-hospital presentations of NTBP may be attributed to several factors. Research and funding priorities for ambulance services usually focus on areas with higher disease burdens, acute life-threatening conditions, or public health concerns. NTBP may not be as prevalent such as cardiac chest pain, therefore it may not receive sufficient attention compared to to more critical health concerns.

Conducting high-quality research in the pre-hospital setting is challenging. Ambulance responses are time-sensitive, and collecting data in the emergency setting can be logistically difficult. NTBP may not be considered a priority by researchers or academic institutions for ambulance care. Identifying established quality pre-hospital research is impossible without interest or fewer research initiatives or opportunities for funding and collaboration. The available studies demonstrated that NTBP has various underlying causes, which can lead to diverse populations within this group (GBD 2021; Buchbinder et al. 2018). This heterogeneity may complicate research efforts, as it requires larger sample sizes and more complex study designs to account for potential confounding factors. This scoping review found that the lack of quality research for NTBP indicated a lack of collaborative effort between researchers, ambulance services, healthcare institutions, and funding agencies.

Despite a comprehensive search of various academic databases, only one retrospective observational study that directly addressed the demographic and clinical characteristics of NTBP to a UK ambulance provider was found. This lack of published research indicates that pre-hospital presentations of NTBP have not yet been extensively researched or documented. While finding limited research for ambulance presentations

of NTBP was disappointing, the evidence gap presents an exciting opportunity to stimulate interest and encourage future studies in this area.

In the next chapter, the methods that were chosen respond to the research questions.

Chapter 3: Methods

3.1 Overview of the Chapter

Chapter three outlines the methodology employed for describing the sample of this retrospective observational study. Pre-existing data from SAS, Information Services Division (ISD) Scotland records, electronic patient report forms and other sources, such as the National Early Warning Score (NEWS) (Royal College of Physicians 2017), from patient records are used. The findings focus on the accuracy and clinical acuity of the selected tests for identifying patients with NTBP. A focus on evaluating sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) in the context of ACs' diagnostic accuracy of NTBP and aMPDS' ability to detect high acuity presentations of NTBP using the National Early Warning Score (NEWS) as a proxy is described. Appropriate statistical parametric methods were employed to analyse all data and were used for the calculations of sensitivity, specificity, PPV and NPV.

3.1.1 Research Approach

The main aim of this study was to define the adult patient population that presents to the Scottish Ambulance Service (SAS) with non-traumatic back pain (NTBP). This observational follow-up study employed a quantitative research design, using retrospective data (STROBE 2022; Creswell 2014). This section will describe the setting; participants; variables; data sources and measurements; biases; study size; quantitative variables; and statistical methods (STROBE 2022).

The SAS is a frontline emergency service, which provides immediate medical care and/or clinical advice to 5.517 million people, across 30.420 square miles (ONS 2022; Scottish Ambulance Service 2023a). It is governed by a special health board, funded by the Scottish Government's Health and Social Care Directorates (Scottish Ambulance Service 2023b). Divided into five regional divisions with five divisional headquarters (DHQ) – Southwest (Ayr), Southeast (Edinburgh), West Central (Motherwell), East Central (Dundee), and North (Inverness) – SAS serves the whole population of Scotland (Scottish Ambulance Service 2023a). These regions work with 14 territorial NHS boards, responsible for the delivery of health and frontline care nationwide (Health Financial Management Association 2023).

Low acuity conditions such as NTBP are presenting more frequently to UK ambulance services (Rizzardo et al. 2016; Robinson et al. 2004). This is creating increasing pressure on already hard-pressed ambulance resources (Cladridge and Parry 2021). In addition to the main aim of this thesis, a literature review investigated how often episodes of this condition accounted for emergency (999) calls, and how these were managed, clinically.

3.2 Key questions

Four key aims were derived from the main aim of the study, which was to define the patient population that makes 999 calls to the SAS for NTBP:

1. What is the patient demographic for NTBP 999 calls including socioeconomic status (SIMD) with associated NEWS scores?
2. What is the positive predictive value (PPV) for ambulance clinicians' diagnosis of true NTBP and does this differ by dispatch priority?
3. What is the sensitivity and specificity, positive predictive value (PPV) and negative predictive value (NPV) of aMPDS on objective clinical acuity measured by NEWS for ambulance clinician coded 05NTBP?
4. Which out-of-hospital clinical interventions were used by ambulance clinicians (ACs) to treat these patients?

3.3 The study setting and design

This retrospective observational follow-up study used archival data relating to people who had called 999 for an episode of NTBP, in 2018. From a total of 640,399 emergency calls, 9701 were identified as NTBP. Following cleaning, 8824 records informed research questions one and four, and 9293 records informed research questions two and three.

This study was based in a prehospital ambulance care setting. The study participants were adult women and men who required support from SAS for an episode of NTBP. The records of interest were gathered from all the 999 (emergency) calls made to SAS for NTBP in 2018. The SAS uses a colour-coded emergency response system. This classifies the urgency of the call, from those who have immediately life-threatening conditions (purple and red), to those who have lower-grade emergencies (amber, yellow

and green). The data collection for this study focused on amber, yellow and green calls, those that best describe NTBP. All the patients had made at least one or more 999 calls over 365 days between January and December 2018 (Scottish Ambulance Service 2018; Scottish Ambulance Service 2023b).

In Scotland there are two systems that facilitate call prioritisation, which determines whether the call requires ambulance response or telephone advice. These are the New Clinical Response Model Acute Medical Priority Dispatch System (aMPDS) C3 TerraPACE (a software platform used to manage and document all calls made to SAS) and NHS 111 pathways (International Academies of Emergency Dispatch 2020; Scottish Ambulance Service 2023a; Clawson et al. 2008). All calls were based on the SAS and ambulance clinicians' classification of the nature of the clinical issue recordings for back pain, coded by the SAS as 05 'back pain'. The 05 coding was awarded either on initial call triage by the SAS aMPDS or following ambulance clinicians' clinical assessment (for details see Chapter 3, section 3.6 and Chapter 4, section 4.2.7; and Appendix 1, Clinical Response Model).

The SAS aMPDS C3 TerraPACE system is a stratification tool that is a standardised, computer, algorithm-based telephone interrogation system. The aMPDS system is used by most NHS UK ambulance services to dispatch the most appropriate medical resource to the person making the call (IAED 2023). Ambulance call takers ask a series of scripted questions to assess the severity and urgency or nature of the call. The system is designed to detect, triage, and prioritise emergency life-threatening calls. Emergency (999) calls are initially answered by qualified, but non-clinical, ambulance call takers. Computer-aided algorithms enable the prioritisation of ambulance resources to respond to the highest priority or life-threatening calls (IAED 2023). All calls are categorised to a level of acuity ranging from low to high and the C3 system provides a description of the nature of the call . There are 33 codes that provide these descriptions describing the most common types of emergencies that are presented to ambulance providers (IAED 2018; Clawson et al. 2008). The codes are categorised alphabetically from 01 *abdominal pain* to 33 *various problems*, and, in this study, NTBP is an 05 code (see Table 22 in Section 4.2.7). Call takers and dispatchers identify red flags, such as cardiac arrest or coronary chest pain, through a scripted algorithm that specifically seeks life-threatening signs and symptoms. Key descriptors that are call triaged assign a C3

colour that denotes the severity of the call with purple being immediately life threatening to green being low priority (IAED 2018; Clawson et al. 2008). The status of the call determines the response time of the ambulance. The dynamic design of the aMPDS enables ambulance controllers to ensure callers are triaged and then directed to the most appropriate ambulance response, or care pathway, through the triage model called *What is the problem?* (Scottish Ambulance Service 2018); Scottish Ambulance Service 2023a; Appendix 1). All emergency ambulances are integrated into this system by TerraPACE computer terminals. The system has two components. The first of these is cab based technology located in the front of the ambulance. A computer screen displays the nature of the 999 call to the ACs. Once the emergency call is acknowledged a computerised satellite navigation directs the crew to the locus of the patient. The system is live and synchronised with aMPDS accounting for its dynamic design. ACs acknowledge that their ambulance is mobile, at scene, left scene, arrived at hospital and clear of an incident. A full record of the emergency call is recorded in this manner. In the back of the ambulance a tablet for recording the clinical management of patients is linked to the aMPDS. This is called an electronic patient report form (EPR) and contains the same information delivered to TerraPACE in the front of the cab. On arrival at hospital all clinical details are printed off and provided to receiving hospital staff. ACs also are issued with airwave radios which are integrated to aMPDS and perform all of the same functions as the cab based technology. Airwave radios ensure crews are constantly available to respond to emergency calls at all times they are available. Strategically, this model is used nationally across Scotland in all its major control centres located in Glasgow, Edinburgh, and Inverness.

NTBP is recognised as a chronic condition (Purcell 2016). Any repeat calls made for the same episode of NTBP in 2018 were identified to determine whether ambulances responded more than once for the same episode (and how often), only the first call made by a patient for an episode of NTBP was included in the analysis. Any patients who had called the SAS for repeat episodes of NTBP within the year were also included. All remaining calls were discounted as they were not categorised as NTBP as either the initial or final diagnosis (Sedgwick 2014).

All calls were based on the SAS and ACs' categorised for back pain, coded by the SAS as 05 'back pain'. The 05 coding was allocated either during the initial call triage made by the SAS aMPDS or following ACs' clinical assessment when attending the call.

3.4 The ED definition of true NTBP (Dorsalgia)

Dorsalgia was identified as a true diagnosis of NTBP from the available linked ED data. Dorsalgia (prefixed ICD 10-M54) is an umbrella term that describes a variety of conditions that cause back pain. These include a spectrum of different illnesses or injuries to the musculoskeletal system and connective tissue, including the neck and spinal processes (International Classification of Disease ICD-10 code M54.5, World Health Organization (WHO) 2019a). Dorsalgia is a term that is not used by SAS, but is a medical classification used by the ED, which was used in this thesis to determine whether ACs' diagnoses were accurately diagnosed as NTBP by comparing them with those made by ED clinicians.

3.5 Data sources and data extraction

Data were collected from the central SAS data warehouse in Edinburgh and Information Services Division (ISD) Scotland, accessed from the unscheduled care data mart (UCD) (Public Health Scotland 2020). Data recorded from the calendar year January 1st to December 31st, 2018 were extracted. The included data were routinely extracted from the electronic patient report (ePRF), which comprise a series of forms that are completed by front-line clinicians at the time of care. The forms include a calculated NEWS score based on the physiological parameters of a patient's baseline observations (Royal College of Physicians 2012). The forms are designed on the medical model of patient assessment known as the A-E approach (BMJ 2016). Further data fields include past medical history, allergies, social and familial history, and all medications (Resuscitation Council UK 2021; BMJ 2016). Past research using these data identified that, proportionally, and by division, West Central and Southwest receive 50%, East Central and Southeast, 40%, and the North, 10% of 999 calls, reflecting each of the major population centres, respectively, in Scotland (Scottish Ambulance Service 2009; Scottish Ambulance Service 2022). Data available from the three ambulance call centres of SAS were used in this analysis.

Data obtained from the SAS contained all demographic and clinical outcomes for patients attended to by ACs. The clinical data also included a record of all patients who had been conveyed and non-conveyed to ED and the treatments or interventions they received. These records concluded with the patient's handover at ED. Data obtained from ISD Scotland provided the final clinical diagnosis of NTBP, which was made by ED doctors. ISD Scotland provided linked data for the ED clinicians' final medical diagnosis for these patients (World Health Organization ICD10-version 2010). The ED clinicians' final diagnoses were not recorded in the SAS data, but were accessed via the linked, shared data, held within the UCDM (Public Health Scotland 2020). This linkage enabled a review and comparison of the final patient ED outcomes against the SAS diagnoses.

The ethical considerations relating to the obtaining of these date were unproblematic, as the data already existed, had already been anonymised, and did not involve any new interventions or exposures. An application for ethics approval was made to the University of Stirling NHS, Invasive or Clinical Research (NICR) Ethics Committee, and this was granted in March 2019 (See Appendix 2).

The statistical data included in this study are separated into two main areas, demographic and clinical. All variables are reported here as frequencies and percentages. Descriptive statistics are used for presenting and summarising all findings.

3.6 Demographic data

The demographic statistical data that were collected described the key population features of the people who required ambulance care for NTBP in 2018. This included their age, gender, and their Scottish Index for Multiple Deprivation (SIMD) (Scottish Government 2023), based on their postcode, and the date(s) and number of emergency calls made to SAS for NTBP. The following variables describe the information that was provided from the SAS data.

The postcode was recorded as a combination of five or seven letters and numbers. This is a coding system used by the Royal Mail to define four different geographical units across the United Kingdom (ILR Specification 2013/2014). As a component of its aMPDS, SAS utilises postcodes to guide ambulances to a patient's locus. Although addresses were available via a live data hyperlink, they were omitted from the study to

protect patient confidentiality. The postcode provided a geographic representation for NTBP across Scotland. Postcodes were linked and used to identify the Scottish Index for Multiple Deprivation (SIMD), and to determine whether there were any repeat ambulance attendances for NTBP.

Each SIMD area is categorised either as a scale of between 1 and 5 or 1-10, allocated to postcodes, with SIMD 1 being the most deprived and SIMD 5 the least deprived (Scottish Government 2020). For this thesis, the SIMD 1–5 scale was favoured over the alternative SIMD 1–10 scale. Using the condensed scale afforded the simplification of descriptors and easier analysis of the research data (Dawes 2008).

To ensure patient confidentiality, all 999 calls generate their own unique seven-digit patient identification number each time an ambulance is dispatched. On completion of a call, and once the job is closed, this number permanently identifies all the details of the call made to SAS. If a job is live, and additional resources are requested by attending ambulance clinicians, the job number is shared with these extra ambulance resources. This number was used to check whether two or more ambulance resources had attended the same patient who had called SAS for assistance.

If a patient is not transported and an ambulance re-attends the same address twice within one day, a new number is provided. This ensures patient confidentiality but may make the identification of any repeat calls challenging. To resolve this, an analysis of the address and postcode for each call was completed to identify whether there were any repeat calls for more than one episode of NTBP. Determining whether there were any repeat calls helped to considered whether NTBP could be symptomatic of more serious conditions. From this perspective, the number of calls for NTBP that received one or more ambulance responses was examined.

The dispatch codes and C3 descriptors (key signs and symptoms) assigned to all 999 calls for NTBP were explored. The dispatch code is a unique combination of letters and numbers that best describes a patient's presenting complaint. Each code additionally provides a description of the patient's main symptoms. Non-clinically trained ambulance call takers and controllers assign one of thirty-three dispatch codes, following telephone triage (see Table 5). The design of the aMPDS system enables ambulance controllers to target ambulances towards patients with the highest acuity or

immediately life-threatening conditions first (Scottish Ambulance Service 2018). The expected target response times are described in Table 6.

Table 5: aMPDS C3 descriptors for all 999 calls made to SAS

aMPDS C3 descriptors 01–33 for 2018 (final coding 05 back pain from ambulance clinicians)
01Abdominal pain, 02 Allergies, 03 Animal bites, 04 Assault, 05 Back pain, 06 Abnormal breathing, 07 Fire call persons reported, 08 Respiratory arrest, 09 Cardiac arrest, 10 Chest pain abnormal breathing.
11 Choking, 12 Fitting, 13 Diabetic emergency, 14 Drowning or near drowning, 16 Moderate eye injury, 17 Falls, 18 Headache, 19 Heart problems, 21 Haemorrhage/ Laceration, 22 inaccessible incident/ entrapment, 23 Intentional overdose, 24 Maternity,
25 threatening suicide, 26 sick person, 27 Central stab wounds, 28 Stroke, 29 Transportation arrest, 30 Traumatic injury not dangerous proximal body, 31 Unconscious, 32 Unknown problem, 33 Transfer, Clinical support desk (CSD) Green, Yellow, Amber or Red.

The SAS aMPDS uses 33 protocols designed by the Department of Health (DOH 2002) that best describe a broad range of medical or traumatic conditions (Clawson et al. 2007). The aMPDS has been used since April 2002 to prioritise emergency calls to UK ambulance services (International Academies of Emergency Dispatch 2018). The specific classification of a patient's described presenting complaint triggers a category of response. Immediately life-threatening emergency calls are awarded a purple colour coding (Table 7). The acuity of the condition is aligned to a colour that reflects the target response time and expected ambulance performance.

Table 6: NCRM aMPDS C3 TerraPace: Expected Performance Response Times

NCRM C3 colour coding	**Target Response Time, in minutes with performance expectations**
Purple: immediate life threatening (ILT)	75% of all calls attended within 8 minutes
Red ILT	75% of calls attended within 8 minutes
Amber, yellow B2, B3, B5 and B6	No response time target
Yellow uncategorised	No response time target
Green	No response time target
Unknown	No response time target

Table 7: Colour categories and levels of ambulance response

Purple Response Category ▪ Highest response priority ▪ Cardiac arrest rate over 10% ▪ Respond with closest resource. ▪ Paramedic attendance essential ▪ Minimal of three responders to scene + double crewed ambulance if not in that response ▪ Consider partner agencies to support response
Red Response Category ▪ Second highest response priority ▪ Cardiac arrest rate >1% and defined need for resuscitation ▪ Response with the closest resource + double crewed ambulance if not that response ▪ Paramedic attendance essential
Amber Response Category ▪ Third response category ▪ <1% cardiac arrest rate ▪ Defined need for acute pathway care. ▪ Response with the right resource – emergency transporting ambulance. ▪ Paramedic attendance preferred
Yellow Response Category ▪ Fourth response category ▪ <1% cardiac arrest and no defined acute pathway care ▪ Response with the right resource – ambulance for defined hospital need and PRU for potential alternative pathway care
Green Response Category ▪ Fifth response category ▪ Exclusion of above categories ▪ Potential for additional clinician led telephone triage. ▪ Face to face assessment when required

Tables 8–10 illustrate call categorisations for 05 NTBP, with the colours green, yellow, and amber demonstrating the different levels of acuity. These align with the C3 call description, which dictates the level of ambulance response.

Table 8: Green calls for 05 NTBP

Dispatch code	C3 Description	Colour
05A01	Non-Traumatic Back Pain	Green
05A02	Traumatic Back Pain >6hours	Green

Table 9: Yellow calls of 05 NTBP (higher acuity signs and symptoms)

Dispatch code	C3 Description	Colour
05C00	Back Pain Charlie Override	Yellow
05C02	Diagnosed Aortic Aneurysm	Yellow
05C03	Back Pain or Near Fainting > 50 years	Yellow
05C04	Back Pain with Difficulty Breathing	Yellow
05D01	Back Pain Not Alert	Yellow

Table 10: Amber calls for 05 NTBP (with higher acuity signs and symptoms)

Despatch code	C3 Description	Colour
05C01	Back Pain not alert	Amber
05C02	Difficulty speaking between breaths	Amber
05C03	Back Pain near fainting > 50 years	Amber
05D02	Back Pain Ashen Grey Colour	Amber

In 2018, one of five colours was assigned to every 999 call made for NTBP (Scottish Ambulance Service 2018; Appendix 1) to prioritise each call on the basis of clinical need. NTBP is described as a non-life-threatening condition, thus reflecting a lower acuity call. From the available data, the calls classified with colours green (5 lowest), yellow (4), and amber (3) were investigated. The highest-level calls, coded purple (1) and (2) red, were omitted as they indicated an immediate threat to life. This high acuity status does not reflect the pathophysiology expected of NTBP (Purcell 2016).

If a higher priority categorisation was initially awarded by ambulance controllers (Appendix 3) the working diagnosis of '05 back pain, made by ambulance clinicians' downgraded the higher acuity of that status (Tables 5–10). Calls could also be upgraded if a patient was found to be very poorly. This downgrading or upgrading was based on the clinical findings made by ambulance clinicians on scene with a patient, or through telephone triage in ambulance control centres (ACC). The inclusion of this data accounted for the total presentations of NTBP to the SAS, providing the dataset for examination. This investigated whether NTBP was a low acuity condition, or possibly symptomatic of a more serious, high acuity complaint.

The time an emergency call is made to the SAS, the time a vehicle is dispatched, and the time the ambulance arrives on scene is each recorded in the C3 call triage system (Scottish Ambulance Service 2018). There were five outcomes reviewed in the available data:

1. The C3 time of the call made to ACC and the time the ambulance was dispatched.
2. The C3 time the ambulance arrived on scene.
3. The C3 time the ambulance left the scene. (This helped to confirm whether a patient was conveyed or non-conveyed to the ED).
4. The C3 time the ambulance arrived at its hospital destination.
5. The C3 time the ambulance cleared from hospital.

Following call prioritisation, four-time different time recordings were investigated. The calendar date included the day, month, and the year (2018). Time was recorded in the 24-hour clock format in hours and minutes. Both time and date were dispatched to the ambulance resource. This clarified whether a call was close to midnight and the job concluded in the early hours of the following day.

A list of all ED units across Scotland informed the areas where NTBP was assessed and provided with a final diagnosis. Blank areas confirmed non-conveyance, where patients remained in the community or were signposted to other healthcare providers, such as GPs or other primary health care resources.

3.7 Clinical variables

A National Early Warning Score (NEWS) was automatically electronically calculated in ACs' electronic patient report forms (ePRF). NEWS was selected as the independent variable to measure patient acuity associated with NTBP. This required the provision of all baseline fields to generate NEWS (Royal College of Physicians 2017; Marsden 2018). Analysis of the completed clinical baselines helped ambulance clinicians to determine the cause of the patient's condition. A review of these elements then determined the level of acuity for NTBP when the patient presented to SAS. This information was used to establish whether each 999 call for NTBP was low acuity or symptomatic of more serious conditions, those which warranted an ambulance response.

The NEWS tool is described as a track and trigger system and has been incorporated by the SAS into ePRF to improve the detection of acutely unwell patients, with the aim of improving patient safety and clinical outcomes (Royal College of Physicians 2017). In 2017, NEWS2 was published, but in 2018, these updates were not fully integrated by SAS.

A NEWS score is calculated through the measurement of a respiratory rate, heart or pulse rate, oxygen saturation (SPO_2), temperature, systolic blood pressure, and level of consciousness (Glasgow Coma Scale, GCS) (Royal College of Physicians 2017).

Early recognition of deteriorating adult patients that may present with perceived minor symptoms is achievable with NEWS (Royal College of Physicians 2017). An evaluation of the NEWS score for 05 NTBP was investigated to determine the acuity of the patient's condition, and the level of ambulance response was also explored.

A literature review of all the analgesics used to treat back pain was conducted. The main drugs investigated were Entonox (an inhaled analgesic gas); morphine sulphate; paracetamol; and ibuprofen.

3.8 Statistical methods

Descriptive statistics, using parametric tests, were used to describe the main demographic and clinical characteristics of the data (Dancey and Reidy 2017; Pallant 2017). Measurements of central tendency and variability, including the standard deviation (SD), in the data, addressed research questions one and four.

For testing null hypotheses, the probability (*p*-value) was set at 0.05.

For research question two, a breakdown of all calls diagnosed as 05 NTBP by ACs was compared to the final ED diagnosis to determine the accuracy of the detection and diagnosis of NTBP by SAS. The positive predictive value (PPV) for ACs and ED were used for this analysis.

3.8.1 Measurements required for calculating the PPV

The PPV was determined by calculating how likely it was for someone positively diagnosed with NTBP to have the condition. The true positive calls (TP) were the calls that were identified as NTBP by ACs or GPs and then diagnosed as dorsalgia by ED

clinicians. The Negative predictive value (NPV) was the probability that a patient who was not diagnosed as having NTBP by ACs did not have NTBP. False positives (FP) were the calls that were thought to be NTBP by ambulance clinicians or GPs but were diagnosed as something else by ED clinicians (Lalkhen and McCluskey 2008).

The PPV was calculated by measuring the True positive (TP) ÷ (TP+ False positive FP) = PPV (Molinaro 2015).

3.8.2 Positive predictive value (PPV) of ACs' ability to correctly diagnose NTBP

The purpose of determining the PPV had two main objectives. These were to demonstrate ACs' ability to assess and diagnose 05 NTBP and to look at General Practitioner's (GP) ability to accurately diagnose 05NTBP and to see how these differed. These were both based on a final ED diagnosis of true back pain (dorsalgia).

The PPV for ACs was calculated using all the 3240 emergency calls coded as 05NTBP that had a final diagnosis and were transferred to ED. The final medical diagnosis in ED confirmed all recorded cases of dorsalgia (true NTBP). This analysis determined the accuracy of ACs' ability to diagnose NTBP.

An additional investigation demonstrated the accuracy of the GPs' ability to diagnose NTBP. This was possible as ACs must record the GPs' diagnosis on the SAS C3 system.

3.8.3 Testing PPV

The PPV was the probability that a person who received a positive test had NTBP (Lalkhen and McCluskey 2008). The PPV was calculated by dividing the number of TPs by the total number of positive test results.

- Test 1: Investigated the PPV for ACs, and for the GPs urgent and routine calls for 05 NTBP.
- Test 2: Investigated the PPV for ACs' diagnosis of 05 NTBP by C3 colour coding of green, yellow, amber, red, and purple calls.

The calculations for tests 1 and 2 were determined through the analysis of the total data of 9293 calls diagnosed as 05 NTBP by ACs.

3.8.4 Calculations for the overall PPV

The PPV for these tests were calculated using the formula PPV = TP ÷ (TP+ FP).

3.9 Sensitivity and specificity analysis of aMPDS on objective clinical acuity measured by NEWS for ambulance clinician coded 05 NTBP

Research question three determined the sensitivity and specificity of aMPDS on objective clinical acuity measured by NEWS for ACs coded 05NTBP.

Sensitivity and specificity testing were selected for measuring the ability of aMPDS to detect the acuity of patients with NTBP presenting to the SAS (Trevethan 2017; Lalkhen and McCluskey 2008). This method afforded independent analysis of the system from the population of patients presenting with NTBP (Lalkhen and McCluskey 2008). According to Lalkhen and McClusky (2008), the value of this test lies in its ability to confirm or disprove the presence of a medical condition, disease or *further a diagnostic process*.

The analysis of sensitivity and specificity confirms or refutes the presence or absence of a condition, when judged against the '*Gold Standard definition'* of NTBP (Fawcett, 2006; WHO 2019a).

The Sensitivity or True Positive Rate (TP) categorised the proportion of patients triaged as high acuity NEWS ≥7 by C3 aMPDS.

The False Positive (FP) categorised the proportion of patients identified as high acuity by C3 aMPDS but were low acuity NEWS <= 7.

The Specificity or True Negative Rate (TN) categorised the proportion of patients triaged by C3 aMPDS as low acuity.

The False Negative (FN) categorised by C3 aMPDS patients as low acuity but were high acuity NEWS ≥7.

The positive predictive value (PPV) and negative predictive values (NPV) of the system's ability to triage NTBP defined the level of acuity of this perceived low-risk condition.

These data contain all ambulance clinician-coded 05NTBP within the SAS during the 12-month period. The numerator is the number of patients with NTBP who had a positive test, and the denominator is the total number of patients with NTBP who were tested. Therefore, in this case, the denominator is ACs' diagnosis, and the numerator, the test, is aMPDS triage. The purpose of this analysis was to determine the accuracy of aMPDS in identifying the true clinical acuity of these patients. This test was necessary as aMPDS was developed to identify patients with the greatest clinical need.

For this analysis, ACs' NEWS score was used as a proxy measure for clinical acuity. Generally, a NEWS ≥=7 is associated with higher clinical risk and within the hospital requires immediate referral to a critical care team. Evidence from prehospital care suggests 48-hour mortality rates of around 70% for this patient population. It is reasonable to suggest that these patients would benefit from rapid ambulance response and be categorised by aMPDS as a red or purple call. The accuracy of the aMPDS to identify potentially life-threatening calls the true positives (TP) categorised as red or purples but also had a NEWS≥=7, and the true negatives (TN) calls that were not categorised as purple or red and had a NEWS ≤=7, was measured (Table 11).

Table 11: The comparison of NEWS triage of NTBP by ACs and aMPDS

	aMPDS predicts high clinical acuity	**aMPDS predicts moderate to low clinical acuity**
Actual clinical acuity NEWS ≥ 7	True Positive – identified C3 aMPDS high acuity/ NEWS ≥7.	False negative (FN): Categorised by C3 aMPDS as low acuity/ NEWS ≥7.
Actual clinical acuity NEWS < 7	False Positive (FP). Identified C3 aMPDS high acuity/NEWS <7	True Negative (TN) – Categorised by C3 aMPDS as low acuity/ NEWS <7

3.9.1 Testing sensitivity, specificity, PPV and NPV of NEWS triage for NTBP by ACs and aMPDS

Sensitivity, specificity, PPV and NPV are four measures that are used to evaluate the accuracy of a diagnostic test (Lalkhen and McCluskey 2008; Geeky Medics 2023). Sensitivity was the percentage of TPs, or the proportion of people detected to be unwell with NTBP triaged by aMPDS. The specificity was the percentage of TNs, or the people

who were thought not to be acutely unwell by aMPDS call triage. The PPV was the probability of the people who were positively thought to have NTBP following call triage by aMPDS. The NPV were the people triaged as not having NTBP by aMPDS call triage.

- Sensitivity = TP/ (TP+FN)
- Specificity = TN/ (TN + FP)
- Positive Predictive Value (PPV) = TP/ (TP + FP)
- Negative Predictive Value (NPV) = TN/ (FN+TN)

This analysis demonstrated the ability of aMPDS to detect the clinical acuity for NTBP as defined by NEWS ≥=7. Sensitivity and specificity of these data demonstrated whether any patients triaged by aMPDS were of a high, moderate to low, or of no clinical risk for NTBP. The NEWS (Royal College of Physicians 2012) is displayed below in Table 12.

Table 12: NHS National Early Warning Score (NEWS) (Royal College of Physicians. 2012)

	Score						
Physiological parameters	3	2	1	0	1	2	3
A+B – Respiratory rate	< or 8		9–11	12–20		21–24	>25
A+B – Scale 1 Oxygen Saturations	91	92–93	94–95	96>			
A+B Scale 2 If target is 88–92% e.g., COPD	<83	84–85	86–87	88–92	>93–94 on air	95–96 on oxygen	>97 on oxygen
Any supplemental oxygen		Yes		No			
C- Systolic Blood Pressure	<90	91–100	101–110	112–219			>220
C– Heart rate	<40		41–50	51–90	91–110	111–130	>130
D Level of consciousness (score C for confusion)							C, V, P, U
E – Temperature	<35		35.1–36.0	36.1–38.0	38.1–39.0	>39.1	

3.9.2 The National Early Warning Score (NEWS) for NTBP

The inclusion of the NEWS data was used to determine whether the patients were of high acuity, or low acuity, and to explore whether the NTBP was combined with additional adverse symptoms that may indicate a more sinister pathology (Table 13).

Table 13: A summary of NEWS thresholds and triggers (Royal College of Physicians 2012)

NEW scores	Clinical Risk
0	Low
Aggregate 1–4	
Red Score* Individual parameter scoring 3 Aggregate 5–6	Medium
Aggregate 7 or more	High

3.10 Clinical interventions

A review of medicines used by ACs, GPs, advanced ambulance practitioners and one nurse practitioner for the treatment of NTBP was conducted.

For ACs, the administering of Morphine sulphate; Entonox; paracetamol; ibuprofen; diazepam and oxygen were selected for the review. These medicines conform to the current list of drugs available to ambulance clinicians to administer (Brown et al. 2021).

The administration of additional drugs, such as Oramorph, Codeine, Co-codamol, Diclofenac, Gabapentin, Naproxen, Tramadol, Voltarol, and Solpadol, accounted for the administration of medicines by GPs or ambulance advanced practitioners and one community nurse practitioner. These medicines were not routinely administered by ACs but were recorded in the ePRF datasets. Medications were sometimes used in combination therapy for enhancing analgesia (Brown et al. 2021). Ordinal statistics were employed to determine the drugs of choice for the management of NTBP.

The inclusion of medicines was used to investigate how the acuity of NTBP was managed, per call category. Additionally, the presence of pain was investigated to predict transport or non-transport to hospital. Recorded pain scores were used for this purpose. These included all available scores for pre- and post-analgesia.

The numeric pain scale (NRS), which measures pain on a scale of 0–10, is a standardised pain score, used in UK ambulance services. These values were also investigated. A scale of 0 referred to no pain, 1–3 mild pain, 4–6 moderate pain and 7–10 severe pain (Brown et al. 2021). The mean post-analgesic pain score for this population was determined.

Chapter 4 presents the results of the analysis described here in Chapter 3. To achieve this, a discussion of the main findings and how they relate to the four aims of the study is also presented. In particular, these results will be discussed in the context of the previous studies described in the scoping review which identified the most relevant evidence, drawn from the broader literature for NTBP.

Chapter 4: Results

4.1 Overview of the chapter

In the results chapter of this study, the most meaningful results, drawn from the data analysis, are presented. This chapter will summarise the outcomes and interpretations of the research in a structured manner. It includes tables, graphs, and textual explanations to illustrate and support the main conclusions that will be discussed in Chapter 5. This results chapter aims to present a comprehensive and objective account of the research findings, providing a foundation for the subsequent discussion and conclusion chapters.

4.1.1 Introduction

Four research aims are explored in this chapter, which are:

1. What are the demographic characteristics of patients who made 999 calls for NTBP, including socioeconomic status (SIMD) with associated NEWS scores?
2. What is the positive predictive value (PPV) for ambulance clinicians' diagnosis of true NTBP and does this differ by dispatch priority?
3. What is the sensitivity and specificity, positive predictive value (PPV) and negative predictive value (NPV) of aMPDS on objective clinical acuity, as measured by NEWS for ambulance clinicians coded 05NTBP?
4. Which out-of-hospital ambulance clinical interventions were used to treat these patients?

4.2 Research question 1: To establish the patient demographic for NTBP 999 calls in 2018

In 2018, the SAS responded to 649,399 emergency calls across Scotland (personal communication with Alan Brown, SAS 2019). Following the cleaning of the data, 34,148 (5%) were excluded as these were patients who were less than 16 years of age (an exclusion criterion). Of the remaining 615,251 calls, 307,625 (50%) were recorded as being made by women, and 301,473 (49%) by men. Gender was not recorded in 6153 (1%) of the calls. Of the 615,251 calls, 8824 (1.4%) were coded as NTBP (code 05). In Figure 2 the flow chart demonstrates the breakdown of data that was used to answer each research question.

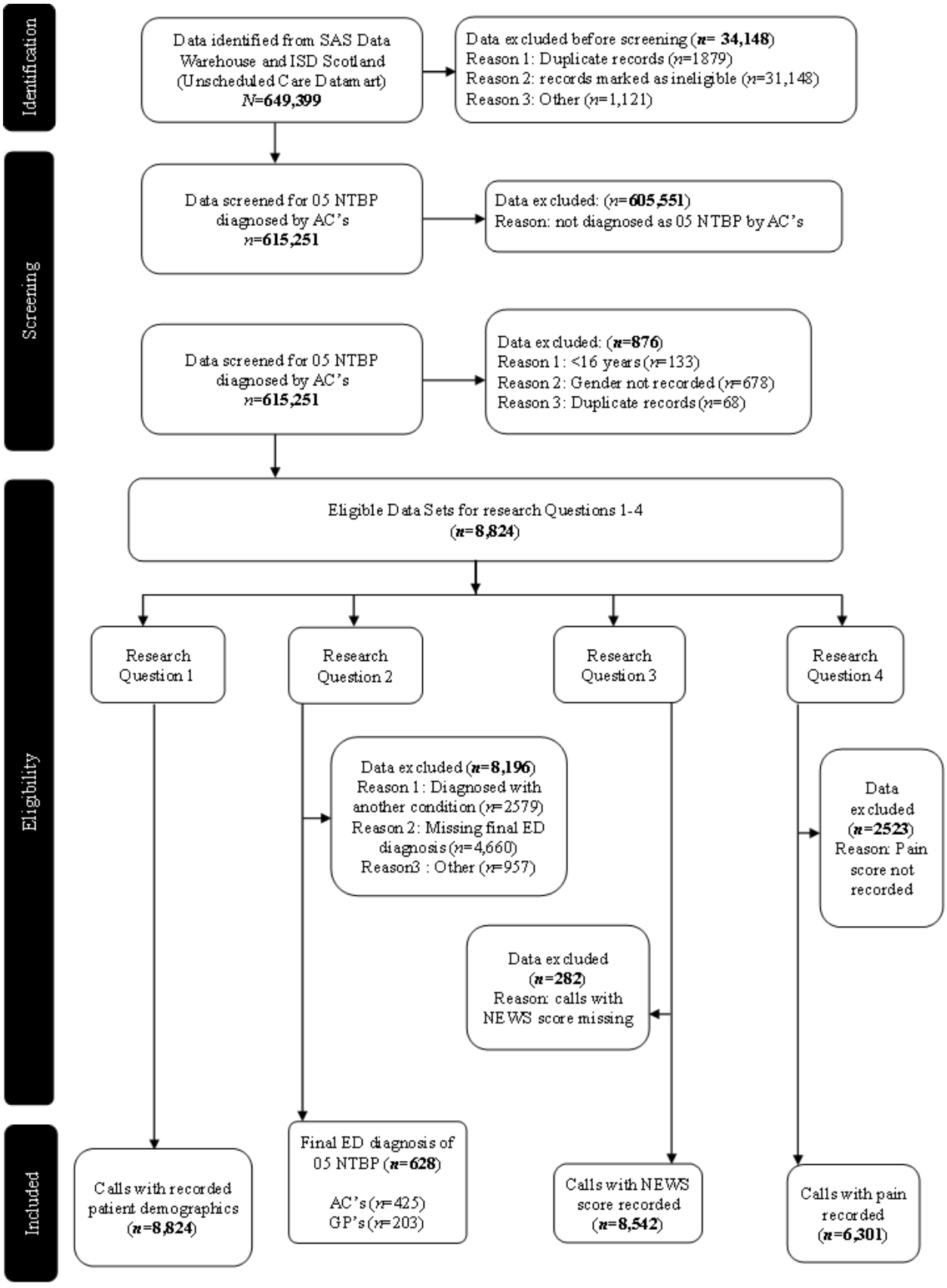


Figure 2: Flow diagram to demonstrate the breakdown of data for each research question

Table 14 demonstrates the median age for all patients that presented to SAS with NTBP. By gender, the median age for women was 62 years, and 58 years for men. The mean age for the whole population was 60.

Table 14: demographics for NTBP patients (8824) presenting to SAS by median age by gender

Gender	Median Age (IQR)
Women	62 (44–79)
Men	58 (42–72)
All	60 (43–77)

Table 15 (page 63) shows the total number of adult NTBP calls, categorised by age and gender. The total number of 999 calls were analysed to determine any differences in calls per patient group. Age was grouped by 10-year intervals (Table 15). The highest number of cases were found in women aged 60–69 years, 1006 (21%) compared to 632(16%) men. The total number of calls for this age group was 1638 (18%). This represented the largest proportion of 999 calls for the collection. In ages 70–79 years there were 888 (18%) women and 458 (12%) men from a total of 1346 (15%) of calls from this age group.

The highest number of calls made by men were found in those aged 50–59 years. This comprised 747 (19%) men compared to 733 (15%) women. The total number of calls for this age group was 1480 (17% of all calls in this age group). In ages 40–49 there were 727 (19%) men and 812 (17%) women, from a total of 1539 (17% of the total of all 8824 calls).

Except for the 50–59 age group, women consistently made slightly more calls than did men. Presentations of NTBP to the SAS were demonstrated to be associated with older women patients. This suggested two possible explanations. The first was that older women were more likely to have a NEWS ≥7. On review of the results, this may be true for all the age groups, statistically.

Table 15: the adult patient population presenting with NTBP to SAS by age group and gender

Both genders by age groups	**Men Frequency (Within group %)**	**Men Overall %**	**Women Frequency (Within group %)**	**Women Overall %**	**Total frequency 999 calls (%)**
16–19	219 (43.1%)	2.4%	289 (56.9%)	3.2%	508 (5.7%)
20–29	516 (47.4%)	5.8%	573 (52.6%)	6.4%	1089 (12.2%)
30–39	597 (49.1%)	6.7%	618 (50.9%)	6.9%	1215 (13.6%)
40–49	727 (47.2%)	8.1%	812 (52.8%)	9.1%	1539 (17.2%)
50–59	747 (50.5%)	8.3%	733 (49.5%)	8.2%	1480 (16.5%)
60–69	632 (38.6%)	7.1%	1006 (61.4%)	11.2%	1638 (18.3%)
70–79	458 (34.0%)	5.1%	888 (66.0%)	9.9%	1346 (15%)
80–89	1 (11%)	0.00%	8	0.1%	9 (0.1%)
90–99	0		0		0
100	0		0		0
Total	3897 (44%)	44.2%	4927(56%)	55.8%	8824 (100%)
Total patients					8824

4.2.1 Repeat 999 calls for NTBP

Any repeat 999 calls that were made to the SAS over 12 months in 2018, were investigated.

Repeat calls were identified by using the patient's name, age, address, and postcode. There were 905 repeat calls for NTBP. Only 10% of patients had more than one 999 response for their condition, over the year (Table 16).

Table 16: All repeat calls for NTBP, made to SAS for 12 months in 2018

Repeat calls for NTBP	**Number of calls made to SAS (n %)**	
0	7919	(89%)
1	402	(4.5%)
2	402	(4.5%)
3	56	(0.6%)
4	16	(0.2%)
5	11	(0.1%)
6	7	(0.1%)
7	4	(0.05%)
8	4	(0.05%)
9	2	(0.025%)
10–14	1	(0.012%)
Total	8824	(100%)

4.2.2 Emergency calls for NTBP by socioeconomic status.

The Scottish Index of Multiple Deprivation (SIMD), status for each patient who called was investigated. This was to review whether SIMD had any association with emergency calls for NTBP. The SIMD status was identified from individual postcode addresses that were input into the Scottish Government's online scoring tool (SIMD 2023). The SIMD online scoring tool is an EXCEL document that enables multiple post codes to be uploaded and provided with a SIMD status. The postcode data was entered manually into the document. The patient population were described as residing within SIMD1, the highest level of deprivation, to SIMD 5, the lowest level of deprivation. Further analysis took place to compare the SIMD status cross-referenced with the C3

aMPDS primary triage data, generated from each 999 call. This showed whether people from areas of high or low deprivation made the most calls to SAS (Office for Health Improvement and Disparities 2022; SIMD 2020).

It was expected that, if the entire Scottish population were divided into quintiles and a random sample of people was taken from any group, 20% of people would be found in each quintile. It was found that 2453 (29%) calling for NTBP lived in SIMD 1 (the most deprived), 1851 (21%) in SIMD 2, 1614 (18%) in SIMD 3, 1303 (14%) in SIMD 4, and 961 (11%) in SIMD 5 (the least deprived) areas of Scotland. These results demonstrated that more people than were expected lived in SIMD 1 and fewer than expected lived in SIMD 5 (Figure 3).

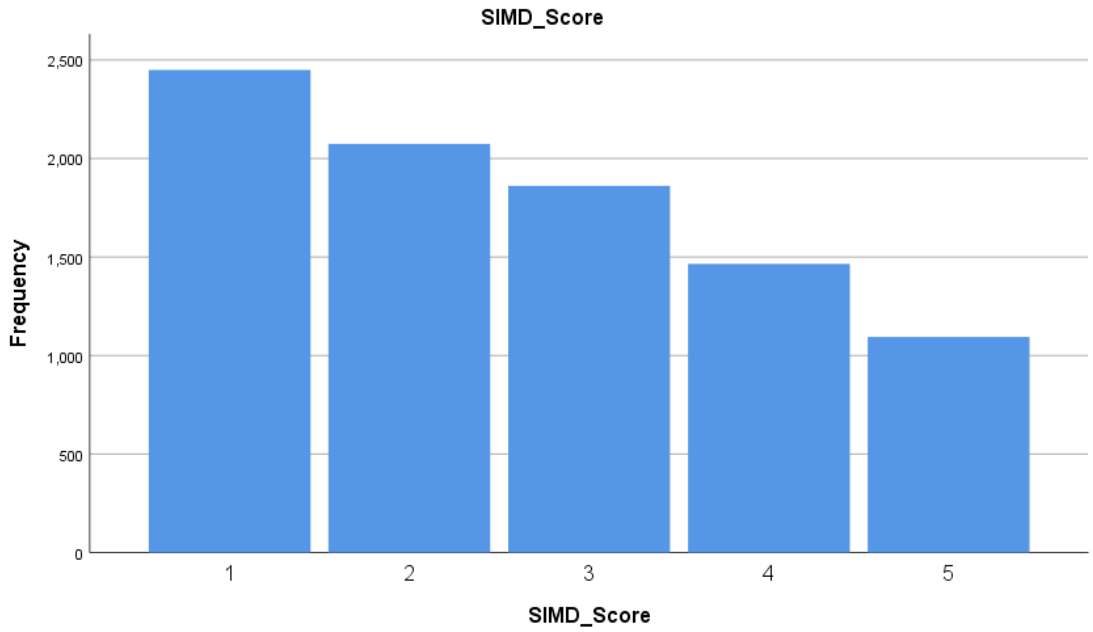


Figure 3: SIMD Score

The results demonstrated a gradual decline in 999 calls as areas became more affluent. This suggested that higher levels of deprivation are associated with a greater number of emergency calls to SAS.

NTBP was found to be more common amongst people living in SIMD 1. It was also possible that their threshold for calling SAS was lower than people living in more affluent areas.

4.2.3 The acuity of NTBP by NEWS and SIMD Status

The NEWS was stratified by age, gender, and SIMD status for presentations of NTBP. There were a total of 8542 (97%) patients with a NEWS score recorded, and 300 (3%) calls for which this information was missing. For the whole population, 4215 (49%) had a score of 0 and were categorised as having no risk, 2033 (24%) were categorised as low risk with an aggregated score of 1–4, 907 (11%) as medium risk with an aggregated score of 5–6, and 1403 (16%) as high risk, with a NEWS of 7 or more (Table 17).

The NEWS scores that were calculated defined the level of acute illness associated with these presentations of NTBP. From these results, it was possible to describe the clinical acuity of the presentation of the patient population.

Table 17: Calls for NTBP by SIMD and NEWS

Total number of Calls for NTBP by SIMD status	**NEWS score 0 No risk**	**NEWS 1–4 Low risk**	**NEWS 5–6 Medium risk**	**NEWS >7 High risk**	**Total calls**
Gender	4215 (49%)	1970 (23%)	923 (11%)	1434 (17%)	8542 (100%)
Men	1911 (45%)	833 (23%)	418 (11%)	545 (15%)	3708 (43%)
Women	2304 (55%)	1137 (23%)	504 (10%)	889 (18%)	4834 (57%)
Age					
16–19	211 (44%)	139 (29%)	61 (13%)	65 (14%)	476 (6%)
20–29	486 (48%)	238 (23%)	150 (15%)	137 (13%)	1011 (12%)
30–39	575 (51%)	306 (27%)	118 (10%)	127 (11%)	1126 (13%)
40–49	740 (51%)	329 (23%)	155 (11%)	223 (15%)	1447 (17%)
50–59	682 (49%)	286 (21%)	155 (11%)	256 (18%)	1379 (16%)
60–69	809 (46%)	438 (25%)	167 (9%)	338 (19%)	1752 (20%)
70–79	692 (51%)	296 (22%)	99 (7%)	257 (19%)	1344 (16%)
80–89	4 (57%)	1 (14%)	2 (28%)	0	7 (0.08%)
Total	**4199 (49%)**	**2033 (24%)**	**907 (11%)**	**1403 (16%)**	**8542 (100%)**
SIMD					
SIMD 1	1235 (48%)	1114 (45%)	92 (4%)	42 (2%)	2483 (29%)
SIMD 2	1081 (51%)	890 (42%)	87 (4%)	43 (2%)	2101 (25%)
SIMD 3	802 (47%)	787 (46%)	74 (4%)	31 (2%)	1694 (20%)
SIMD 4	624 (48%)	608 (47%)	44 (3%)	27 (2%)	1303 (15%)
SIMD 5	406 (42%)	506 (53%)	35 (4%)	14 (1%)	961 (11%)
Total	4148 (48%)	3905 (46%)	332 (4%)	157 (2%)	8542 (100%)

4.2.4 NEWS by age and gender and SIMD status

The clinical acuity of NTBP for this population was analysed. Age, gender, and SIMD were investigated. The age of the adult population was investigated by ten-year intervals, including those calls made by people aged from 16–89 years. These were dichotomised by gender and compared to the calculated NEWS scores for each age category. SIMD data demonstrated the level of acuity of NTBP for the people living in SIMD 1 to SIMD 5.

From the total available population, 4199 (49%) patients had a NEWS of 0, whilst 2033 (23%) had a NEWS of 1–4. When these figures were combined, it was found that, in 6232 (73%) cases, patients did not initially have life-threatening symptoms. This suggests that presentations of NTBP to SAS were usually of low acuity. Moderate NEWS scores of 5–6 accounted for 907 (11%) compared to 1403 (16%) people with a NEWS of 7 or more.

People living in SIMD 1 made the most calls, 2483 (29%) to SAS compared to SIMD 5 961 (11%), which had the fewest. As areas became more affluent, the number of calls for NTBP declined. A NEWS score of 5–6 (medium risk) accounted for 4% and a NEWS ≥ 7 (severe risk) for only 2% of all calls. It was determined that SIMD status did not affect the acuity of NTBP.

The results in Table 18 illustrate that women aged 60–69 years (*n*=1067; 61.4%) and 70–79 (*n*=887; 66%) were the largest patient groups for making calls for NTBP. Table 19 shows that the largest group of men were those aged 50–59 years, with a total of 704 (50.5%).

Table 18: NEWS scores for all women patients by age groups

Women: age groups and frequency per group (%)	*NEWS score 0 no risk*	*NEWS score 1–4 low risk*	*NEWS score 5–6 medium risk*	*NEWS ≥ 7 severe risk*	Totals
16–19 (56.9%)	120	79	35	37	271
20–29 (52.6%)	257	126	79	73	535
30–39 (50.9%)	293	156	60	65	574
40–49 (52.8%)	392	174	82	118	766
50–59 (49.5%)	334	140	76	125	675
60–69 (61.4%)	493	267	101	206	1067
70–79 (66%)	457	195	65	170	887
80–89 (0.1%)	4	0	2	0	6
Total	**2350**	**1137**	**500**	**794**	**4781**

Table 19: NEWS scores for all men patients by age groups

Men by age groups and frequency per group (%)	*NEWS score 0 no risk*	*NEWS score 1–4 low risk*	*NEWS score 5–6 medium risk*	*NEWS ≥ 7 severe risk*	Totals
16–19 (43.1%)	91	60	26	28	205
20–29 (47.4%)	229	112	71	64	475
30–39 (49.1%)	282	150	58	62	552
40–49 (47.2%	348	155	73	105	681
50–59 (50.5%)	348	146	79	131	704
60–69 (38.6%)	316	171	66	132	685
70–79 (34%)	235	101	34	87	457
80–89 (0.1%)	0	1	0	0	1
Total	**1849**	**896**	**407**	**609**	**3761**

By gender and acuity, women aged 60–69 years, along with a NEWS of 5–6, accounted for 101 (9.4%) of calls, and those with a NEWS ≥ 7 accounted for 206 (19.3%) of all cases. For women aged 70–79, a NEWS of 5–6 accounted for 65 (7.3%) and a NEWS ≥ 7 for 170 (19.1%). For men aged 50–59 years, a NEWS of 5–6 accounted for 79 (11.1%) and a NEWS ≥ 7 for 131 (18.6%) of all cases. These results demonstrated that older women were the largest population for NTBP and were more likely to have a NEWS of 5–6 (medium risk) or a NEWS ≥ 7 (severe risk).

When the moderate and severe calls were combined, 2310 (27%) of people were suggested to be unwell. This finding indicated that NTBP can present as a more serious or potentially life-threatening condition. This also indicated that NTBP could not always be considered low acuity, and that it sometimes required immediate medical care from SAS.

4.2.5 SIMD status and NEWS

Comparing the SIMD status for each person who called with their NEWS records overall indicated that there was no difference between NEWS scores and SIMD status. This demonstrated that people living in more affluent areas were just as unlikely to be unwell with NTBP as people living in areas of high deprivation.

4.2.6 The total of all emergency calls made to SAS in 2018

All patients were recorded as 05 NTBP by the attending ambulance clinicians. Table 20 shows how all calls for NTBP and non-NTBP were distributed according to priority. The data presented in this table enabled a comparison of five classifications and helps to demonstrate the variability in clinical acuity classifications of NTBP presentations of this population to SAS. These are shown in columns one to four. Column one indicates the C3 aMPDS levels following telephone triage by ambulance call takers and dispatchers. The total incident counts show how many calls SAS responded to by level of acuity, in 2018. The calls for 05 *back pain* represent a subset of all calls that are included in the main dataset. The final number of ED diagnoses for the calls coded as 05 NTBP are recorded in column four. A comparison of these data enabled an exploration of the severity of NTBP and its final ED diagnosis (columns 3 and 4).

Table 20: All calls for NTBP ACs' diagnosis and Final ED diagnosis

C3 call colour	Total Incident count totals for all calls (n %)		999 calls coded 05 NTBP by ambulance clinicians		Final Emergency Department diagnosis of NTBP
Purple priority 1	9591	(0.1%)	8	(0.1%)	0
Red priority 2	67,535	(11%)	230	(3%)	9 (1.4%)
Amber priority 3	119,018	(19%)	1654	(19%)	82 (13%)
Yellow priority 4	318,361	(52%)	4739	(55%)	296 (47%)
Green priority 5	5936	(1%)	117	(1%)	6 (0.95%)
Unknown	1610	(2%)	20	(0.22%)	1 (0.15%)
GP Urgent Calls	117,919	(19%)	2048	(23%)	226 (36%)
Routine/planned	9240	(1.5%)	8	(0.09%)	2 (0.31%)
Total	615,251		8824		628

4.2.7 Clinical Response Model colour hierarchy levels for ambulance response

The priority of each of the calls included in the analysis was described by a colour which determined the level of ambulance response (see Table 21). Considering this variable afforded independent analysis of the system from the population of patients presenting with NTBP (Lalkhen and McCluskey 2008).

Table 21: hierarchy of emergency calls by colour

Purple Response Category • Highest response priority • Cardiac arrest rate over 10% • Responded to with the closest ambulance resource • Paramedic attendance essential • Minimal of three responders + double crewed ambulance if not in that response • Consider partner agencies to support the response
Red Response Category • Second highest response category • Cardiac arrest rate >1% and defined need for resuscitation • Response with the closest resource + double crewed ambulance if not in that response • Paramedic attendance essential
Amber Response Category

• Third response category • <1% cardiac arrest and no defined acute pathway care • Response with the right resource – emergency transporting ambulance • Paramedic attendance preferred
Yellow Response Category • Fourth response category • <1% cardiac arrest and no defined acute pathway care • Response with the right resource- ambulance for defined hospital need and PRU for potential alternative pathway care
Green Response Category • Fifth response category • Exclusion of the above categories • Potential for additional clinician-led telephone triage • Face-to-face assessment when required

Within the context of aMPDS and C3 categorisation, the greatest proportion of NTBP fell under the yellow call response, with a total of 4860 (55%). This reflected the largest population of emergency ambulance workload in emergency calls for 2018, which too were yellow, and numbered 38,361 (52%). The highest acuity calls, those for purple (0.09%) category response level one, and red, category response level two 249 (3%), represented the smallest proportion of all calls. Amber calls were categorised as the third response level. They accounted for 1656 (19%) of these data. Only 117 (1%) of calls were green, triaged as the lowest priority level. Doctors' urgent and planned calls were arranged by GPs and were coded 05 *back pain* by attending ambulance clinicians. These results suggested that a high proportion of patients with NTBP were not determined by aMPDS to be of high acuity, with life-threatening conditions.

From linked data, provided by IDS Scotland, it was found that only 628 (7%) of the 8824 patients who called with NTBP were diagnosed with ICD-10 M54 dorsalgia, or true lower back pain (WHO ICD-10 2021) (Table 22). This suggests that patients were more often recorded as being symptomatic of back pain rather than having true dorsalgia. This finding indicated that presentations of true NTBP were small-scale and not a common presentation in prehospital care.

Table 22: aMPDS description of all calls diagnosed 05 NTBP

aMPDS Code	Dispatch description	C3 colour					
		Green *n* (%)	Yellow *n* (%)	Amber *n* (%)	Red *n* (%)	Purple *n* (%)	Total call number
01	Abdominal pain	1	125	6	0	0	132
02	Allergic reaction	0	3	0	16	0	19
04	Assault	0	24	0	0	0	24
05	Back pain	36	1400	34	0	0	1470
06	Breathing problems	0	101	318	60	3	482
07	Fire, persons reported	0	4	0	0	0	4
09	Cardiac arrest	0	0	1	1	2	4
10	Chest pain, breathing difficulties	1	3	952	0	0	956
11	Choking	0	0	0	1	0	1
12	Fitting	1	7	0	20	0	28
13	Diabetic emergencies	0	12	0	1	0	13
14	Drowning	0	0	0	1	0	1
16	Eye injury	0	1	1	0	0	2
17	Fallen	13	480	20	22	0	535
18	Headache	0	5	0	0	0	5
19	Heart problems/ chest pain	0	8	19	2	0	29
21	Haemorrhage	0	53	1	1	0	55
22	Inaccessible incident	0	1	0	0	0	1
23	Overdose	0	22	0	1	0	23
24	Obstetric birth	0	5	0	8	0	13
25	Threatened suicide	0	11	0	1	0	12
26	Sick person abnormal breathing	8	224	51	0	0	275
27	Central stab wounds	0	0	0	1	0	1
28	Stroke	0	20	59	0	0	79
29	Transportation Accident	0	40	0	20	2	62
30	Traumatic injury	9	512	1	18	0	540
31	Unconscious, or fainting	3	167	1	16	3	190
32	Unknown problem	1	17	0	4	0	22
33	Various emergency conditions	1	1415	105	37	0	1558
99Y99	No description	0	1	0	0	0	1
CSDA-Y	No description	0	0	65	2	0	67
SSDR-Y	No description	0	6	0	1	0	7
C3	No dispatch description	43	103	19	0	0	165
GPs calls	Various descriptions	-	-	-	-	-	**2048**
Total	**All calls for NTBP**	**117**	**4767**	**1654**	**230**	**8**	**8824**

4.2.8 How the initial calls for NTBP were triaged by aMPDS

A comparison of aMPDS initial triage, ambulance clinicians working diagnosis of 05 back pain, and the ED clinicians' final diagnosis for these data, was conducted. A total of 33 aMPDS codes were assigned, each with a colour categorisation and a dispatch

description. All calls were diagnosed as NTBP by ACs following their working assessment. The aMPDS code and dispatch description show how these calls were initially triaged by ambulance call takers and dispatchers. It was found that 1479 (16.7%) of these calls were coded 05 *back pain* by caller triage and ACs (Table 22).

4.2.9 The final medical diagnosis of 05 back pain

A final medical diagnosis for each call was obtained from ICD-10-linked data. It was found that the ED clinicians' diagnosis for these patients was often complex. Of all the calls that were admitted via ED, only 628 (7%) received a final diagnosis of M54 Dorsalgia, acute back pain, from ED clinicians (WHO 2020). These diagnoses are presented alphabetically in Table 22, demonstrating the range of conditions these patients had. From the total data included in the analysis, 3240 (36%) patients were diagnosed with a specific condition. There were 5584 (64%) cases where the final diagnosis was not recorded. These patients were diagnosed as 05 NTBP by ACs without a final ED diagnoses it was not possible to verify a cause of their symptoms. The incomplete recording of data presented a significant challenge for this thesis and this finding was consistent with SAS and ISD Scotland. There were 304 final diagnoses for NTBP made for patients who were originally categorised by SAS call takers and ACs as 05 NTBP. The final diagnoses recorded for all patients are summarised in Table 23. The final medical diagnoses suggested that a prehospital working diagnosis of NTBP was difficult. The ambulance clinicians described the main symptoms patients had, which were recorded as 05 NTBP back pain.

Table 23: Final ED diagnosis of all calls coded 05 NTBP by ambulance clinicians

ED final diagnosis	Number of patients
Abdominal and pelvic pain Abnormalities of gait, heartbeat diagnostic imaging, breathing, mobility and movement, Abscess of Anal and Rectal Regions, Actinomycosis (rare bacterial infection) Acute, renal failure, myocardial infarction, tubule-intestinal nephritis, pancreatitis, sub-acute endocarditis. Adverse effects, not elsewhere classified Agranulocytosis (low WBCs). Aortic aneurysm and dissection, angina pectoris, atrial fibrillation and atrial flutter, alcoholic liver disease, Alzheimer's disease,	284
Bacterial infection of unspecified site, bacterial pneumonia, bronchiectasis, benign neoplasm of ovary, burn and corrosion of head and neck	12
Calculus of kidney and ureter, cholelithiasis, cholecystitis, chronic ischaemic heart disease, cellulitis, cerebral infarction, chronic kidney disease, cardiomyopathy, cervical disc disorders. Complications of procedures, not elsewhere classified, genitourinary devices, implants, and grafts. Cutaneous abscess, furuncle and carbuncle, coxarthrosis (arthrosis of the hip), Crohn's disease, cystic kidney disease	199
Delirium, not induced by alcohol and other psychoactive substances, diaphragmatic hernia. Diseases, of the tongue, mineral metabolization, salivary glands, continuity of bone, diverticular disease of the intestine, disorders of the continuity of bone, dislocation, and sprains, dissociative (conversion)disorders, dizziness and giddiness, disturbances of skin sensation. Dysphagia, duodenal ulcer	70
Dorsalgia	628
Epilepsy, examination and observation for other reasons, essential hypertension	10
Fractures, lumbar spine and pelvis, neck, sternum and thoracic spine, ribs, multiple body regions, faecal incontinence, fibrosis and cirrhosis of the liver, fibroblastic disorders, fracture of the femur, follicular lymphoma,	246
Gastro-Oesophageal Reflux Disease, Gastritis and Duodenitis, Gastric Ulcer	12
Hypotension, heart failure, hepatic failure, hyperplasia of the prostate, haemangioma and lymphangioma, hyperparathyroidism and other disorders	26
Influenza, seasonal, non-identified virus, intracranial injury. Injuries to the eye and orbits, nerves of the spinal cord and neck, unspecified body parts, irritable bowel syndrome, intracranial, intraspinal abscess and granuloma	30
Lymphoid leukaemia, leiomyoma of uterus	3
Malaise, various malignancies, mental and behavioural disorders due to alcohol, meningitis, myositis	165
Non-inflammatory disorders of the ovary, fallopian tubes and broad ligament, nausea and vomiting, nerve root and plexus compressions in diseases, non-follicular lymphoma, nonrheumatic aortic valve disorders, neuromuscular dysfunction of bladder, not classified elsewhere.	28
Other disease and disorders (numerous diagnoses from abdominal hernia to other signs and symptoms involving the nervous and MSK systems)	923
Pain in throat and chest, pneumonia, pulmonary embolism, poisoning by psychotropic drugs, pyogenic arthritis, pain not classified elsewhere, pulmonary oedema, paralytic ileus and intestinal obstruction, without hernia, pneumonitis due to solids or liquids, pleural effusion, pyogenic arthritis, Parkinson's disease, phlebitis, pyothorax, pilonidal cyst, pneumothorax, portal vein thrombosis, postprocedural disorders of the digestive system.	274
Retention of urine, reactive arthropathies, respiratory failure, not classified elsewhere	13
Scoliosis, syncope, secondary malignancies, senility, superficial injuries various, spondylosis, sickle cell disorders, stomatitis and related lesions, streptococcal sepsis, sleep disorders, shoulder lesions, shock not classified elsewhere	141
Tubulo-intestinal Nephritis, non-specified, the toxic effect of corrosive substances, TIA, Type 1 diabetes mellitus	21
Unspecified (various), acute lower respiratory infection, renal colic, urticaria, haematuria, dementia, unknown causes of morbidity, ulcer of limb	96
Various infections of unspecified sites, ventral hernia vasomotor and allergic rhinitis, vascular disorders of the intestine, varicella (chickenpox), viral pneumonia	15
Total number of recorded diagnoses from ED	3240
Not recorded	5584
Number of conditions diagnosed from 05 NTBP	304
Total number of available patients	8824

4.3 Research question 2: What is the positive predictive value (PPV) for ambulance clinicians' diagnosis of true NTBP and does this differ by dispatch priority?

A breakdown of all calls diagnosed as 05 NTBP by ACs was compared to the final ED diagnosis to determine the accuracy of the detection and diagnosis of NTBP by AC. There were 8824 cases available for this analysis. These data were obtained from linked data shared between SAS and ICD Scotland. Dorsalgia was diagnosed in 628 cases. Given that a final ED diagnosis was not recorded in 5588 cases of patients presenting to SAS with NTBP, it was not possible to determine the accuracy for most diagnoses. It was possible to determine the PPV for doctors' urgent and routine calls.

The linked dataset, obtained from ISD Scotland, contained the final ED diagnosis for NTBP. However, it did not contain all the recorded clinical information such as NEWS, pain scores or analgesics provided by ACs. This accounted for the slight difference in results between the two datasets that had to be used to investigate each research question.

The positive predictive value (PPV) demonstrated ACs' and GPs' ability to diagnose true NTBP (dorsalgia) in the prehospital setting.

4.3.1 Analysing the PPV

The PPV was calculated to determine the accuracy of ACs and GPs' diagnoses of 05 NTBP analysis one and two. Sensitivity and specificity for analysis three were used to examine the accuracy of the ability of aMPDS to triage the acuity of NTBP. This was measured against all available NEWS scores. The sensitivity compared the true status of the acuity of people with NTBP. The specificity was the proportion of people triaged as not being high acuity cases by aMPDS or ruled out as being unlikely to be severely unwell (Lalkhen and McCluskey 2008).

- Analysis 1: Investigated the PPV for ACs' and for doctors' urgent and routine calls for 05 NTBP.
- Analysis 2: Investigated the PPV for ACs' diagnosis of 05 NTBP by C3 colour coding of green, yellow, amber, and red calls.
- Analysis 3: Investigated the sensitivity and specificity of aMPDS on objective clinical acuity measured by NEWS for called coded 05NTBP by ACs.

The calculations for tests 1 and 2 were determined through the analysis of the total data of 8824 calls diagnosed as 05 NTBP by ACs (Tables 24 and 25).

Test 3 was determined through making a comparison between the clinical acuity of these patients demonstrated by NEWS and coded as 05 NTBP by ACs.

Table 24: PPV of NTBP by Call Categorisation, Final AC Diagnosis and Conveyance Outcome

C3 call colour	Coded as NTBP by ACs	Not transported to ED	Final ED diagnosis missing	Total with an ED diagnosis	Confirmed as NTBP by ED Clinician	Other condition diagnosed	PPV
Purple	8	6	3	0	0	0	N/A
Red	230	40	63	168	10	158	5.95%
Amber	1654	10	1150	598	92	516	17.8%
Yellow	4767	1276	2118	1602	317	1275	19.9%
Green	117	57	42	23	6	17	26.1%
Subtotal with aMPDS code *	*6776*	*1393*	*3376*	*2340*	*425*	*1972*	*17.7%*
GP's urgent calls **	2048	N/A	1273	840	203	607	23.6%
Overall total	**8824**	**1393**	**4660**	**3240**	**628**	**2579**	**19.3%**

*PPV of Ambulance Clinician diagnostic accuracy

**PPV of GP diagnostic accuracy

A total of 8824 calls were coded as 05 NTBP by ambulance clinicians, 7431 (84.2%) of which were transferred to ED. This meant that 1393 (15.7%) of these patients were left at home with a final diagnosis of 05 NTBP. This SAS dataset does not record whether any of these patients sought any further medical attention afterwards.

Of the 7431 patients who were transferred to ED, the final diagnosis for 4660 (60%) calls were not recorded by ED, as their system (ISD Scotland) permits a blank option for final diagnosis, which is not possible on the SAS C3 data system.

Of the 3240 (41.1%) patients who were transferred to ED where a final diagnosis had been recorded, 628 had a final diagnosis of dorsalgia. This resulted in a combined PPV for ACs and GPs of 19.3%.

True emergency calls (i.e., those solely attended by ACs) accounted for 7156 of these calls. Of these, only 5767 patients were transported to the hospital, where 2391 had a final diagnosis recorded. A total of 425 of these were found to be dorsalgia, resulting in a PPV for ACs of 17.7%.

GPs' urgent and routine calls account for 2113 (23.9%) of these calls. All these patients were transferred to the hospital with a final code of 05NTBP, entered by ACs based on the GPs' diagnosis/reason for transfer to the hospital. Only 840 had a final ED diagnosis recorded, of which 200 were dorsalgia. This resulted in an overall PPV of 23.6% for GPs.

From the 8824 calls diagnosed as 05 NTBP by ACs, 1426 calls were call triaged as 05 NTBP by aMPDS. On further analysis, 234 (2.5%) of these were identified as being coded as purple and red. Purple and red calls receive the highest priority-based dispatch, established on the caller's descriptions of life-threatening conditions. These do not include NTBP. This demonstrated that aMPDS was not good at identifying NTBP, which is thought to be a low-risk condition.

Table 25: number of calls diagnosed as 05 NTBP by ACs compared to initial aMPDS triage

C3 call colour	Diagnosed as 05 NTBP by ACs	Call triaged as 05 NTBP by aMPDS
Purple	8	0
Red	249	0
Amber	1656	33
Yellow	4860	1348
Green	117	32
Unknown	20	N/A
Doctor's urgent calls	2057	N/A
Routine or planned	8	N/A
Missing data	151	N/A
Overall total	**8824**	**1426**

4.4 Research question 3: Sensitivity and specificity PPV and NPV of aMPDS on objective acuity measured by NEWS for ambulance clinician coded NTBP

These SAS and ISD data contained all ambulance clinician-coded NTBP within the SAS during the 12-month period. The numerator is the number of patients with NTBP who had a positive test, and the denominator is the total number of patients with NTBP

tested. Therefore, in this case, the denominator is ACs' diagnosis, and the numerator, the test, is the aMPDS triage. The purpose of this analysis was to determine the accuracy of aMPDS in identifying the true clinical acuity of these patients. This test was important, as aMPDS was developed to identify patients with the greatest clinical need.

For this analysis, the NEWS score recorded by ACs was used as a proxy measure for clinical acuity. Generally, a NEWS ≥=7 is associated with higher clinical risk, and within the hospital requires immediate referral to a critical care team. Evidence from prehospital care suggests 48-hour mortality rates of around 70% for this patient population. It is reasonable to suggest that these patients would benefit from rapid ambulance response and should be categorised by aMPDS as a red or purple call. The accuracy of aMPDS to identify true positives (TP), i.e., those calls that were categorised by aMPDS as red or purple that also had a NEWS ≥=7, and the true negatives (TN), i.e., those that did not receive a purple or red call that had a NEWS ≤=7, was measured. Table 26 includes the breakdown of these results to support the calculation of PPV and NPV of aMPDS on its clinical acuity.

Table 26: Comparison of NEWS triage of NTBP by ACs and aMPDS

	aMPDS predicts high clinical acuity	**aMPDS predicts moderate to low clinical acuity**
Actual clinical acuity NEWS ≥= 7	True Positive (TP): Identified C3 aMPDS high acuity/ NEWS ≥7. n=5	False negative (FN): Categorised by C3 aMPDS as low acuity/ NEWS ≥=7. n=186
Actual clinical acuity NEWS <= 7	False Positive (FP): Identified C3 aMPDS high acuity/NEWS <7 n=232	True Negative (TN): Categorised by C3 aMPDS as low acuity/ NEWS <7 n=7802

4.4.1 Outcome of testing

The low sensitivity and high specificity suggested that the aMPDS was more likely to miss high acuity presentations of NTBP (Lalkhen and McCluskey 2008).

- Sensitivity = TP/ (TP+FN) = 5/ (5 + 186) = 2.6%
- Specificity = TN/ (TN + FP) = / (7802+232) = 97.11%

- Positive Predictive Value (PPV) = TP/ (TP + FP) = / (5+232) =2.1 %
- Negative Predictive Value (NPV) = TN/ (FN+TN) = 7802(186+7802) = 97.6%

The aMPDS was not good at detecting high clinical acuity for NTBP as defined by NEWS ≥7. This was determined by the low sensitivity of 2.6% and low PPV of 2.1%. The high specificity of 97.6% suggests that patients who were triaged to be moderate to low clinical risk by aMPDS were of true clinical risk (NEWS <7).

4.5 Research question 4: To explore what out-of-hospital ambulance clinical interventions were used to treat these patients

The medications administered to these patients (categorised as 05 NTBP) were investigated. These medications were administered by either ACs (ambulance paramedics or technicians), or, in some cases, by GPs or the advanced specialist practitioners who attended some of the calls. Table 27 describes the common drugs prescribed by ACs and GPs for managing the symptoms of NTBP. It is important to note that ambulance technicians may only administer Entonox, paracetamol and ibuprofen for analgesia, whilst paramedics may prescribe morphine and diazepam in addition to these drugs. The other medications listed in this table (from Oramorph onwards) can only be administered by GPs/and or advanced specialist practitioners.

Table 27: Medications used to treat 05 NTBP for all patients

List of medications for 05 NTBP	*Total number of medications used by ACs and GPs to treat 05 NTBP*	*Patients transported to ED with analgesia (as a single drug or in combination therapy)*	*Patients provided with analgesia (as a single drug or in combination therapy) but were left in the community*
Entonox	2409	2226	183
Morphine	1055	1024	31
Paracetamol	568	148	420
Ibuprofen	278	118	160
Diazepam	31	24	7
Oramorph	2	0	2
Codeine	7	3	4
Co-codamol	25	5	20
Diclofenac	34	34	0
Gabapentin	1	1	0
Naproxen	2	1	1
Tramadol	2	2	0
Voltarol	1	1	0
Solpadol	1	1	0
Totals	4416	3588	828

Some patients received a combination therapy, receiving some drugs from the ACs and some from the GP/advanced practitioner present. It was not possible from the SAS dataset to accurately separate these data per patient or to determine whether calls were attended by a double ambulance technician crew only (which would limit the range of medications that could be prescribed). It was also not possible to determine whether these data were simply missing.

In addition, the SAS dataset did not record whether the patient refused analgesia altogether. A total of 4416 medications (singularly or in combination therapy) were administered to some of the 8824 adult patients on the SAS dataset.

It was found that Entonox, administered in 2409 (54%) SAS calls, morphine in 1055 (24%) calls, paracetamol (13%), and ibuprofen, together, in 286 (6%) calls, appeared to be ACs' analgesic drugs of choice for these patients. The analgesic inhaled gas Entonox (BNF 2023a) and IV morphine are usually administered for patients with moderate or severe pain (BNF 2023b). This was confirmed by the average pain score of 6 recorded for those patients who were administered these medications. All other listed medicines are normally administered by a GP or other prescribing advanced health care professional. These drugs were not within the scope of ACs' practice in 2018.

The presence of additional drugs administered to the patients included in the analysis, from Oramorph to Solpadol, as listed in Table 27, accounts for GP visits that generated urgent and routine calls to SAS. It was demonstrated that Oramorph (0.02%), codeine (0.07%), Co-codamol (0.28%), Diclofenac (0.38%), Diazepam (0.35%), Gabapentin (0.01%), Naproxen (0.02%), Tramadol (0.02%), Voltarol (0.01%) and Solpadol (0.01%) were used to treat NTBP. These medications are also used in combination therapy for enhancing analgesia (Brown et al. 2021).

Normally, and in accordance with practice guidelines, medication is only be administered to patients who are found to be in pain, and the type of analgesia administered depends on the severity of that pain (and the grade of ACs in attendance). By examining the pain score for the calls for which this information was recorded, it was possible to eliminate the number of patients who did not receive any drug therapy at all, as they had a pain score of 0 (no pain), and patients with a pain score of 0 would not require or be administered any analgesia.

There were 304 patients recorded as not being in pain on the first examination by ambulance clinicians. Analgesia was only provided to patients who had a pain score of 1 or more (Table 28).

Table 28: a comparison of pain scores pre- and post-analgesia

Pain score	The number of patients recording pain scores before analgesia	The number of patients recording pain scores after analgesia
0 no pain	304	2149
1–3 Mild pain	955	465
4–6 Moderate	2347	1169
7–10 Severe	2695	1470
Not recorded or missing	2523	3571
Total No Recorded	6301	5253
Total number	**8824**	**8824**

An influencing factor on whether analgesia was given and what type of analgesia was given may have been down to the time that the ACs spent on scene and the distance from ED. From this SAS dataset it was not possible to evaluate this. ACs only administer paracetamol as fast-melt tablets. This dispersible form of paracetamol starts to become effective in 15 minutes with peak plasma concentration in 30–90 minutes, whilst paracetamol in tablet form takes up to 30–45 minutes to take effect (tablets are not carried by SAS). For ibuprofen, it takes 30 minutes to become effective with a peak plasma time of 1 to 2 hours (Datapharm 2022). The duration of time that the ACs were on the scene may indicate that they started effective treatments but left before full analgesia was obtained. A larger number of patients received paracetamol and ibuprofen over stronger medications (e.g., IV morphine). This finding suggests that these over-the-counter medications may have been very effective for some people with NTBP.

4.5.1 Modified Pain scores

Whether pain scores alone accounted for ambulance transport or non-transport to ED was explored. These factors were evaluated on all known pain scores that were taken before or after analgesia was provided. It was thought that a pain score ≤4 would be more likely to result in non-transport to ED.

The overall mean pain score was 6, which was described as moderate to severe. These results were calculated on the average of all recorded pain scores before any analgesia was administered. From the total dataset of 8824 calls, this information was recorded for 2807 (31.9%) patients, and, for 6017 cases (68.1%), this information was not recorded or missing. A pain score of 6 or greater indicated that some people had experienced pain that was associated with a higher level of discomfort. This finding suggested that pain levels associated with NTBP could have been an influencing factor for some of the 999 calls. There were 845 (9.6%) patients who were not transported to ED but did receive some type of analgesia from SAS or attending GPs. Their mean pain score after pain modulation was found to be 4 out of 10. This suggests that, on average, these people remained in a moderate level of pain.

4.5.2 Patients transported or not transported to ED by pain score

A large proportion of patients were not recorded with an initial pain score, which impacted the accuracy of this analysis. To ensure rigour, only patients with pre-analgesic and post-analgesic scores were included. From 237 patients, it was found that 689 (29%) had a moderate to severe pain score and were not transported to ED. The highest number of patients were recorded as having a pain score of 8 (21%) (Table 29).

Table 29: number of patients with moderate to severe pain not conveyed to ED

Numeric rating score for pain	Description of pain	Number of patients not conveyed to ED
4	Moderate	71 (10%)
5	Moderate	124 (18%)
6	Moderate	97 (14%)
7	Severe	92 (13%)
8	Severe	142 (21%)
9	Severe	72 (10%)
10	Severe	91 (13%)
Total		**689 (29%)**

It was thought that all patients who were found to be in severe pain, modified or not modified by analgesia, would always result in transport to ED. Due to their potency and requirement for close monitoring, two medications were thought to be predictors for transport to ED by SAS. Intravenous (IV) morphine was administered but the patient not transported to ED in 31 cases (0.35%). IV or rectal Diazepam was administered but,

again, the patient was not transported to the hospital in 24 cases (0.27%) (Brown et al. 2021). It was not possible to determine why these patients were not transported to ED from the available data. Table 30 demonstrates that patients were transported to ED with no to moderate pain following analgesia.

Table 30: number of patients with no to low pain conveyed after analgesia by ACs

Numeric rating score for pain	Description of pain	Number of patients conveyed to ED
0	No pain	815 (71%)
1	Mild	20 (2%)
2	Mild	69 (6%)
3	Mild	119 (10%)
4	Moderate	126 (11%)
Total		**1149 (13%)**

Being in pain was a factor that influenced ambulance transport or non-transport to ED. It was suggested that there were other factors that determined conveyance. These findings were supported by the range of diagnoses for NTBP. These additional factors would have to be reviewed by individual patient, and would require further study.

The results presented here in Chapter 4 are discussed in detail in the next chapter.

Chapter 5: Discussion

5.1 Overview of the Chapter

Chapter 5 presents a discussion in response to the four main research questions, structured in the order which the analysis was performed. All of the main findings are compared to established research relating to what is known about presentations of NTBP. This discussion focuses on the practical implications of these findings, which relate to the assessment and management and diagnosis of NTBP for ACs working in the SAS. The chapter concludes by presenting several recommendations and offers a narrative in the form of considering the study's strengths, limitations, and potential biases.

5.1.1 Research question 1: What are the demographic characteristics of patients who made 999 calls for NTBP in 2018?

Describing this population's demographic characteristics was necessary for understanding whether there were any unique needs or challenges associated with prehospital presentations of NTBP. The main demographic characteristics examined were age, gender, and socioeconomic status. Demographic characteristics affect many aspects of healthcare, including disease risks, responses to medical treatment, and the patient's care experiences (DePalma 2020). Understanding these demographic characteristics and determining whether they contributed to prehospital presentations of NTBP to SAS is an under-researched phenomenon. Because demographic characteristics are relevant to presentations of NTBP in hospital, seeking similar findings in the literature may help inform ambulance care through a standardised approach (DePalma 2020).

5.1.2 The Demographics of Scotland for Presentations of NTBP to SAS

The people who made more emergency calls to the SAS for NTBP were more likely to be women. In 2018, Scotland had a population of 5.437 million (National Records of Scotland 2021). According to the mid-year census, 51% of the population was female, and 49% was male (National Records of Scotland 2021). There were approximately 150,000 more females than males living in Scotland in 2018 (ONS 2022). In the year of data capture, the SAS responded to 649,399 emergency calls (Mr Alan Brown, personal

correspondence). Of these calls for all ages, 324,699 (50%) were female, and 321,144 (49%) were male, with 3555 (1%) cases where gender was not recorded. These data demonstrated that neither gender made more or fewer calls to SAS than the other. Following data cleaning and excluding children, the 8824 calls for NTBP, 4927 (55.8%) were women compared to 3897 (44.2%) who were men.

Overall, this analysis places a lens on the unique biological, social, and cultural factors that contribute to differences in healthcare conditions. Buchbinder et al. (2018) discuss the significant public health problem of back pain and consider how society needs to do more to address a growing problem. The UK Government, Scottish Parliament and NHS Scotland are taking various approaches to improve healthcare. This demonstrates that conditions such as NTBP are societal and will take many measures to address. Evidence for the societal impact NTBP can be noted by the millions of people it affects worldwide (GBD 2021; GBD 2019; Buchbinder et al. 2018). Its outcomes significantly impact on health, work, and quality of life (GBD 2021; GBD 2019). Scotland has an aging population, poor health and low life expectancy compared to other economically developed countries (Douglas et al. 2017). Douglas et al. (2017) found there are significant health inequalities in health outcomes across different groups of older people living in Scotland. Thus, presentations of NTBP which have been suggested to increases due to population expansion and ageing require careful consideration (GBD 2021; Douglas et al. 2017). NTBP has also been demonstrated to contribute to an increasing loss to work productivity therefore attributing to higher costs for health care providers, which then impose further economic burdens on people and wider society (GBD 2021; GBD 2019). Some of these factors are reflected by the SAS, noted through the development of guidelines and policies to improve ambulance delivery and care. For example, the SAS has worked to increase public awareness of using ambulances. In these data, women were more likely to call SAS, which suggests consideration should be made for developing services that better suit them. This would require further research, as the analysis of descriptive data limits the possibilities to explore this issue.

5.1.3 The Age of the people who called 999

Broader literature associates the causes of NTBP with a variety of factors (GBD 2021; Buchbinder et al. 2018). Age was an essential factor in the presentations of NTBP to SAS. However, it was not necessarily the determining influence for emergency calls.

While it was confirmed that it was more likely to affect older people, people of all ages had called the SAS. Ten people aged 16–24 years were diagnosed with dorsalgia, and 14 for the 16–29-year-old age group. Unexpectedly for dorsalgia, this younger group were more likely to be male. The analysis of the call descriptors suggested that young men were more likely to be associated with traumatic injuries (Taylor et al. 2017; Udry 1998). Trauma was not found to be a cause in any of the women patients in any of the age categories from 16–89 years.

NTBP was represented in each patient group from 16–89 years of age. In comparison with one other UK prehospital study, Capsey et al. (2022) found that people aged 41–50 and 71–80 years were the largest age groups presenting with NTBP. The mean age for Scotland was 60, but the actual demographic for age was much broader than was anticipated. In the youngest age groups, 16–29 years, there were 17.9% patients. For ages 30–69, there were 66.5% patients, and for ages 70–89 15.1%. People aged 80–89 accounted for 0.1% of the sample (table 15). It was demonstrated that NTBP affected people of all ages, with the oldest being the smallest sample size. Some research from primary health care indicates that NTBP commonly affects people aged 30–60 (GBD 2021). This demonstrates the caution of assuming that NTBP is an age-specific condition. Presentations are often associated with arthritic spinal changes that can start at 30 and occasionally be younger. Notably, NTBP can affect paediatric patients, too (Roberts et al. 2019). NTBP unexpectedly affected a more significant number of younger people than was anticipated. This rationale was based on evidence-based research that found that paediatric causes for illness and injuries differ from adults. It is recommended that presentations of NTBP for children require guidance from paediatric specialists, acknowledging that children are anatomically and physiologically different to adults (Kliegman et al. 2021; Roberts et al. 2019). Including these presentations of NTBP may be of value for any future prehospital research. This could be important for considering alternative care pathways for paediatric patients.

Recommended paediatric textbooks note that poor posture, muscle strain, sports injuries, herniated discs, scoliosis, osteoporosis, and ankylosing spondylitis are possible causes of NTBP in younger people (Abdelgawad 2014; Duderstadt 2019; Petty et al. 2016). In the SAS data for this study, people aged 30–79 were more associated with being diagnosed with underlying persistent/chronic healthcare conditions. In

comparison, for the younger age groups of people aged 16–29, these people presented with acute illnesses or symptoms that are assumed to be short-lived and non-persistent. Reviewing the recorded ED data determined that patients aged 16–29 accounted for 18.1% of acute cases of NTBP to SAS. Of these cases, NTBP was caused by viral infections, abdominal and pelvic pains, acute appendicitis, pilonidal cysts, dorsalgia, anal or rectal abscess, and allergic rhinitis. There were no long-term illnesses or degenerative musculoskeletal changes that accounted for their presentations. Approximately 8.7% of the 16–29-year-olds were admitted to the hospital and the rest were discharged. This determined that the calls to 999 for 91.3% of this age group were not emergencies and it may have been more appropriate for them to be treated within primary healthcare, by a GP, or other alternative pathways. This demonstrated that if these options had been available to ACs, 1457 ambulance transportations to ED might have been avoided.

For the older age groups, 30–79 years, 81.7% had acute symptoms of NTBP but demonstrated complex underlying chronic illnesses. These included essential hypertension, fibrosis or cirrhosis of the liver, and a range of cardiovascular diseases, including acute coronary syndromes and cardiomyopathy. The oldest people, aged 80–89 and accounting for 0.1% calls, had chronic medical conditions that had caused NTBP. These included acute renal failure, acute coronary syndromes, spondylopathies, disorders of the renal system, delirium induced or not induced by alcohol and other symptoms that involved cognitive impairment. All recorded diagnoses could be associated with ageing. NTBP was not found to be an age-specific condition but more of a co-factor. The age results described a population with broad and complex medical needs affecting people of all ages. This finding suggested that NTBP could not be considered a condition exclusive to older people. The data analysis found that 43.3% of people aged 30–79 were kept in the hospital for further examinations or observation of their symptoms. Some were admitted to other hospital departments or NHS Scotland facilities. In contrast, approximately 56.7% of these patients were discharged from ED following assessment.

The differences between the age groups were consistent with presentations of NTBP to primary health providers (Meroni et al. 2021; Macfarlane et al. 2012). In this sample, it was older patients ≥30 years who were more likely to be admitted to hospital. The high

proportion of people aged 16–29 who were discharged on the same day as transport from SAS, suggested that they used ambulances differently from the older age groups. The younger population were possibly less likely to be admitted to hospital suggesting they may have called SAS for a means of seeking analgesia, or seeking a quick fix for their symptoms through the ED. This suggests that age may predict ambulance use for NTBP, with younger people being less likely to require emergency assistance.

5.1.4 Gender and NTBP

It is universally agreed that NTBP has multiple causes and many variations (Global Burden Study 2021). Obesity, herniated discs, poor posture, and spinal stenosis are some examples that can affect both men and women. This suggests that these causes and variations can be common to both genders. Some conditions are suggested to be more prevalent in one gender than the other (Woolf and Pfleger 2003). Some examples for women include degenerative disc disease or osteoporosis (Ratini 2021; Wáng 2018). Men are more likely to experience NTBP from mechanical causes, for example, serious injuries. Sprains, strains or injuries to muscles and ligaments and some infective conditions are also possible causes for men (Kherad et al. 2017). For ACs, although there may be some differences in how men and women experience NTBP, the initial approach to pain management should be tailored to each patient. This should consider all the relevant causes of NTBP, such as any underlying causes, the patient's medical history, and their lifestyle factors (Brown et al. 2021).

Women of all ages were more likely to call the SAS than men. It was determined that older women aged 60–69 years and 70–79 years made the most calls. On analysing the patients who were diagnosed with dorsalgia by ED (628 patients), approximately 61% were women, and 39% were men. This result is similar to findings from primary care that demonstrate that women are more likely to seek help from primary healthcare services for NTBP than men (Massé-Alarie and Schneider 2016). Most calls were made by men aged 50–59 years. Their differences were marginal, with only 14 more men making calls than women in the same age range. The final variables to be investigated in the ED data were investigated to explore whether age and gender-specific conditions related to the patients who called SAS. Some limited evidence demonstrates that women present to acute services more than do men (Capsey et al. 2022; Hay et al. 2018). Reasons for this vary, and some research suggests that, as the female spine has a greater

curvature, more stress can be applied to the lower back before pain is experienced (Hay et al. 2018). Pregnant women can experience pain as the baby's weight strains the muscles and ligaments of the lower back. Hormonal changes during the menstrual cycle, pregnancy and menopause can also contribute to back pain, and even lifestyle changes, such as jobs that involve sitting and standing, have been linked to NTBP. In the results for this population, the recorded causes of pain varied, but pregnancy was not found to be the cause of NTBP for any of the women who had called SAS. The SAS routinely responds to maternity and obstetric emergencies, and it was likely that these calls would have been categorised through call triage by aMPDS rather than being captured in these SAS and linked ISD datasets for NTBP.

5.1.5 A review of the causes of NTBP by the most prominent groups by age and gender

The prevalence of a disease is a measure of how common it is within a population. Knowing this can provide the data necessary for understanding how it affects individuals and society. The most commonly diagnosed causes that may have accounted for presentations of NTBP in this sample were investigated. The literature was then explored to identify whether there were any common conditions that were most likely to be attributed to the participants in this study' presentation of NTBP to SAS. The search was based on the demographics of the largest age groups and by gender. For older people aged ≥30 years, more serious pathologies, such as various malignancies, became more notable. The same-day discharge from ED implied that many of these cases for people aged <30 years implied that their NTBP might self-resolve, if facilitated by conservative treatments such as basic analgesia, rest, and, if required, exercise and referral to physiotherapy services.

Older women, aged 60–69 years and aged 70–79 years, were the most significant users of the SAS. Men aged 50–59 years presented in only one of the age group categories as the largest group, where they represented 50.5% calls. Including the two largest age groups of women (those aged 60–69 and 70–79 years) demonstrated how NTBP proportionally became more associated with them as their age increased. These data, therefore, determined why older women were more likely to comprise a higher proportion of the population. The causes of these calls were not so easily verified. These

calls, therefore, were examined to determine whether any common causes were suggested in the results.

The ED data examined in this study demonstrated many types of renal and urological presentations that were diagnosed as causes of NTBP and these were evident for both genders. The largest group for men were those aged 50–59 years. This age group is associated with prostate cancer, the most common form of cancer in men in the UK, and which accounts for 26% of all new patients who present to the NHS (Urology Foundation 2023).

Women aged 60–69 had 74 different diagnoses for NTBP. Dorsalgia was determined to be the most consistent with the ED diagnosis that informed this study. For 376 patients, the final diagnoses were not recorded in the dataset. Therefore, it was impossible to confirm a common reason for NTBP for these women. For women aged 70–79 years, 38.6% were diagnosed with 100 conditions, and, from these, dorsalgia was the most significant documented cause of NTBP, with a total of 6.5% women. For the men aged 50–59, 25.7% patients received a final ED diagnosis, with the diagnoses for 74.2% patients not being recorded. In the linked ISD ED dataset, there were 68 diagnoses, of which 5% were for dorsalgia, the most significant presentation. Various malignancies and acute medical emergencies attributed to urinary retention or respiratory infections were common in all groups. These, altogether, did not exceed any more than ten patients. The complexity of these conditions demonstrated that most people required hospital assessment for further diagnostic testing and evaluation. The results, therefore, determined that no single consistent cause for NTBP generated emergency calls to SAS for either gender. However, it could be suggested that the most common reason that people called the SAS for NTBP was dorsalgia.

This analysis demonstrated that men and women may have different healthcare needs when presenting with symptoms of NTBP. This may be important for informing the development of any future ambulance referral pathways. The Women's Health Plan strategy for Scotland suggests that women are more likely to be affected by health inequalities than men (Scottish Government 2021a). Scotland's *Women's Health Plan 2021–2024* (Scottish Government 2021a) aims to improve the awareness of women's health within Scottish society, acknowledging that there is a problem relating to health inequalities for women. Moreover, the Scottish Government (2021a) has pledged to

become *the world leader in women's health,* detailed in 66 action points (Scottish Government 2021a). This suggests that a one-size-fits-all approach for managing NTBP would not be beneficial for both genders.

5.1.6 Repeat calls for NTBP

Repeat calls for NTBP occurred, but they were randomly distributed across the 12 months of the study. A total of 56 (6.1%) callers made more than three calls to the SAS, and one individual made 14 calls, but that was the exception. There were 402 (4.5%) people who re-called once, and another 402 (4.5%) called two extra times. Based on these data, 905 (10.3%) repeat calls were identified. The people who made repeat calls were characteristically those with complex or non-medical conditions, such as anxiety or depression. Due to the large dataset, listing these by individual cases was impossible. From this analysis, NTBP may have been more likely a description of these patients' chief complaints to ACs. This further demonstrates the limitations of ACs' ability to record their findings more accurately in the aMPDS. It was suggested that, if additional care pathways had been available for ACs, this might have helped to reduce some transportation to ED.

The randomised codes made it difficult to isolate any of the 10.3% repeat calls for inspection (table 16). A new unique code is generated every time a new emergency call was requested for a repeat caller. The code is different for each call, even if the repeat call occurred on the same day. This reflects the live nature of ambulance data, noting that there can be several hundred emergency calls to SAS in one day. Requesting the repeat data from SAS was challenged as each emergency call had to be reviewed manually. Reviewing this SAS data had to be accessed through a hyperlink to live SAS data sets. This required special permissions that made this analysis not possible for this study.

The results of this analysis could only confirm that repeat calls accounted for 10.3% of calls for NTBP. If some of these were for non-medical reasons, it was not possible to identify within the scope of this study. These results align with some evidence that suggests that most members of the public do not make repeat emergency calls for ambulances unless they are genuinely needed (Fisher and Mason 2018).

5.1.7 Emergency Calls by socioeconomic status

NTBP is a condition significantly associated with increased chances of mortality and morbidity in high, middle, and low-income countries (GBD 2021). Socioeconomic status (SES) is considered to be an essential psychosocial contributing factor for a NTBP diagnosis. To explore this relationship, an evaluation of the Scottish Index of Multiple Deprivation Status (SIMDS) was examined for each caller was completed. These were obtained from recorded postcodes for each patient. It was established that higher levels of deprivation were a contributing factor to emergency calls for NTBP (see the Histogram *SIMD Score* in Figure 3 in Chapter 4).

Before this analysis, it was thought that all the calls would have been evenly spread across the quintiles. The rationale for this hypothesis was that the levels of deprivation from across Scotland were implied to be more evenly distributed, nationally (SIMD Scotland 2020). In other words, approximately 20% of Scots lived in each quintile of SIMD 1 to SIMD 5. Therefore, NTBP should not have been more prevalent in one level of deprivation than another. The results revealed a noticeable decrease in emergency calls as levels of deprivation decreased. Comparing the data from those living in the lowest versus the highest SIMD area, it was found that people who lived in SIMD 1 to SIMD 3 accounted for 73.5% of the sample, while 26.5% of this population lived in SIMD 4 and 5 combined. An analysis of these data found that, in the higher areas of deprivation, SIMD 1, 2483 (29%) accounted for the highest proportion of sample determined in the SAS data. As areas became more affluent, there was a notable gradual decline in calls to the SAS. This decline was demonstrated by the results for SIMD 2 to 5. These findings illustrated that the use of ambulance resources became higher as areas became more deprived. This may be partly attributed to health inequalities that have made people living in areas of higher deprivation more likely to make emergency calls for NTBP (NHS England 2021; Public Health England 2017; Peacock and Peacock 2006).

The descriptive nature of these data determined that biological causes of NTBP were the only causes documented in the broader SAS dataset. Although biological reasons were described for most of the calls for NTBP, if there were any associated psychosocial reasons, these could not be determined. This was a limitation of this analysis, prompting the question of whether SES contributed to some of these emergency calls. This again

illustrated the problem of ACs only being able to record patient cases as 05 *back pain* in the aMPDS system. There is some research that demonstrates that ACs are increasingly providing psychosocial care in response to a rise in mental health emergencies (Ford-Jones and Chaufan 2017). Depression, anxiety, living alone and poverty are all related to some of the more complex reasons for presentations of NTBP. This may explain how these psychosocial and socioeconomic factors may contribute to these types of calls. Some other social factors include the potential cost of private taxis to access health care services, having to choose food over fuel or other non-essential commodities, or the individual's inability to access health care due to its locus, which may contribute to increased ambulance calls (O'Caithan et al. 2022). These factors may have explained why some 628 cases of dorsalgia were transported to ED by ACs. This demonstrates that developing a deeper understanding of this population's needs is a more significant societal challenge, supporting a multimodal health care approach to treating NTBP. Therefore, developing better links to social and mental health care pathways could be explored for informing future ambulance guidelines.

Due to the descriptive nature of the dataset, a full investigation of the socioeconomic factors associated with each patient case was not possible. This could be achieved through a future analysis of these data based on a random sample of cases per SIMD grouping. According to the Scottish Government (2020) social factors appear likely to influence poor health and therefore may be likely influencing factors for calling SAS and for making the decision to transport patients to hospital. This may account for people living in SIMD1 being the most significant population for NTBP, illustrating some of the broader societal challenges faced by health care and the Scottish Government.

5.1.8 The acuity of NTBP by the calculated NEWS score

This analysis aimed to determine whether NTBP was a low-acuity presentation to the SAS. All recorded National Early Warning Scores (NEWS) were compared to the SIMD status for this population. The level of clinical acuity can change over time as a patient's condition improves or deteriorates. ACs monitored these patients to ensure that they received appropriate care. The NEWS scores were examined to quantify the severity of NTBP (Royal College of Physicians 2017). In 2018, the SAS used NEWS rather than the updated NEWS2. NEWS2 is an enhanced version of the tool now used in the SAS

(Royal College of Physicians 2017). Acknowledging this shift in practice is significant for comparing the findings of this study with any future studies that investigate the acuity of NTBP, which would be based on the updated tool.

From 8542 cases, 49.4% and 23.1% were found to be of no to low clinical risk, according to their respective calculated NEWS scores (table 17). In total, it could be said that, in 72.5% of patient cases, NTBP was a low acuity condition. There were 10.8% of patients who were found to be at medium risk, and 16.7% patients who were found to be at a higher risk of septicaemia. Clinical acuity refers to the severity or complexity of a patient's medical condition, which determines the level of care and resources required to provide appropriate treatment. ACs assessed acuity on a range of factors, including the patient's medical history, vital signs, physical exam findings, any diagnostic test, and the overall presentation of NTBP (Brown et al. 2021). This assessment is important for prioritising patients and ensuring that those in most need receive appropriate emergency and specialised care. In ambulance care, patients in high acuity are described as being time-critical. NTBP and dorsalgia were not determined to be of low acuity conditions in 17% of cases. This indicates that more prehospital studies for acute high-risk presentations of NTBP are required in order to enhance prehospital guidelines for ambulance care.

The NEWS was calculated on six physiological parameters: respiratory rate, oxygen saturation, pulse rate, systolic blood pressure, the level of consciousness or new onset of confusion, and temperature (Royal College of Physicians 2017). The NEWS is a valuable tool for assessing the severity of illness and predicting patient outcomes. It works most effectively when used in conjunction with clinical judgement and other diagnostic tools to inform patient care decisions. Most patients were recorded as being in pain but were clinically stable. According to the Royal College of Physicians (2017), patients with a low to severe NEWS score should be closely monitored over 12 hours. There were some limitations to interpreting NEWS for this analysis. While a high NEWS score is associated with an increased risk of morbidity and mortality, it was not a definitive predictor of patient outcomes. It was possible that some patients who had a no to low NEWS may have experienced adverse outcomes, while others with a high score may have recovered without any complications (Downey et al. 2017).

The data used in this study suggested that ACs who transported low NEWS to ED may have been based on review of complex pathologies that required further investigation. This suggests that they were transported for specific medical needs rather than the acuity of their calculated NEWS scores. An example of this was noted in the 120 (1.3%) cancer patients who had, on average, a calculated NEWS score ranging from 0–4. These data confirmed the seriousness of some presentations of NTBP that may not have been time-critical but still required admission to the hospital. The 923 (11%) patients with a NEWS score of 5–6 (medium risk) were the smallest group. Like most patients, their final ED diagnosis varied. This usually results from an acute or chronic exacerbation of an underlying cause. This medium risk score suggested that these symptoms could be considered abnormal and may have triggered the need for an escalation of care or closer monitoring If admitted to hospital. These moderate NEWS were caused by a variety of factors that were confirmed by the final ED diagnosis. These included respiratory or cardiac compromise, possible dehydration, infection, or medication side effects. These findings were similar to the 17% patients with a NEWS ≥7. A NEWS ≥7 suggested that these patients were more likely to develop septicaemia. This unexpected finding determined that, in some cases, patients required immediate medical care. This demonstrated that emergency calls for NTBP could not be generally thought of as low acuity dorsalgia and were often far more complicated. The symptoms recorded for these patients suggested a condition more representative of ambulance work. In 28% of occasions, these symptoms, when classified by NEWS, were categorised as being severe on presentation to the SAS. In 72% of these occasions, however, these patients could be described as having no to low risk.

5.1.9 NEWS for NTBP by Age Groups, Gender and SIMD Status

The impact of age and gender on utilising ambulances for NTBP is unknown. In their study, Toloo et al. (2010) suggested that gender and age characteristics in Queensland, Australia, were noted to be growing for younger age groups 0–59 years. This resulted in a 17% increase for women and 18% for men per 1000 population between 2002 and 2009 (Toloo et al. 2010). That study reflected a broader population and was not condition-specific. The condition-specific analysis performed in this study, demonstrated that older women were the most common callers and the most likely to be severely unwell, with a NEWS ≥7. Further research is necessary to determine

differences in how ambulance services are used by age and gender. It is expected that these may vary according to the patient's presenting condition.

By levels of acuity, a total of 27.5% women had a NEWS of 0 compared to 21.6% men. Women aged 60–69 were the most significant users of SAS, representing 12.4% of all calls. From these data, 9.4% were moderate, and 19.3% of high risk on presentation to SAS; for men, those aged 50–59 were the largest age group, with a total of 8.2%. Of these men, 11.2% were of moderate NEWS, and 18.6% had NEWS ≥7 (tables 18 and 19). There is no evidence to suggest that either gender is more likely to have a higher NEWS than the other for NTBP. These results demonstrated that acute presentations of NTBP are more likely to be more prevalent in women. This is consistent with the broader literature drawn from primary and secondary healthcare sources. These results also demonstrated that NTBP could not be considered to be a typical factor for determining a high NEWS score.

The youngest age groups of 16–29 years were more likely to present to SAS with acute presentations of NTBP. For the older population of the study, people aged ≥30 years could be said to be more typical of those presenting to SAS with an acute on chronic underlying condition. An example of this could be noted in the most significant groups of men and women, which had an almost identical series of underlying diseases. Their diagnosis included gastric ulcers, lymphoid leukaemia, myositis, non-follicular lymphoma, crystal arthropathies, and retention of urine, which were documented in 192 cases. The only notable difference for men was the presence of duodenal ulcers. Biological ageing is a complex process, beginning after birth it is generally accepted to become more evident in people around 30 years of age and older (VanMeter and Hubert 2022). This provided the rationale for differentiating between the age groups when considering the causes of NTBP in this population.

Acute conditions are usually sudden in onset and typically last for only a short period of time, often within a few days to a few weeks. In contrast, a chronic condition persists over an extended period, often for months or years (Bernell and Howard 2016). Of the people aged 16–29 years, 18% had moderate to severe NEWS on 27.7% of occasions. Of these patients,30.9% were admitted to the hospital via ED. The causes of NTBP for these people varied, with a small number of cases considered to be chronic conditions, such as sickle-cell disorder, cerebral palsy, and type 1 diabetes mellitus. Most causes

could be related to infections, traumatic injuries, or renal problems. It was found that 71.2% were discharged home on the same day, one died in ED, 13 were transferred to other NHS facilities, and, for 285, the outcomes were not recorded. The 7055 (82.5%) older people aged 30-89 more commonly presented with acute on chronic conditions, demonstrating that their presentations of NTBP were complex. Various malignancies, including lymphomas, with various cardiovascular illnesses and respiratory infections, were associated more with the older age groups.

The results determined that 36.1% people were admitted to the hospital, eight (0.09%) died, 33.9% were discharged home on the same day, 1.9% were transferred to other NHS services, and 27.9% did not have the outcome recorded. These missing data constituted a limitation of this analysis, as it was not clear why this information was not input into the system. It might be speculated that this is because NTBP may be considered a low acuity condition in one-third of emergency presentations to the SAS. Some evidence suggests that medical notes are not always readily available or can be poorly maintained (Abdelrahman and Abdelmageed 2014; Pullen and Loudon 2006). Therefore, the medical outcome of these presentations could not be definitively confirmed without these missing data.

5.1.10 SIMDS and NEWS acuity compared to socioeconomic status

SES was compared with the NEWS score. It was not possible to perform this analysis by age and gender. Therefore, a limitation of these data was that they only provided a descriptive overview for the analysis of the whole study population for the acuity of NTBP by SIMD status. It was determined that: the 29% patients in SIMD 1 were the most significant population; of these people, 5.3% had a NEWS of medium to high risk, with 2% being at high risk. For SIMD 2, 130 (6.1%) of 2101 (25%) patients had a NEWS of medium to high risk, with 43 (2%) having a NEWS ≥7. In SIMD 3, 105 (6.1%) of 1694 (20%) patients had a moderate to severe NEWS, with 31 (2%) a NEWS ≥7. In SIMD 4, 71 (5.4%) of 1303 (15%) patients had a moderate to severe NEWS, with 27% (2%) a NEWS ≥7. Finally, for SIMD 5, 46 (4.7%) patients had moderate to severe NEWS with 14 (1%) a NEWS ≥7 out of 961 (11%) cases.

On average, these results determined there were no differences in SIMD scores by SIMD status. The relationship between SES and the acuity of prehospital presentations

of NTBP to ambulance services is not well established in the literature. While lower SES has been associated with poorer health outcomes and higher rates of chronic pain, its impact on the acuity of NTBP remains less clear (Buchbinder et al. 2018; Hartvigsen et al. 2018; Walcott et al. 2011). Although this is only one descriptive study, these results suggest that SIMD status and NEWS may be a factor rather than a predictor for acute presentations of NTBP to ambulance providers. Further studies that compare similar data with other ambulance services is required to confirm this finding. In this analysis performed here, it may be suggested that a lower or higher SIMD status does not affect the acuity of NTBP.

5.1.11 The Final ED diagnosis of NTBP

The final ED diagnosis was obtained from the ICD-10 linked datasets. It was determined that 36% of patients were diagnosed with specific conditions, whilst 64% had no final diagnosis recorded (table 23). There were 304 different causes for NTBP. These often related to complex medical conditions, some of which may have been difficult for ACs to diagnose, especially in a prehospital setting. On analysis of these data, the most common were 29% classifications documented as other diseases, ranging from abdominal hernia to musculoskeletal problems. ICD-10 M54, dorsalgia, was the most consistent diagnosis recorded, for 19.6% patients. Dorsalgia was not a common condition in its presentation to the SAS, but it was the most common diagnosis of NTBP for ACs. This suggests that developing the ACs' ability to manage and refer NTBP may be worthwhile for the SAS.

These results confirmed that diagnosing NTBP is a complex process. Diagnosis requires not only additional knowledge but also access to further diagnostic tests, such as taking bloods or imaging. The latter are not available to ACs in a pre-hospital setting, but could be accessed through a referral pathway. According to the International Institute for Health and Care Research (IHRI) (2022), how people access healthcare has changed. They highlight that only one in twelve (8%) emergency calls are now for life-threatening illnesses or injuries in the UK. NTBP represents one type of minor presentation, demanding that ACs become more skilled in other areas beyond prehospital emergency care (IHRI 2022; HCPC 2021).

Both preliminary and definitive diagnoses are essential for patient care. For NTBP, ACs guided the initial treatment and transport decisions, while the ED doctors made the definitive diagnoses. The prehospital presentations of NTBP were more often associated with more complex or rarer conditions. For ACs, this required consultation with doctors or other healthcare providers to confirm a diagnosis and develop an appropriate treatment plan. The final ED diagnosis demonstrates these challenges for NTBP and how it presents to the SAS. Although more research is required, the findings suggest that exploring these avenues is crucial for developing better ways of managing acute presentations of NTBP to the SAS.

5.2 Research question 2: What is the Positive Predictive Value (PPV) for ACs' diagnosis of true NTBP (dorsalgia), and does this differ by dispatch priority?

5.2.1 Analysis 1: Investigating the PPV for ACs' and the doctors' urgent and routine calls for 05 NTBP

The purpose of this analysis was to examine the PPV for the accuracy of ACs' and GPs' urgent and routine calls for NTBP. The ACs' calls were compared to the initial call triage and the final ED diagnosis, and the GPs' to the final ED diagnosis. This finding unexpectedly modified this discussion, as these themes relied on an analysis of what people called the SAS for and how their calls were triaged by the aMPDS system. How and why people use the SAS or GP calls for NTBP was impossible to answer because 7398 (83.8%) of people did not call them for NTBP. An examination of all the calls may only suggest that calls for dorsalgia were unlikely. It may be therefore more accurate to report that all these patients were diagnosed by ACs as being symptomatic of NTBP, and that was a severe limitation of the system's ability to input or select causes of NTBP for ACs. In an evaluation of the 2057 (23.3%) GP calls, 5347 (60.9%) were diagnosed, treated, and transported by ACs to ED. The accuracy of the diagnosis of NTBP may have been low, this must be considered within the context that most people did not call the SAS for 05 NTBP.

The PPV confirmed that 425 (4.8%) patients were diagnosed with dorsalgia by ACs and 203 (2.3%) by GPs. The ACs had a PPV of 17.7% and GPs one of 23.6%, with a combined overall PPV of 19.3%. This demonstrates that 78.6% of patients had 05 NTBP that was not caused by dorsalgia. It could therefore be suggested that dorsalgia

was not a common presentation to the SAS. NTBP was, therefore, a term that was more descriptive than diagnostic. The low PPV indicated a higher likelihood of false-positive (FP) results (Altman and Bland 1994). In other words, the diagnostic code of 05 NTBP suggested that most of the people who called the SAS or GPs did not initially complain of back pain. This was verified in the aMPDS data, where 7398 (83.8%) patients were call triaged as one of thirty-three other conditions, with only 1426 (16.1%) specifically triaged for 05 NTBP. These were documented in 32 green, 1348 yellow and 33 amber calls.

This study found that the way in which NTBP was described by ACs differed from the way it was finally diagnosed in the ED. For the SAS, the terminology is important, because it influences the way in which ambulance resources may be prioritised, dispatched, and finally recorded for statistical analysis. Therefore, the way in which back pain is described, defined, or diagnosed is important. Dionne et al. (2008) agree that providing a standardisation for the definition of low back pain may help improve research. This would enable a clearer comparison between studies and any statistical analysis. Definition and description provide two distinct ways of conveying information about a subject. However, they serve different purposes for providing meaning and understanding. For low back pain, two agreed definitions were provided (Dionne et al. 2008). The first of these suggested that back pain should be observed by its symptoms and the length of time these were measured. The severity of back pain was to be investigated as the second question. The ED data defined NTBP as dorsalgia, which, according to ICD-10 M54, establishes the boundaries and essential characteristics of a specific type of back pain. In ACs' diagnosis, 05 NTBP provided a concise explanation of the meaning rather than the origin or cause of the problem. The ED data that informed this study demonstrated that dorsalgia was the preferential term for back pain. Both terms may offer multifactorial causes for NTBP, back pain or low back pain is a much broader description. It was found that agreeing on a common terminology for the purposes of research or statistical analysis is essential. Standardising how back pain is described and defined may be important for a more accurate understanding of its prevalence in ambulance services.

In this analysis, the PPV was used to predict the presence or absence of dorsalgia. The low PPV suggested that most patients diagnosed with NTBP did not have this condition

but were symptomatic of other illnesses or injuries that could be described as back pain. The low PPV suggested that further analysis is required to minimise the occurrence of FPs in the data. These were the people who were diagnosed as having NTBP whose symptoms were attributed to other systemic causes that did not originate in the spinal process. Establishing this difference may be important for the direction of care pathways or the dispatch of appropriate resources, such as advanced urgent care practitioners. This would require sensitivity and specificity testing (Altman and Bland 1994). These tests measure accuracy. In this example, they may help determine how accurate the ACs were in diagnosing dorsalgia. This would require an analysis of all the 615,252 adult emergency calls that SAS responded to in 2018. Subtracting the 8824 cases in these data, the remaining 606,428 patients would require examination to determine how many of them had dorsalgia. This was impossible in the context of this study, but could be investigated in any future research. This type of testing would be necessary to provide a deeper understanding of this question, for it may more accurately pre-test the probability of dorsalgia (Altman and Bland 1994). Not having the scope to explore this issue was acknowledged as a limitation of this test.

The diagnosis of 05 NTBP suggested that all of the patients' presenting to ACs could best be described as having symptoms of back pain. This was regardless of their cause. As discussed, diagnosis is often challenging for health professionals, as locating the specific source of the pain can be ambiguous. Being in pain may be described as a highly subjective experience. There is evidence that some patients may have difficulty in accurately describing their symptoms, which can lead to challenges in the diagnostic process (Davies and Davies 2013; Fink 2000). The examination of these data in this study suggested that NTBP was more descriptive. It was demonstrated that, in most of the causes recorded for NTBP, pain was the most common factor. It is possible that ACs' diagnosis may more accurately reflect the management of the patients' presenting complaint rather than a definitive diagnosis. This demonstrates the challenges of diagnosing NTBP in a prehospital setting, as there are many sources of pain (Nwachuku 2020).

There were no identified studies that investigated ACs' diagnostic accuracy for low acuity conditions. There were some studies that have explored the PPV for ACs' diagnosis of some common emergency presentations to ambulance services. McClelland

et al. (2020) determined that the PPV for ACs' stroke identification was 62%. Brown and McLeod (2018) found similar results in their study for the PPV of an ambulance pre-alert for stroke and transient ischaemic attack. These studies examined the traditional type of emergencies that ambulance services may typically handle. Some emergency studies have measured ACs' accuracy through diagnostic equipment, such as the 12-lead Electrocardiogram (ECG) for MI (Davis et al. 2007). Harbison et al. (2002) reviewed ACs' diagnostic accuracy for stroke using the Face Arm Speech Test (FAST). These studies have provided evidence of the value of such tests and for how they can improve PPV. The multi-various causes for NTBP that present to ACs do not necessarily have a similar test to improve accuracy. My review of how ACs managed NTBP suggested that pain assessment was central to their working diagnosis.

5.2.2 PPV: A Diagnosis of Pain

ACs are trained to diagnose pain and provide appropriate treatment (Brown et al. 2021). Pain is classified based on its intensity, aetiology, duration, and pathophysiology. According to IASP, the latest description is "*an unpleasant sensory and emotional experience associated with or resembling that associated with actual or potential tissue damage*" (Raja et al. 2020). Various factors can influence a patient's ability to describe their symptoms accurately, including language barriers, cultural differences, cognitive or communication impairments, anxiety, and fear (Cosio 2020; Cianfrini and Doleys 2021; Linton and Shaw 2011). Some patients may struggle to describe their symptoms because they lack medical knowledge or are unfamiliar with the appropriate terminology (Fuller et al. 2021). If any of these had been present, they would have been accounted for in the ePRF data.

Two measures achieved the diagnosis of pain. These were the numerical rating scale (NRS) and the SOCRATES mnemonic aid (Brown et al. 2021). Both tools have been demonstrated to be valid, reliable, and appropriate for investigating the domains of pain (Karcioglu et al. 2018; Manna, Sarkar and Khanra 2015). They are used UK-wide in ambulance care to help identify potential causes of pain and guide the selection of further diagnostic tests or interventions (Brown et al. 2021). The NRS measured pain on an eleven-point scale from 0–10. SOCRATES was used to gather information about a patient's experience of pain by examining its characteristics by its *site*, *onset, character, radiation, associations, time course, exacerbating and relieving factors, and severity*

(Brown et al. 2021). Only the NRS could be measured statistically, where it was found that the average pain score was six out of ten, the upper level of moderate for most of the patients who presented. SOCRATES could not be measured numerically and would have been recorded in the ePRF datasets.

While the NRS and SOCRATES framework are valuable tools for assessing and describing pain, they have some limitations. Pain is a complex and multifaceted experience; individuals have different pain thresholds and ways of expressing intensity (Giordano et al. 2010). Subjectivity may introduce variability and make comparing pain scores challenging across the individuals represented in these data. Significantly, the NRS only captured a snapshot of pain intensity at a specific moment; therefore, it could not fully capture any fluctuations or patterns associated with NTBP in this setting. SOCRATES relies heavily on patients' ability to accurately describe and recall their symptoms. Patients may have difficulty articulating their pain experience, especially when influenced by cognitive impairment, language barriers or difficulty in self-reporting. Neither tool specifically addresses psychosocial factors, functional impact, or the influence of environmental factors on pain perception (McGrath 1994). For NTBP, these limitations demonstrate the value of using clinical judgement tools and patient-centred approaches to obtain a more comprehensive understanding of the patient's pain experience. It was partly for these reasons that the STarT Back (Subgroups for Targeted Treatment Back Screening) tool was designed (Hill et al. 2008). The tool was created to assist primary healthcare professionals in making treatment decisions by providing information on the treatment outcomes for patients with NTBP. This tool could be helpful for ambulance care as it promotes a more personalised and targeted approach to management. This includes evaluating psychosocial factors that can contribute to the patient's experience of NTBP (Karstens et al. 2015).

5.2.3 Additional Tools for Measuring NTBP

The STarT Back tool is validated for managing low back pain (Hill et al. 2008). It provides a systematic approach that uses a nine-item questionnaire that includes treatment-modifiable domains (spread of pain, disability, and psychological factors). This helps assess pain, develop a prognosis, and guide appropriate treatment and decision-making. It is used mainly within primary health care and GP practices across the UK. As more patients are known to be presenting to the SAS for assistance, it could

be a valuable tool for ambulance care. This would require further study, for the tool may require some modifications for use in the prehospital setting. STarT Back helps health professionals assess the prognosis or the likely outcome of the disease and the chances of recovery. The short questionnaire helps develop appropriate care pathways identifying patients at low, medium, or high risk of developing chronic back pain (Karstens et al. 2015; Hill et al. 2008). By categorising patients into different risk subgroups, the tool helps guide appropriate treatment pathways. This is suggested to optimise better outcomes for people with NTBP. The tool may be described as facilitating a more holistic, patient-centred approach.

Significantly, STarT back evaluates the psychosocial factors of NTBP that may be considered but not used to guide the outcome. For example, some people have certain beliefs and perceptions about pain. This can lead to fear avoidance behaviour and reinforce the psychological distress that has been suggested to contribute to the development and chronicity of NTBP (Crombez et al. 2012). The STarT back evaluates these factors as part of its design, helping with the initial management of pain exacerbated by anxiety, depression, or other psychological factors. This tool demonstrates how these non-biological factors may contribute to presentations of NTBP, which can be challenging for the prehospital environment. This may include a belief that most over-the-counter medicines are ineffective for their presentation. This could make pharmacological management challenging for ACs. Whether this tool could be used within the prehospital setting for all grades of ACs may best be evaluated on the skills and education for the grade of AC. Therefore, it may be a tool better suited to urgent care practitioners or post-registration paramedics.

It is important to note that, while the STarT Back tool has demonstrated value in low back pain management, it has not been evaluated or tested for the ambulance setting. It, therefore, would not replace a thorough clinical evaluation by an AC, but rather assist in risk stratification and treatment decision-making. These factors should be part of a comprehensive assessment considering multiple factors. These may include the consideration of individual patient characteristics and the application of clinical judgement.

In the United States, a growing body of literature supports using Patient Reported Outcome Measures (PROMs) for assessing NTBP (Rasmussen-Barr et al. 2021;

Waterman et al. 2012). PROMS have been designed most often for use by physiotherapists (Greenhalgh and Meadows 2015; Chartered Society of Physiotherapy 2023). The multidisciplinary approach of the NHS suggests they may have value for advanced practice in the SAS. Their advantage lies in an ability to inform patients of their choices regarding their ongoing treatment and its providers. This information may facilitate a better understanding of managing and referring patients from acute to secondary care. This may help improve cooperation between ambulance services and secondary services (Devlin and Barham 2011). Adopting a multimodal approach to managing pain could be considered for NTBP. A multimodal approach for enhancing analgesia for the better management of NTBP has been recommended in one Cochrane study (Kamper et al. 2015). Baxter et al. (2023) in their pilot study propose that non-opioid pain management for low back pain is important. They investigate the effectiveness of the multimodal mechanical stimulation as a non-pharmacological alternative for pain relief. The developing research indicates that the availably of tools may provide ACs with more alternatives for advising patients not transported to ED. This suggests that ambulance services should contribute to any future studies shared with partners such as primary health care. This may help inform better management of NTBP.

The purpose of the PROMS questionnaire is to enable a full assessment of a patient's symptoms and to determine how these symptoms affect their quality of life (Greenhalgh and Meadows 2015). The results can help them better self-monitor their symptoms and their treatment's effectiveness. The outcome of these measures may help a patient identify where additional support for their condition may be required. These outcomes may help direct them to alternative care pathways as an alternative to the SAS. The completed questionnaires should ideally be shared digitally with patients' GP services on completion of the assessment. Although these are not validated tools for ambulance care, some research trials have led to developing three core domains for PROMS designed to manage NTBP better (Chiarotto et al. 2019). These include a review of physical functioning, the associated pain intensity and how this impact the patient's quality of life. These assessments are known as the Oswestry Disability Index (ODI) version 2.1a, or the Ronald Morris Disability (RMD), which assesses physical functioning. The NRS measures pain (Chiarotto et al. 2019).

Although there may be benefits to using additional tools such as PROMS, there are some limitations. The most apparent is that they have not been developed for the ambulance sector. Therefore, determining appropriate measures to help these patients would need to be arranged between health partners that included the SAS and GP or physiotherapy services. Questionnaires can be taxing and laborious to complete. They must be designed to best meet the patients' and the ambulance sector's needs to contribute to the best outcomes (Office for Health Improvement and Disparities 2020). This may not be easy to achieve, but it demonstrates the value of and need for more research.

5.2.4 The Diagnostic Accuracy for NTBP

Research specifically relating to ambulance care of NTBP is limited. A review of the available literature for the diagnostic accuracy or PPV of ACs' assessment for NTBP found no studies. A search of the literature for similar types of minor illnesses and injuries for comparison did not identify any. This confirmed that there is a significant knowledge gap which requires attention for the further development of the paramedic profession.

Paramedic research has seen significant developments in recent years. In 2001, 'paramedic' became a protected professional title, requiring registration with the Health and Care Professions Council (HCPC 2017). Professionalisation has resulted in the development of paramedic research, which continues to contribute to advances in prehospital care. Evidence-based guidelines and protocols, specific to paramedic practice, have been designed to standardise approaches to various medical conditions, trauma management, resuscitation, and other emergency interventions (Brown et al. 2021). Developing the evidence base demonstrates a need for more specialist research paramedics. This small descriptive study highlighted that developing these roles is necessary for growing and developing the paramedic profession.

Much highly worthwhile research has been carried out within the SAS. Scotland's Out-of-Hospital Cardiac Arrest Strategy (OHCA) is an excellent example of how the organisation has saved more lives (Scottish Ambulance Service 2022). Other notable examples include other advances for the survival of trauma patients in cardiac arrest, injured by blunt force trauma and paediatric cardiac arrest. Most ambulance research

has focused on these types of traditional emergency calls. Although these emergencies are central to paramedicine, they are only suggested to contribute to less than 10% of the ambulance workload (IHRI 2022). NTBP represents the type of non-traditional presentation that contributes to increasing ambulance pressures. This demonstrates that the need to develop an understanding of the conditions that may contribute to 90% of ambulance work provides an argument for creating more research opportunities to develop this area of paramedic practice.

While the diagnostic accuracy of this example of a non-traditional emergency presentation remains uncertain, one study has measured ACs' PPV diagnosis of some common emergency conditions. Paramedics were described as being "*satisfactory*" in their preliminary diagnosis for most of the emergencies they assessed (Koivulahti et al. 2020). The authors noted that the ACs' diagnostic accuracy varied by condition. Greater diagnostic accuracy was achieved when they were presented with the types of common emergencies that are central to AC education (Brown et al. 2021). Anaphylactoid shock, for example, was diagnosed with 100% accuracy between ACs and ED doctors. ACs' diagnoses of other conditions ranged from being of a good to a high standard (Koivulahti et al. 2020). These included cardiac presentations, neurological (stroke) conditions, or other visible injuries. Establishing the diagnostic accuracy for NTBP requires further investigation and implies that more research would be of value for non-traditional emergency calls.

ACs primarily work in the prehospital setting providing emergency medical care and transportation to individuals in emergencies. They are often the first healthcare providers to assess and treat patients at the scene of an accident, or during medical emergencies or transport to the hospital. In comparison, in the UK, nurses typically work in hospitals, clinics, long-term care facilities, and other healthcare settings, providing ongoing patient care. According to the Nuffield Trust, nursing is the largest profession, and is integral to the NHS (Palmer and Rolewicz 2022; Royal College of Nursing 2022). Nursing has developed its evidence base and informs many aspects of healthcare for the UK. These differences between the professions demonstrate the need for collaboration and cooperation. All 15 professions allied to medicine provide their own skillsets. The ambulance sector has relied on the evidence produced by emergency medicine, nursing, and other sectors, such as physiotherapy. Developing future research

requires NTBP to be managed from a prehospital context, as this unique environment requires its own understanding, especially if this means that more patients can remain within the community healthcare system.

5.3 Research Question 3(i): Investigating the PPV for ACs' diagnosis of NTBP by C3 colour coding aMPDS and ACs' factors for Triage, Treatment and Transport

The low PPV for ACs' diagnosis of NTBP was compared to the aMPDS call triage for these emergencies. As all calls were diagnosed as 05 NTBP by the ACs, examining the aMPDS C3 call descriptors was necessary to review how the calls were initially triaged. This analysis required an exploration of the aMPDS call triage system. This was used to help explain the diagnostic accuracy of the ACs' and GPs' diagnoses that may have accounted for the low PPV for NTBP. This analysis found that the aMPDS limited the ACs' and the GPs' data in how their diagnosis could be documented. This resulted in diagnostic code 05 *back pain* being awarded to all the calls. It appeared unlikely that a GP would diagnose a call as back pain. It was more likely that their confirmed diagnosis would have been recorded in a medical admission letter and a phone call to a receiving doctor. The letter would have been left with the patient and taken by the ACs to the hospital for the receiving medics. The ACs may have met with the GP before the patient's transport, but, in most cases, the GP would have left the patient to continue with their house calls. Back pain may, therefore, have best described how the patient presented to the SAS at the time of their transport to the hospital. Alternatively, 05 NTBP may have been the closest description to a GP diagnosis. This may account for why some cases indeed were recorded as NTBP or dorsalgia in ED data, but were more commonly something else that could manifest as back pain in the prehospital setting. This changed the focus of the analysis of this research question to examine how the aMPDS system initially triaged 83.5% of the calls diagnosed as 05 back pain. The low diagnostic PPV may reflect the system's inflexibility to document a working diagnosis more accurately by ACs and on behalf of the GPs.

5.3.1 Triage of NTBP by the aMPDS

The primary function of the aMPDS is to provide a standardised and systematic approach to emergency medical dispatching (Clawson et al. 2008). Call screening achieves this, enabling dispatchers to gather essential information from callers using

specialised scripted questions. The questions are designed to identify the nature and severity of the emergency quickly and accurately. Prioritisation of the calls is based on the information provided by the caller, which results in allocating an appropriate resource (IAED 2018). Dispatchers may provide standardised instructions to guide callers in providing immediate care, such as cardiopulmonary resuscitation (CPR), controlling haemorrhage, or managing childbirth. The aMPDS was designed on a hierarchical model that considered the type and severity of the reported emergency before prioritising and dispatching an ambulance response (Clawson et al. 2008). The advantage of the aMPDS is its design to be flexible and adaptable to emergencies, following a general structure for assigning codes to the calls.

The aMPDS has two sets of codes defining all the emergency calls made to the SAS. Clawson aMPDS codes are called *Chief Complaint Protocols* (IAED 2018; Clawson et al. 2008). These protocols provide specific instructions to ambulance dispatchers regarding the questions to ask and the actions to take, based on the caller's responses. The codes cover various medical conditions and complaints. Within the system are detriment codes that indicate a medical condition's severity or potential severity. These codes help dispatchers to determine the appropriate level of response and resources required for each call (IAED 2018). In 2018, the SAS used six call detriments to describe the urgency of their ambulance responses. Omega (O) codes were for conditions that may not have required an emergency ambulance response; Alpha codes (A): were for minor or non-urgent calls that were not considered to be of an immediate threat to life; Bravo codes (B) were potentially urgent calls, which did not pose an immediate threat to life but still may have required prompt medical attention; Charlie codes (C) were for severe or potentially life-threatening conditions that may have required immediate medical intervention; Delta codes (D) were considered for all time-critical or life-threatening conditions requiring an immediate response to preserve life or prevent further deterioration; and Echo codes (E) were non-survivable conditions, in which a patient may have been determined to be beyond help or was deceased (IAED 2018). Each code consists of a letter representing the general category of the emergency, followed by a two-digit number that specifies the severity level. For example, *A01* was an emergency call related to abdominal pain or problems with a low severity level.

In comparison, 09E02 is categorised as an emergency call for a cardiac arrest, initiating the highest level of response from SAS (IAED 2018). The aMPDS codes were used to guide a call taker or dispatcher in asking questions and gathering information about the emergency. The SAS aMPDS also used colour codes or C3 colour to categorise the priority level of the calls green, yellow, amber, red, and purple. These were the colour identifiers for 2018. In version 13.0, the aMPDS was estimated to have 1828 detriment outcomes (IAED 2018).

5.3.2 Call Determinants for NTBP

One notable study has explored the aMPDS relationship with patient acuity (Feldman et al. 2006). The authors determined that the aMPDS had moderate sensitivity and specificity for detecting the high acuity of illness or injury. From 197,882 emergency calls, 1553 (1.5%) calls were explicitly for back pain. These were examined for comparison with the data. Feldman et al. (2006) stated that there were 1483 (95%) calls that were categorised as Alpha, 57 (3.7%) were Charlie, and 13 (0.8%) were Delta. This suggested that most of the calls for back pain were low acuity. In comparison with these data, in this study it was determined that 425 (4.8%) patients were diagnosed with dorsalgia by ED. Of these, 84 (19.7%) were prioritised Delta, and, of these, 10 were classified as red, 61 as amber, and 13 as yellow. There were 232 (54.5%) Charlie calls, of which 34 were classified as amber, and 198 as yellow. There were 104 Bravo calls, of which all 104 were classified as yellow. Moreover, there were five Alpha calls: four were classified as green, and one as yellow. These results suggest that aMPDS had over-triaged most calls for NTBP dorsalgia. It was, therefore, possible to comment that the aMPDS may have had a higher specificity for detecting potentially life-threatening symptoms than for detecting dorsalgia.

The specific protocols and guidelines of the aMPDS are designed to detect life-threatening conditions. Abnormal breathing problems are one example and are recognised by the aMPDS as a significant predictor of cardiac arrest (CA) (Clawson et al. 2008). This led to the introduction of the *Breathing Problems Protocol*, which is used to enhance the detection of signs and symptoms associated with high acuity conditions (IAED 2018; Clawson et al. 2008). In these data, 492 (5.5%) calls were triaged with *breathing difficulties.* Of these, 111 (22.5%) were classified as yellow; 318 (64.6%) as amber, 60 as red (12%), and 3 (0.6%) as purple calls. From these calls, 58 patients were

diagnosed with dorsalgia and all were classified as amber. These were associated with the determinants *Alpha, Charlie, Delta, and Echo*.

Although back pain may be symptomatic of muscle strain or carrying extra weight, it may be associated with at least 12 other potentially life-threatening conditions. These may include pneumonia, MI, acute coronary syndromes, cauda equina syndrome (CES), gastroesophageal reflux disease (GORD), gall bladder disease, aortic dissection, rib fracture, and lung cancer. Further analysis of these by call description determined 11 amber calls were triaged as ICD-10D 05 heart attack or angina history with chest pains. These conditions were found in another 111 (1.2%) calls in the SAS data used in this study. The high specificity of the aMPDS triaged 7398 (83.8%) calls in this way. The aMPDS is designed to err on the side of caution and to prioritise patient safety by potentially over-triaging patients. This is not a criticism of the system, which is designed to be patient-centred. Detecting high-acuity presentations reflects why the ambulance service exists: to save lives. These results may support evidence relating to how people's use of ambulances has changed to include greater use of emergency resources for lower acuity conditions. Investigating what people perceive to constitute an emergency call to the SAS would be beneficial, as this could not be determined from these results described in this thesis.

The eight (0.09%) purple and 249 (2.8%) red calls were unexpected findings in a back pain study. Neither of these categories has a 05 coding because NTBP is not considered immediately life-threatening by the aMPDS (IAED 2018). The addition of the call determinant Delta and the assignment of the highest colour priority level amber demonstrated how generating higher acuity calls for the condition was possible. The accuracy of the purple calls appeared to be more sensitive than the red, and the red calls were more likely to have been over-triaged. The purple call descriptors described patients as having *ineffective breathing,* being in *cardiac or respiratory arrest,* being *a known asthmatic* experiencing *ineffective breathing,* or being *unconscious with agonal* (not getting enough oxygen to breathe) or *ineffective breathing*. Five of these patients were not transported to ED, suggesting that they might have died. This conclusion was based on the severity of their call descriptors, which were cardiac or respiratory arrest. ACs may pronounce death in such cases, which may account for these patients not being transported to ED (Brown et al. 2021). One of the patients who were transported

to ED was triaged as being unconscious with *ineffective breathing*, diagnosed as 05 by ACs, and received a final ED diagnosis of a pulmonary embolism (PE). The other two were triaged as being symptomatic of severe or potentially life-threatening asthma presentations with *ineffective breathing*. PE may be more symptomatic with breathing difficulties, but back pain too can be an associated complaint (Brown et al. 2022). Why ACs miscoded the two asthma emergencies is unknown, as 06 provides a code specifically for abnormal breathing. Why 05 *back pain* was selected as a diagnosis for these patients by the ACs is uncertain and would require further investigation. The triage accuracy for these calls may have been as high as 99.7% compared to the ACs' diagnosis and, where appropriate, ED final diagnosis.

The aMPDS call triaged 249 red calls, of which nine were diagnosed as dorsalgia by ED. The call aMPDS descriptors of these patients described them as known COPD/ COAD patients who were *not alert* secondary to *breathing difficulties*. It could not be confirmed whether any of these patients were repeat callers recorded in the demographic data.[1] Other descriptions included *having asthma, suffering from continuous or multiple fits, being unconscious with effective breathing,* or *being in a medical emergency requested by a GP.* The hospital data determined that 82 of these patients were discharged home following ED assessment. There were only four recorded diagnoses, which included an unspecified acute lower respiratory tract infection, a syncope or collapse, an unspecified paralytic syndrome, and one case of dorsalgia. Ten patients were transferred to other hospitals, and 100 were admitted to an assessment unit in either a medical or surgical ward. All of these patients had a series of complex problems of which back pain may have been more symptomatic. These results suggested the high specificity of the aMPDS determinants. The results further demonstrated the complexities of some of the symptoms presented in these patients, which may have made diagnosis difficult for ACs.

[1] Chronic Obstructive Airway Disorder (COAD) became known as COPD in the UK in the late 1990s to early 2000s as part of an international effort to standardise the terminology and classification of chronic obstructive lung diseases (Brown et al. 2021). COAD may be reflecting the IAED terminology based on North American English.

There were 1426 (16.1%) patients classified in the green, yellow, and amber categories, all triaged with a 05 NTBP by the aMPDS. In these data, 33 (1.9%) of the 1656 calls categorised as amber cases, 1348 (27.7%) of the 4860 categorised as yellow, and 32 of the 117 (27.5%) categorised as green were all initially call triaged as 05 NTBP and diagnosed as 05 *back pain* by ACs. These results indicate that the high specificity of the aMPDS may have triaged more low-acuity calls that were NTBP. Compared to the ACs' diagnosis, it demonstrated that NTBP could still be triaged as a higher acuity condition that may be serious but unlikely to be immediately life-threatening. This was noted in the high proportion of yellow calls. It was impossible to determine how many of these calls received a final ED diagnosis of dorsalgia. The calls demonstrate the value of enabling more significant clinical input to the system. A review of the literature found only one systematic review for the accuracy of medical dispatch systems. The authors determined that there is a dearth of evidence for the accuracy of medical dispatching systems (Bohm and Kurland 2018). The findings from the SAS data suggest that AC input may improve accuracy of the aMPDS for recording NTBP, but this would require further study.

The accuracy of the aMPDS is related to the ability of the system to classify and prioritise emergency calls based on the severity of the patient's condition. The system uses a standardised protocol of scripted questions to provide dispatchers with the necessary information to make the correct triage decision. The aMPDS is continually evaluated in SAS, and its protocols are updated to ensure the highest accuracy and effectiveness (IAED 2018). Its accuracy may be affected by various factors, such as the dispatcher's training and experience, the caller's ability to provide accurate information, and the complexity of the patient's condition. The influence of factors were evident in some of the patient presentations in this study. These factors were also suggested to influence ACs, acknowledging that they represented a wide demographic of frontline staff, consisting of different grades and varying levels of experience.

ACs' diagnosis refers to the various resources and guidelines used to enable ACs to diagnose and treat patients clinically in the prehospital setting. Decision-making, clinical judgment and critical thinking are all determined by the individual's level of education, training, and experience. The accuracy of ACs' diagnosis, therefore, varied depending on the individual's level of training and experience, the complexity of the

patient's condition, and the resources available in the prehospital setting. In SAS, AC diagnostic literature is based on the latest prehospital knowledge as new research and treatments become available (Brown et al. 2022). In SAS, as in other UK NHS ambulance services, AC resources include the JRCALC electronic pocketbook guidelines, SAS national clinical bulletins and Situation Background Assessment and Recommendations (SBAR), ensuring standardisation and safety of the patient through dynamic review of equipment and treatments and peer-reviewed research studies.

Significantly, this analysis reconfirmed that the ACs' diagnosis compared to the call triage was a completely different outcome. A review of the two systems illustrated that they both have their advantages and disadvantages. For the ambulance controllers, call triage involved assessing the patient's symptoms and medical history over the telephone. The system, therefore, relies on the information the caller provides, which may not always be accurate or complete. This could lead to the incorrect prioritisation of calls and a delay in getting the appropriate care to those who require it. The standardisation of the model does not afford flexibility to accommodate unique situations or specific needs. NTBP, with its complexities, was suggested to be one such medical condition that did not neatly fit into one of the predefined 36 categories. This could have been attributed to some of the cases being over-triaged. The aMPDS assumes that the patient or caller speaks English as a first language. This could have an impact on communication, presenting difficulties that may affect the accuracy of the process. There was a limited ability to assess low-acuity presentations of dorsalgia, as the system is primarily designed to triage medical emergencies (IAED 2018). This does not mean that aMPDS cannot triage lower acuity calls; understanding how efficiently it detects them requires further study.

5.3.3 The Call Triage of NTBP aMPDS SAS by Acuity

According to Hinchey et al. (2007), low-acuity conditions could be reliably identified in patients without high-acuity illness or injury by the MPDS with 99% accuracy. The aMPDS has gone through many updates since the study was published. Although the system may be accurate in most cases, it can despite its substantial upgrades, over-triage calls (Hoikka et al. 2016). Over triage may be defined as dispatching an ambulance using blue lights and sirens to a low acuity medical compliant such as NTBP (Ceklic et al. 2022). Some research has found that the over-triage of calls may have caused some

lower acuity conditions which led to inappropriate use and overload of ambulances (Hoikka et al. 2016). Under-triage may also negatively impact the chances of patient survivability as people who are acutely unwell may have to wait longer for an ambulance. Any method that could better align acuity to triage that could help aMPDS become more sensitive to calls that require an immediate response (Hoikka et al. 2016). Based on the aMPDS data analysed in this study, the system may have over-triaged some calls, but it could not be said that they did not warrant an ambulance response or some level of assistance. That 1393 (15.7%) of patients of all colours and categories were not transported to ED is an interesting result that requires further study.

The 1393 (15.7%) patients who were left in the community following their assessment by ACs may have been under-triaged by the aMPDS. It could not be said that these callers did not require some medical assistance. Determining whether this were the best use of AC resources would require further investigation. The findings demonstrated that aMPDS had more options to triage NTBP than ACs had to document their diagnosis. This may help to identify common themes from the aMPDS triage that prompted an emergency response. A further limitation of this analysis was that it could not be said that these patients had dorsalgia or back pain, for it was not possible for ACs to record their diagnosis. These data may then have demonstrated that there were 1818 (20.6%) (1393 + 425) calls for dorsalgia and, of those, 23.3% required transfer to the ED. This would have confirmed a more accurate presentation of NTBP to the SAS.

This analysis found ACs (19.9%) and GPs (25.6%) had a low diagnostic accuracy for NTBP. The results were significantly affected in the way that their diagnosis for all calls was documented and recorded. It could only be said that the 8824 calls, including the 2057 GPs' Urgent and Routine calls, may have been more of a description than a diagnosis made by the attending ACs. According to the initial call triage, it was determined that 1426 calls were triaged as 05 by the aMPDS, indicating that the way in which NTBP is recorded by its diagnosis is essential for establishing a better understanding of its prehospital presentation. Investigating the 1393 calls left in the community and all 628 calls diagnosed as dorsalgia may provide a greater understanding of these presentations. This may help to determine why people seek assistance from the SAS for NTBP. In addition, these results may help inform aMPDS of the types of additional questions that may be required for more accurate triage.

5.3.4 Research Question 3 (ii). The Sensitivity and Specificity Positive Predictive Valve (PPV) and Negative Predictive Value (NPV) of aMPDS on objective acuity measured by NEWS for ambulance clinicians coded 05 NTBP

The sensitivity and specificity, PPV and NPV analysis of the aMPDS call triage were compared with the objective NEWS score recorded in the baseline observations. These were the people who were diagnosed by ACs as being more likely to be severely unwell and, therefore, more likely to become categorised as being time-critical based on their calculated NEWS scores. Comparing aMPDS call triage to patient assessment examined whether the ambulance controllers could detect high-acuity patient cases through the scripted triage algorithms. The outcome of this analysis demonstrated that the aMPDS identified five (2.6%) patients who were high acuity. The clinical results in comparison found that ACs diagnosed 1403 (16.4%) of patients with a NEWS ≥7 and 7139 (83.4%) with a low to moderate NEWS ≤6. These results demonstrate that aMPDS had a low sensitivity for detecting patients who were more likely to be clinically unstable and to deteriorate. It was more accurate in confirming the patients with a NEWS ≤6 were low acuity and were unlikely to deteriorate. This suggests that a lower ambulance response may have been possible for most of these patients. The high specificity of 97.1% and an NPV of 97.6% differed from the low sensitivity score. These results were more consistent with the ACs' working diagnoses that determined 83.4% of patients had a NEWS ≤6. The findings considered whether the detection of clinical acuity mattered and whether a more sensitive aMPDS system might improve prioritisation for dispatching ambulance resources.

Some patients may have been more likely to be over-triaged. This may have had consequences for priority-based dispatch, meaning that some patients who were of a lower acuity may have received ambulances at a higher priority level, amber or red. The eight purple calls in these data were appropriately triaged and received a fitting ambulance response. Of the 246 red calls, 22 (8.9%) patients, and of the 1656 amber calls, 81 (4.8%) patients, had a NEWS≥7. Of the 4860 yellow calls, 130 (2.6%) patients had a NEWS ≥7. These were the patients who might have waited longer for an ambulance, particularly if the system was under peak time pressures. Based on NEWS ≤6, 224 (91%) of the red and 1575 (95%) of the amber calls may have been over-triaged. This might have impacted the dispatch of ambulance resources if the system

was under pressure. Crucially, these results are subjective, and it is important to acknowledge that NEWS scores alone are not definitive findings. Some patients may have a low NEWS score but could still be found to be time-critical emergencies. The value of these results establishes that the aMPDS may over-triage calls and this could have implications for patient outcomes. Only further study would establish a deeper understanding of these results. Further analysis suggests that any results may help SAS highlight modifications to call questioning that could help develop and improve call triage.

5.3.5 High acuity presentations of dorsalgia

The SAS data was examined to establish whether there were any time-critical presentations of dorsalgia that may not have been associated with high NEWS scores. Spinal pathologies associated with severe neurological disability, such as spinal cord compression syndrome (SCCS) or cauda equina syndrome (CES), or other non-spinal causes, such as retroperitoneal processes, are some notable examples (Brown et al. 2021; Edlow 2015b). The detection and diagnosis of CES are perhaps one of the most important of these conditions for ACs to recognise. The signs and symptoms are signposted for CES, and its detection is explicit in JRCALC guidelines (Brown et al. 2021). There were no records of any of these presentations found. Of the patients who had a NEWS ≥7, no obvious consistent cause was detected. It could be argued that the acuity, therefore, may not have mattered, as all of the patients received an ambulance. If ambulance resources are limited, then these details are important to ensure that the person in greatest need is prioritised accordingly. Further analysis determined that there are no existing prehospital pathways for CES should it be detected through call triage or ACs diagnosis. Further exploration of potential developments for specific ambulance care pathways for CES is therefore recommended.

5.3.6 Test for Establishing Diagnostic Accuracy of aMPDS

The NEWS is a tool developed by the Royal College of Physicians to improve the detection and response to clinical deterioration in adult patients. It is considered to be a key element in enhancing patient safety and improving patient outcomes (Royal College of Physicians 2017). The calculated NEWS score afforded a comparison between calls telephone triaged and then diagnosed by ACs. It was the addition of this diagnostic tool that enabled the detection of high-acuity presentations of NTBP. NEWS was used as a

proxy measure or as an indicator of the patient's acuity at the time of their call triage. These measures correlated the physiological data to the call descriptors, enabling inferences to be made about the calls. A limitation of this analysis was the potential for measurement error, and it was acknowledged that the results may not have perfectly captured the underlying construct. From this perspective, all of these findings were descriptive and subjective to interpretation. The sensitivity and specificity measurements established the aMPDS performance for detecting the patient acuity that was associated with NTBP (McNamara and Martin 2023). Sensitivity determined the percentage of individuals who were detected as having high acuity NTBP by aMPDS. These were the proportion of true positive results (among all positive results), which provided an estimate of the ability of the aMPDS to correctly identify high-acuity cases. Specificity established the proportion of true negative results (among all negative results), which enabled an estimate of the ability of aMPDS to correctly rule out individuals who were low acuity cases (McNamara and Martin 2023). These were how the results were calculated, providing an understanding of how ambulance resources were prioritised and dispatched for NTBP.

In this analysis, a diagnostic odds ratio (DOR) combined the sensitivity and specificity to calculate the PPV and NPV (Knottnerus and Muris 2003). The PPV was the proportion of patients who were positively identified by aMPDS with high acuity NTBP or a NEWS ≥7. The NPV was the proportion of patients who were of a low to moderate acuity determined by a NEWS of ≤6. PPV and NPV use the prevalence of a condition to determine the likelihood of a test diagnosing a specific disease (McNamara and Martin 2023; Knottnerus and Muris 2003). As both PPV and NPV are related to sensitivity, specificity, and prevalence, PPV is greater when prevalence is high. Therefore, the significance of a high PPV suggests that a condition has a greater prevalence in its specific setting. Thus, when a condition is rare the prevalence is low. This was determined in this prehospital presentation of NTBP to SAS. Greater specificity of NTBP would be required to achieve a higher PPV. This confirmed that the aMPDS was not sensitive enough for detecting high acuity cases of NTBP defined by a NEWS ≥7. The high specificity determined that aMPDS was better at triaging possible life-threatening signs and symptoms that were later diagnosed as 05 *back pain* by ACs. These were the diagnostic codes of the aMPDS that accounted for most of the emergency calls being triaged as something other than NTBP. The outcome of these

findings demonstrated how patients with NTBP were more likely to be triaged by the aMPDS system with another condition. Specificity in this context more accurately described the aMPDS for its triage of NTBP. This finding queried whether call triage or AC diagnosis was more accurate. That 7398 (83.8%) calls were triaged as one of 36 other conditions, and that dorsalgia was diagnosed as one of 304 other diagnoses, demonstrates that this was not a straightforward comparison. Understanding the complexity of this result would require further study. A review of the ePRF data documented for these cases would be essential. Only an examination of these results may help determine the true prevalence of NTBP as it presents to the SAS.

5.3.7 Investigating Unnecessary Visits to ED

There were 1500 patients conveyed to ED who were discharged promptly following assessment. It is possible therefore that some of these individuals may have been unnecessarily transported. Based on the C3 call descriptors, these individuals were appropriately triaged by aMPDS. It could be suggested that as they were discharged soon after admission these patients did not require transport to ED. But caution is required with such assumptions. It is unknown how many of these patients required more advanced assessment in the ED, beyond that which is offered by ACs. It has been identified that many of these patients had complex chronic altered physiology, and so any consideration around transport or non-transport requires caution and must be evidence-based informed. Doctors may have ordered additional diagnostic tests that could not be performed in the prehospital setting. The outcome of these tests may have determined whether these patients were safe for discharge on the same day and/or had bespoke needs with necessary referral for ongoing primary care. Further analysis of these data could identify patients who may have been suitable for non-transport and treatment at home by ACs. These findings highlight a specific sub-group of patients who present to SAS with NTBP that merits further investigation.

More knowledge and understanding are required about this patient cohort. As such, a sequential mixed or multiple research methods will be used to fill this evidence gap. The clinical predictors of hospital admission (from the ED), including the NEWS and known red flags as identified in JRCALC Guidelines, will be determined (Brown et al. 2021). This evidence will identify those patients who must be conveyed to the ED. To achieve this a review of the clinical assessments and investigations of ED doctors is

required. This will identify higher acuity conditions enabling a comparison to the scope of practice for ACs. Developing an understanding of the reasons for transport and non-transport by ACs and patients is also recommended. This inquiry will be designed to investigate the short-, mid-, and longer-term outcomes and care pathways for those discharged from the ED or admitted to the hospital. Collectively these findings will inform the development of an optimum care pathway. In addition, low-acuity presentations that could be managed and referred to a GP should also be included.

5.3.8 The development and evaluation of both high and low-acuity care pathways and educational intervention for health professionals that ambulance staff could interface with GP settings

Low acuity pathway: Developing a low-acuity referral pathway (or appropriate multiple referral pathways) and educational intervention to identify patients presenting with these different presentations of NTBP will be developed from Study One. These data will be analysed to investigate the clinical predictors of admission for those patients conveyed to the ED with NTBP. The findings will be used to inform the next stage, which is the proposed intervention for ACs to better interface with GP settings. Adopting a sequential mixed methods approach will enhance our understanding of patient clinical acuity, reasons for ambulance call-out, ED investigations and respective outcomes of this patient cohort. The proposed qualitative work will also determine the patients' objective and subjective needs and their acceptability of non-conveyance and referral within the community. The low acuity pathway (referral to the patient's primary carer, i.e., their GP) will target those patients identified as not having needed either enhanced assessment or admission to hospital from within the ED.

The low acuity pathway guidance will be based on existing evidence informed JRCALC Guidance on 'Low Back Pain (Non-Traumatic)' and the results of Study One, thus seeking to ensure a safe, effective and high quality approach to patient care. The educational intervention will again be informed by the results/findings of Study One, thus filling any identified gaps in clinical and assessment knowledge that may be associated with poorer outcomes.

5.3.9 Resolving the uncertainties for clinical observations and concerns for Cauda Equina Syndrome encountered by SAS

Pathways currently exist in SAS for various high acuity pathologies, most notably acute coronary syndromes, and specifically acute myocardial infarction (AMI), and for Trauma Care (Brown et al. 2021). These are supported by a strong evidence base that has informed the development of 'checklist' style red flags. I propose that a similar pathway could be developed for NTBP, such as Cauda Equina Syndrome (CES) and one for an undifferentiated high acuity to ED, which may help identify time-critical cases that should go immediately to the appropriate centres, by-passing ED to receive definitive care. Complex conditions that are not immediately life-threatening but do require medical review or further tests (conditions/presentations as identified in study one) could be referred to a professional for professional discussion.

5.3.10 Tracer Condition: Cauda Equina Syndrome

It is important to develop any high-acuity guidance using a stepwise approach and perhaps a tracer condition, with learning spread to other presentations as the evidence is developed. It has been discussed that CES is a rare orthopaedic emergency, which if left untreated can lead to permanent disabilities, including bowel and bladder dysfunction. Although the diagnosis of CES is mainly made through symptoms and physical examination, it can only be confirmed with an MRI scan (or CT if the patient is not safe for MRI). Time is of the essence, thus these patients must be identified and taken to a centre with the specialist resources that are required to treat them. Not all hospitals in Scotland have an MRI scanner and those that do often do not have 24-hour access to scanning. ACs are educated to identify the red flags for CES, but, at present, cannot directly refer patients to dedicated centres with specialist pathways in place that are designed to diagnose and treat these patients without delay.

A multidisciplinary approach for direct access to Trauma and Orthopaedic (T&O) services for CES patients is currently being developed at University Hospital Wishaw (UHW), Lanarkshire. This project aims to improve CES care through cross-discipline collaboration and streamlined management of prehospital CES cases. The project at UHW does not currently include the SAS but has the potential to do so. This would enable ACs to directly collaborate with T&O services, enhancing access and ensuring prompt care for CES patients.

Developing a pathway to include the SAS could establish a direct line of communication between ACs and the receiving orthopaedic consultant (Greenhalgh et al. 2016), thus bypassing the need for ACs to admit CES patients to the ED. This would eliminate the time spent waiting for an ED assessment and subsequent internal referral to orthopaedics. It is proposed that this referral pathway should be developed as part of the ongoing study for my proposed clinical guidelines for NTBP. Developing this intervention may contribute to resolving any clinical uncertainties for the prehospital detection of CES.

5.4 Research question 4: the ambulance clinical interventions used to treat patients with NTBP

5.4.1 How ambulance clinicians managed NTBP

The management of NTBP typically involves a multimodal approach that aims to reduce pain, improve functions, and prevent the recurrence of symptoms (NICE 2020). According to NICE (2020), clinicians should consider pharmacological and non-pharmacological routes to achieve this purpose. Pharmacology may be summarised as how drugs interact within the body to produce therapeutic effects (British Pharmacological Society 2023). The purpose of this science is to help promote the health and well-being of people through the development of safe and effective drugs for the treatment and prevention of illness and injury. There is some research that suggests pain can be poorly managed and may even be left untreated in prehospital care (Iqbal and Spaight 2015). The medications that were used by ACs for NTBP specifically were for analgesia (Brown et al. 2021). Capsey et al. (2022) suggest that similar pharmacological treatments are used in NEAS in England, and Vella et al. (2022) in Australia and New Zealand. How NTBP was pharmacologically managed by the ACs of SAS and GPs was examined, and the results are presented below. Non-pharmacological treatments were not documented.

5.4.2 Patients conveyed and non-conveyed to ED with and without analgesia

Four common ambulance analgesics were used to manage NTBP on 4416 (50%) occasions. The more potent pain relievers, Entonox, was administered to 2409 (54.5%) patients, and morphine to 1024 (23.1%), which accounted for most instances where analgesia was administered. Paracetamol and ibuprofen were less frequently

administered, to 568 (13%) and 278 (6%) patients, respectively. On examination of these results, it was possible to determine the medications used by ACs to manage dorsalgia on 628 occasions. The remaining patients were symptomatic of NTBP that was caused by other conditions. It was only possible to review these cases descriptively, as SAS ePRF data is stored on a live system. This made the individual analysis of 8824 patients too time-consuming, as each ePRF record required opening individually. Having too many ePRF records open at once impacts the real-time recording of data by ACs. This made it difficult to examine the ePRF data, which is where all treatments and rationales for actions are recorded. The clinical data that were analysed here were only able to provide a global overview of how this population was managed.

The medications administered by the SAS were used singularly or in combination. Combination therapy is recommended in ambulance care and has been part of ambulance practice for many years (Brown et al. 2021). Combination therapies can exploit the chances for better efficacy, decrease the toxicity of drugs and reduce the development of drug resistance in long-term care (Foucquier and Guedj 2015). There is strong evidence that some drug combinations work better than one drug alone (Plana, Palmer and Sorger 2022). In addition, a further ten drugs, including NSAIDs (Diclofenac/Voltarol and Naproxen), other opiates (Orapmorph, Tramadol, Solpadol, Codeine, Co-codamol) and some anti-convulsant medications used as nerve-blocking agents (Gabapentin and Diazepam), were administered by GPs. In most cases, the patients who described their pain as being moderate to severe reduced their pain score to reflect a more moderate level of pain post-treatment by SAS. This was noted in all the cases where analgesia had been provided by ACs. Complete analgesia was not achieved in most presentations of NTBP or dorsalgia. The safety of these drugs or suitability for this management is unknown and would require further study. This would be necessary should patients not be transported to hospital or if they were to be advised to self-manage their own symptoms in a community setting.

5.4.3 The pharmacological and non-pharmacological management of pain

A review of the pathophysiology of NTBP was investigated to understand why some analgesics are considered more effective than others for treating this condition. The pathophysiology of NTPB is relevant to understanding which analgesics may be more

effective than others. Developing this knowledge is essential for providing a rationale and developing better pathways for ambulance care. The different possible underlying mechanisms of NTBP were determined as being mechanical factors, degenerative changes, inflammatory disorders, infections, cancers, psychological factors, and neurological disorders, and were all attributed to different presentations of NTBP (Licciardone 2004). Recording the effectiveness of these analgesics in relation to the different underlying factors that cause pain may provide a clearer rationale for the administration of some opiates (morphine) that are not recommended in current guidelines for NTBP (Brown et al. 2021).

No specific guidelines for the management of NTBP in SAS were available to ACs when the study was set in 2018. During the time of this study, ACs relied on managing pain or identifying and treating life-threatening conditions such as cauda equina syndrome (CES) or abdominal aortic aneurysm (AAA), which are time-critical emergencies synonymous with NTBP (JRCALC 2021). Recent updates to JRCALC (2021) guidance for *low back pain (non-traumatic)* have now been developed to treat NTBP. There have been no studies to evaluate the effectiveness of these additions post-2021. The new guidelines recommend and promote analgesics and advise on some non-pharmacological strategies, such as exercises or heat therapy, for better patient care (Brown et al. 2021). In these, a multimodal approach to pain management is advocated, and non-steroid anti-inflammatory drugs (NSAIDs), namely ibuprofen, are the first-line analgesics of choice for ACs (Brown et al. 2021; NICE 2020). There has also been the inclusion of non-pharmacological interventions (Brown et al. 2021). Non-pharmacological interventions include exercises, stretches, and alternative forms of analgesia, such as heat (Brown et al. 2021). As discussed, none of these non-pharmacological therapies are currently taught in the ambulance curriculum. Of these, the strength of evidence for heat is moderate, suggesting that this therapy may boost circulation, allowing nutrients and oxygen to promote recovery to damaged tissues, reduce inflammation and improve back stiffness (Medical News Today 2023). Whether these are effective measures for managing NTBP in a prehospital setting is unknown.

In 2018, it was possible that reassurance, positioning and, if necessary, immobilisation would have been the non-pharmacological interventions recommended or used by ACs for some presentations of NTBP (Brown et al. 2016a). These actions were not

documented and were not possible to verify. Establishing how non-pharmacological interventions are measured and documented is essential. Evaluation of these types of interventions, therefore, suggests the need for further study. Future research should consider how these interventions could be recorded in ePRF data. Researchers could use this data to evaluate their overall effectiveness in AC care.

5.4.4 Non-steroid anti-inflammatory drugs (NSAIDs) for modulation of NTBP

NSAIDS (ibuprofen, naproxen, diclofenac/ Voltarol) were found to be the least used drugs for NTBP in SAS. They are now advised to be the most appropriate analgesic for NTBP, including in prehospital care for UK ambulance services (Brown et al. 2021). Although guidance for treating inflammatory disorders of the lumbar spine, including dorsalgia, arthritis and other causes of mechanical NTBP, suggest NSAIDs, they were not favoured by ACs. A review of inflammatory mechanisms associated with NTBP, presented below, was conducted to determine why NSAIDs are described to be more effective than the more potent analgesics demonstrated.

Inflammation is a complex biological response by the body to harmful stimuli such as pathogens, damaged cells, or irritants (Tortora and Derrickson 2020; Licciardone 2004). Inflammation is central to most illnesses and injuries that are medical or traumatic. In prehospital care, most medications have some effect on the depression of this mechanism. Some have more potent effects, notable in ibuprofen, hydrocortisone, and aspirin (Brown et al. 2021). The inflammatory response associated with NTBP is thought to localise in the axial skeletal joints of the lumbar spine in some presentations (Lassiter and Allam 2022). This load-bearing area of the spine accommodates most of the body weight. This explains why lower back pain, the most common site of the spinal process, is associated with illness, injury and general wear and tear over a human lifespan (Lassiter and Allam 2022; Sieper and Poddubnyy 2017).

A summary of the inflammatory process for NTBP accounts for both acute and chronic pain. It involves inflammatory mediators activating immune T cells and macrophages that produce inflammatory cytokines. These cause tissue damage and pain perception but demonstrate how infection, virus or cancers can cause NTBP. Synovitis involves the inflammation of the synovial lining of the lumbar process that causes stiffness and pain. Enthesitis is the site where tendons or ligaments (entheses) can become inflamed,

causing the sensation of chronic pain and stiffness (Lassiter and Allam 2022; Sieper and Poddubnyy 2017). Bone erosion through wear and tear or conditions such as rheumatoid or osteoarthritis can lead to pain and deformity of the spinal process. Nerve irritation or compression of the disc(s) is one of the most serious presentations of NTBP, CES, and can lead to severe manifestations of pain with neurological symptoms such as bladder, sexual dysfunction or paraplegia if left untreated (Brown et al. 2021). Genetic factors may also predispose some individuals to chronic inflammatory lower back pain with the presence of the HLA-B27 gene (Sieper and Poddubnyy 2017).

Inflammation is a vital biological process that protects and enables the human body's healing in its response to injury, infection, and other forms of stress. Nevertheless, it is also a process that can become harmful if prolonged or excessive. The pathophysiology of NTBP demonstrates how this process could be linked to the presentation of acute and chronic pain in this population. Understanding some of these processes, therefore, is essential for ambulance care. Developing a more profound understanding may help inform ACs about why some medications may be more effective than others. For acute prehospital settings, this could explain why NSAIDs should be the first-line treatment of choice for NTBP (Brown et al. 2021). This was relevant to the results of this study, as the pain treatment was preferential to addressing the mechanism for the pain, which may have been related to inflammation for the 628 patients diagnosed with dorsalgia.

A systemic inflammatory-mediated response includes the manifestation of pain as part of the healing process (Lassiter and Allam 2022). This demonstrates that understanding the mechanism of pain is essential. This suggests that treating inflammation should be emphasised for the prehospital management of NTBP, justifying NSAIDs as the first-line drug of choice. The ineffective actions of opiates (morphine) or weak NSAIDS (paracetamol) have very limited anti-inflammatory mechanisms, making them unsuitable for the treatment of NTBP (Brown et al. 2021). These drugs were used the most for treatment. The limited use of NSAIDs may indicate that developing a deeper understanding of the inflammatory causes of NTBP could benefit ACs. An update of guidelines in this regard could develop a better understanding of the indications for dorsalgia by stating that pain symptoms are induced by an inflammatory-mediated reaction that causes pain. The management of pain for NTBP with NSAIDs is, therefore, more likely to reduce inflammation and provide more effective analgesia

(Brown et al. 2021). A review of current guidelines compared to these retrospective data would afford a comparison for future research on evaluating the effectiveness of treatments for NTBP in SAS.

5.4.5 Morphine and Entonox for managing NTBP

A review of the authentic low acuity presentations of NTBP, diagnosed as dorsalgia, enabled a more accurate understanding of how SAS pharmacologically managed this condition. Of the 628 patients diagnosed with dorsalgia, 331 (52.7%) were treated with a combination of the following medications. Morphine was administered 65 (10.3%) times, singularly, and 243 (38.3%) times in combination with Entonox. Entonox was administered on 178 (28.3%) occasions as a single therapy. Paracetamol was provided on 15 (2.3%) occasions, and ibuprofen 8 (1.2%) times. There were no drugs recorded for 297 (47.2%) patients. These findings demonstrate that strong analgesics were more likely to be used for dorsalgia.

5.4.6 Generic Pain guidelines, NTBP and JRCALC

Without specific guidelines for managing NTBP in 2018, ACs may have referred to general guidance for the administration of analgesia (Brown et al. 2016a). For the moderation of severe pain, this may explain why morphine was provided to some of the patients with NTBP. Opioids, such as morphine, are now no longer recommended for NTBP (Brown et al. 2021; Knezevic et al. 2021; Shaheed et al. 2017). Although there are now specific guidelines for low back pain provided in JRCALC, there is still no advice on providing analgesia. Confusingly, in the general clinical guidelines for analgesia the moderation of severe pain recommends the administration of morphine (Brown et al. 2021). This finding suggests that how NTBP is defined, whether it is dorsalgia or a condition symptomatic of NTBP, requires clarity. There may be some occasions when morphine was justified for some patients and others where NSAIDS or other drugs would have been more appropriate. This demonstrates that being able to accurately record the diagnosis of NTBP is relevant to understanding its true management.

It is suggested that the decision to use opioids for acute NTBP in the prehospital setting is evaluated on a case-by-case basis. These decisions should take into account the patient's medical history, the severity of the pain, and the potential risks and benefits of

alternative treatment options. Some evidence suggests that opiates may be appropriate for short-term pain management. In other cases, non-opioid or non-pharmacological interventions may be more appropriate (Deyo et al. 2015). Therefore, if the administration of morphine is deemed necessary, it should be cautiously provided and only for short durations of time (Brown et al. 2021).

5.4.7 Entonox and Penthrox medical gases for managing moderate to severe pain

Entonox was primarily used for the treatment of NTBP. It was allocated to some 2409 (54.5%) patients diagnosed with moderate to severe pain. Of these patients, 243 had dorsalgia. Entonox is described as a ready-to-use analgesic that is 50% oxygen and 50% nitrous oxide, it is inhaled and takes around 2 minutes to become effective (Entonox BNF 2023a). It can be effective in seconds and its rapid absorption across pulmonary tissue allows rapid elimination via breathing. The patient's level of consciousness determines the ability to maintain gas flow.

Entonox has a low-fat solubility; therefore, it does not accumulate in body tissues, reducing the risks of overdose. Its analgesic properties are equivalent to 10mg of intravenous morphine, suggesting more sedation than muscle relaxation (Eaton 2000). The British National Formulary (BNF 2023a) suggests an elimination half-life of 5 minutes. With a rapid onset of action and often-potent effects, Entonox is determined to be one of the best analgesics of choice for acute presentations of severe pain associated with NTBP in ambulance care. A thorough search of the medical literature found no studies or articles that specifically investigated the prehospital use of Entonox for NTBP. For ambulance care, its indications are stated as being for the presentation of *moderate to severe pain* or *labour pains* (Brown et al. 2021). This determines its broad use and demonstrates that it does not provide targeted pain relief for something as specific as NTBP. As NTBP was found to have a wide range of causes, its effectiveness depended on the patient's presentation and the underlying cause of their NTBP. From this analysis, it could not be concluded how effective Entonox was for dorsalgia.

Another volatile gas suggested for managing severe pain associated with NTBP is Methoxyflurane (Penthrox). In SAS, this is a potent analgesic gas used mainly by the Special Operations Response Teams (SORT). The potential benefits of this drug suggest that it could have broader use in SAS, extending to non-traumatic conditions such as

dorsalgia. This indicates that it is worthy of further research. Penthrox induces global muscle relaxation and insensitivity to pain without compromising a patient's level of consciousness (Aronson 2016). This is advantageous for conditions such as NTBP, where muscle spasms and extreme discomfort can make patient extrication challenging for ACs and patients alike. A limitation of Penthrox is its high lipid solubility. This results in the drug's slow uptake, from about 15–30 minutes (Aronson 2016). It is a beneficial drug for severe pain and, due to its action, could be a drug of choice for NTBP. Analgesia can last up to 30 minutes, and, as it does not depress the central nervous system as Entonox or morphine do, this reduces the risk of airway compromise and respiratory and cardiac depression. If intermittently inhaled, it can provide analgesia for up to one hour (Brown et al. 2021). This determines why it remains a drug that requires direct medical supervision and monitoring (Larsen 2012).

Research has demonstrated that Penthrox works most effectively as a combination therapy complementing Entonox and morphine (Aronson 2016). NTBP has medical causes, sometimes associated with musculoskeletal injury. For any severe pain associated with these types of presentations of NTBP, Penthrox is limited by its indications. Its indications for ambulance care are limited to traumatic injuries only under current SAS guidelines. The actions of Penthrox state it can be used safely with non-opioids such as NSAIDS or morphine for analgesia. The administration of morphine suggests that the patient should be in *severe pain* (Brown et al. 2021). The lack of a pain score provides no interpretation of how severe pain is measured. This could leave further ambiguity for ACS in combination therapy. A systematic review published in the European Journal of Pain (Herkes et al. 2019) evaluated using Penthrox for pain management in emergency medicine. The review included nine studies and found that it effectively reduced pain in various acute pain conditions, including trauma-related and procedural pain (Herkes et al. 2019).

Unlike Entonox, there is limited evidence for using Penthrox for NTBP (Heydari et al. 2019). The efficacy and safety of the drug for managing various settings, including musculoskeletal pain, were investigated. This research found that Penthrox achieved sound analgesic effects and was generally tolerated by patients (Heydari et al. 2019). According to Siriwardena et al. (2021), Penthrox reduces moderate or severe pain faster than Entonox or other parenteral drugs used in ambulance care, including using a

combination of morphine and paracetamol. This indicates that it could be more effective for managing moderate to severe NTBP. Entonox and Penthrox are both cited as drugs that can help 'get people off the ground to stand' so they may be examined (Brown et al. 2021). This demonstrates the value of Penthrox and how it could be used in a broader context for pain management. This would require further study to evaluate whether this drug was feasible and could be used safely for the treatment of NTBP.

5.4.8 Combination therapies for moderate to severe pain: ibuprofen and paracetamol

The management of mild to moderate presentations of NTBP relied on two medications – ibuprofen and paracetamol (acetaminophen). Paracetamol is described as having a weak non-steroid inflammatory (NSAID) action and is ineffective for managing NTBP alone (Machado et al. 2015). It is thought to achieve analgesia by inhibiting the central nervous system's cyclooxygenase (COX) pathway. Inhibiting this pathway modulates pain by reducing prostaglandins, inflammatory and pain mediators generated by COX. Paracetamol enhances endocannabinoid transmission and decreases serotonergic inhibitory pathways to achieve analgesia (Machado et al. 2015). Although paracetamol is cited as one of the essential over-the-counter medicines for analgesia, there is no convincing evidence to suggest it is an effective oral analgesic for reducing the symptoms of acute NTBP (World Health Organization 2019b; Machado et al. 2015). According to Chou et al. (2015), the strength of evidence for managing acute NTBP with paracetamol is low. The recent addition of intravenous administration of paracetamol to the SAS offers ACs an alternative strong analgesic option to morphine (Brown et al. 2021). Some limited research supports that this may be more effective than oral tablets for managing acute pain with reduced complications of nausea and vomiting associated with opioids (Charlton et al. 2020). Whether this would offer analgesia for severe NTBP would require further investigation.

Paracetamol is suggested to be more effective for NTBP if it is administered as a combination therapy (Brown et al. 2021). A small number of patients (25) were administered co-codamol, and solpadol on one occasion. These medications combine paracetamol with the opioid codeine to enhance analgesic effects. The effectiveness of these medicines for managing NTBP could not be verified as being more effective than other medications. In ambulance practice, NSAIDs (ibuprofen, diclofenac/voltarol) are

recommended as the first-line drugs for managing NTBP. They treat pain and inflammation by inhibiting COX-1 and COX-2 enzymes, decreasing the production of prostaglandins that mediate inflammation and pain (Nikolakopoulos et al. 2020). NSAIDs treat presentations of mild to moderate pain, pyrexia, soft tissue injuries or as a combination therapy (Brown et al. 2021; Qaseem et al. 2017). However, they were found to be the least used form of analgesia on 278 occasions for NTBP and only eight times for dorsalgia. Ibuprofen was administered on only eight occasions for dorsalgia by ACs. Some research suggests that the strength of evidence for acute NTBP is low to moderate (Chou et al. 2015).

Evidence suggests that diclofenac is a more potent force-effective NSAID for NTBP (Machado et al. 2015). This NSAID is not routinely used by ACs, but is prescribed by advanced practitioners for SAS for back pain. Diclofenac, in comparison, was administered to thirty-one patients by GPs. Diclofenac is commonly used to treat NTBP and has been demonstrated to be effective for the short-term relief of NTBP (Machado et al. 2017). The authors suggested that the intramuscular (IM) route may provide more rapid analgesic effects rather than if the drug was administered orally.

Qureshi et al. (2019) demonstrated that IM administration of diclofenac achieved a 50% reduction of pain in 30 minutes compared to 1 hour if taken orally. No adverse events were reported, and the IM route was suggested to be the delivery of choice. Ibuprofen and diclofenac have relatively rapid absorption rates and short half-lives of 2–4 hours (Giagoudakis and Markantonis 2005). Ibuprofen is presented to ACs in tablet or suspension forms (Brown et al. 2022). Diclofenac is not routinely administered by front-line ambulances but is available to advanced practitioners. Further study is required, but research suggests that IM diclofenac could be the first-line drug of choice for dorsalgia. This could be developed as a patient group directive (PGD) available to paramedics. It has been found that most NSAIDs, including ibuprofen and diclofenac, can reduce presentations of severe pain to a moderate level. This could have reduced the number of patients transported to ED for dorsalgia as close monitoring for side effects was not required as with opiates. The ability to administer IM diclofenac may be necessary for the ambulance sector, whose treatment is limited by the presentation of pain rather than the cause of the pain, and which may make one analgesic more suitable than another.

Some patients received a combination of therapies from ACs to manage pain and these were suggested to reduce severe to moderate pain. The varieties were mostly Entonox and morphine, as paracetamol and ibuprofen were less commonly used in combination for NTBP. This study analysed the overall analgesic effects of these drugs singularly or in combination to allow their effectiveness to be thoroughly evaluated. It was determined that total analgesia was only achieved partially for those who received analgesia. This determined that further study for determining the most effective drugs for managing dorsalgia is required.

Several studies suggest that combination therapies, including multiple medications, may be more effective in treating NTBP. Evidence that combining paracetamol and ibuprofen is one such treatment (Machado et al. 2017; Williams et al. 2014). A limitation of combination therapy has been noted in that optimal dosage and duration of treatments still need to be established. Therefore, guidance for obtaining or maintaining analgesia, especially for prehospital care, would remain open to the interpretation of ACs. This approach may not be appropriate for everyone, as individual responses to these therapies may vary.

5.4.9 Diazepam and other medications administered by GPs for NTBP

Diazepam was administered to 31 (0.7%) patients. This is a benzodiazepine class of medication used to treat seizures, anxiety, and muscle spasms. Since 2018, diazepam has been replaced with midazolam as the drug of choice for managing prolonged or repeated convulsions and symptomatic cocaine toxicity, as directed by JRCACL (Brown et al. 2021). It was possible that diazepam may have been used under medical guidance to reduce severe spasms associated with NTBP. It could have been administered for symptoms of severe anxiety that can exacerbate NTBP. According to medical evidence, the use of benzodiazepines is not supported or recommended for the acute management of NTBP, and it is not routinely administered for this purpose.

Gabapentin is an anti-convulsant medication that is considered effective for NTBP caused by disk herniation, sciatica, spinal stenosis, and diabetic neuropathy (BNF 2023c). Gabapentin was administered to one patient but this was prescribed by a GP. Ebell (2019) argues that gabapentin is not effective for low back pain with or without radiculopathy. The drug was cited as being ineffective for managing pain and was

associated with adverse drug reactions (ADRs), including inducing harmful thoughts, nausea and vomiting, pyrexia, lethargy, muscle pain and gastrointestinal disturbances. In some cases, it may cause an anaphylactic reaction (Ebell 2019). The administration of this drug was rare and, without access to the GP notes, a diagnosis could not be confirmed. Gabapentin is not used in UK ambulance practice and is a prescription-only medicine. This finding may suggest that it is a drug that would not be suitable for extended prescribers working within SAS should additional medicines be considered for NTBP. A review of all the medications used to treat acute NTBP found that NSAIDs are the drugs of choice. This analysis was subjective, as there were many different causes for NTBP. Further study with patients diagnosed with dorsalgia may provide a better understanding of the practical pharmacology appropriate for NTBP.

5.4.10 The effects of analgesia for the modulation of NTBP by SAS

The effectiveness of analgesics pre- and post-administration and the presence of pain were compared to investigate whether analgesia would always result in transport to ED. It was determined that pain was not a predictor for transport or non-transport to ED. From the 8824 patients, 6301 (71%) were recorded with a pain score, and 2523 (28.5%) pre-analgesia. There were 5253 (59.5%) recorded with a score post-analgesia, with 3571 (40.4%) not recorded post-analgesia and, of the patients documented with a pre-analgesic pain score, 304 (3.4%) had reported being in no pain on examination by ACs. The finding that 304 patients did not report being in pain was unexpected, suggesting that there were other reasons people call SAS for NTBP. It was not possible to review these cases individually; there was some evidence that may explain this finding. Seventy-five of these patients were for doctors' urgent or routine calls and had received a home face-to-face visit from a GP. Thirty-one patients received diazepam on one occasion; Oramorph on two occasions; codeine on seven occasions; co-codamol on 25 occasions; diclofenac on 34 occasions; gabapentin on one occasion; naproxen on one occasion; tramadol on one occasion; Voltarol on one occasion; and Solpadol on one occasion. Doctors usually request an ambulance within one to four hours of their consultation. This would have resulted in an adequate time frame for these medications to take effect. The medicines were opiates, NSAIDS and one anti-convulsant, Gabapentin. Gabapentin is sometimes administered for treating sciatica, a type of neuropathic back pain caused by disc herniation.

The analgesias provided by GPs appeared to have been effective. Without their diagnosis, it was impossible to determine why these drugs were administered. It is possible that some of these could have been provided for dorsalgia, but there were also many other conditions. These included the opiates allocated singularly or combined, reportedly ineffective for dorsalgia in the broader literature. The final ED diagnosis for this variety of conditions may account for the effectiveness of some of these drugs provided by the GPS.

A further observation noted that twenty people provided with Co-codamol and one with Tramadol were left in the community. This suggested that these analgesics had been adequate for these patients. Nevertheless, without further study, the reasons for these decisions were unknown.It was demonstrated that, if ACs could more accurately record their working diagnosis, a deeper understanding of the associated analgesia for NTBP could be provided. For the remaining 229 patients, some received calls for fits, allergic reactions, choking, drowning, fainting, impending fit (aura), asthma, or were triaged as being unwell or ill by aMPDS. All these patients reported not being in pain to ACs, but all were diagnosed as being symptomatic of NTBP. The findings demonstrated that, in some instances, being in pain was the by-product of a condition but not necessarily the reason why people called an ambulance. The descriptive nature of the data limited further investigation of these incidences, and obtaining a better understanding this requires further study.

The results indicate that some patients who were treated with analgesia were left in the community. Of these patients, 183 (7.5%) had received Entonox, 31 (2.9%) received morphine, 420 (73.9%) received paracetamol, and 160 (57.5%) ibuprofen. These results demonstrate that those who had received paracetamol were more likely to be left in the community. In one systematic review and another review that examined 13 clinical trials involving more than 5,000 patients paracetamol is reported to be ineffective for NTBP as a single therapy (Abdel Saheed et al. 2021; Machado et al. 2015). It was possible that it may have been provided in combination with ibuprofen; confirming this would require further investigation.

Paracetamol is administered in a dispersible fast-melt tablet form in the SAS. It becomes effective after 15 minutes and is capable of achieving complete analgesia within 30–90 minutes (Nikolakopoulos et al. 2020). Ibuprofen starts to become effective

within 30 minutes, reaching a peak plasma time within 1–2 hours (Nikolakopoulos et al. 2020). The average time spent on the scene for ACs was 43 minutes. This suggests that these over-the-counter medications could have started to become effective during the consultation.

Two-hundred-and-fourteen patients were administered Entonox and morphine but were left in the community. This was unexpected but would require further investigation to establish a better understanding. Entonox can become effective in 15–20 seconds, and, depending on how much is inhaled, its duration does not typically last longer than 15–20 minutes (BNF 2023a). Its limited side effects can include dizziness, nausea, muscle spasm, and drowsiness, but usually fade a few minutes after discontinuation of the gas.

The onset and therapeutic effects of morphine can be instant if administered by intravenous injection, which is why it is the first-line route of choice for severe pain in SAS (Brown et al. 2021).This suggests that pain control was not achievable by the over-the-counter medications that are accessible to everyone. Therefore, the administration of IV morphine or Entonox was provided to 31 patients, but the reason why they were not transported to ED was unknown. The reasons for these decisions were likely documented in the ePRF and not viewable in the descriptive data. It was possible that some patients may have refused to travel to the hospital after receiving this analgesia. This suggests that some people had called SAS only for access to better analgesia. Another option was that the attending AC had a professional-to-professional discussion with a senior medic, thus determining that a patient could be better managed in the community. These outcomes are only speculative and would require further investigation. However, they do demonstrate the importance of drug safety.

5.4.11 Drug safety

There is a growing concern about the safety of patients prescribed opioids for pain management post-injury (Zheng et al. 2022; Biancuzzi et al. 2022). Some recent international studies have found that opioids have been misused, abused, or diverted following prescriptions (Zheng et al.2022; Biancuzzi et al. 2022). It was found that morphine had been administered to thirty-one patients who were not transported to ED. The administration of morphine may have been justified, without further access to the data, no conclusion could be made. These cases demonstrate that drug safety is an issue

that requires further research for the prehospital setting. This is necessary for informing practice guidelines and best practice.

No repeat calls for the 31 patients who were administered morphine and were not transported to ED were identified within 24 hours in the available SAS data. This suggested that no ADRs were reported to the SAS. ADRs refer to the unintended and harmful effects of medications, ranging from mild to severe to even fatal, and can occur in any patient population (MHRA 2023; NICE 2022). Various factors, such as inappropriate dosing, drug interactions, or patient-specific factors, such as sex, age, weight, or genetics, can cause ADRs. Understanding ADRs is, therefore, crucial for understanding drug-effective analgesia, particularly if a patient is not transported to ED. In the SAS and UK ambulance care, ADRs are mitigated by providing clear guidelines that provide ACs and patients with the indications, contraindications, cautions and side effects of a prescribed drug within the scope of practice (Brown et al. 2021).

Although not fully understood, physiological differences between the sexes have become more widely acknowledged in biomedical research, informing healthcare (Crimmins et al. 2020). These differences may determine why women are more likely to experience an ADR than men (Zucker and Prendergast 2020; UC Berkley News 2020; Wilson and Nakagawa 2022). Research has found that women are 50–75% more likely to have ADRs than men (Wilson and Nakagawa 2022). This has been linked to the dosages and combinations of some of the same drugs administered between the sexes (Zucker and Prendergast 2020; UC Berkley News 2020; Wilson and Nakagawa 2022). The authors remind us that men and women respond differently to drug therapy and, therefore, can impact the safe and effective management of patient care (Zucker and Prendergast 2020). Women, particularly older women, were more likely to present to SAS with NTBP. This suggests that further studies to review safety and effective drug therapy for managing NTBP could be useful (Zucker and Prendergast 2020; Soldin and Mattison 2013). This could have implications for providing patient advice or for combination therapies that could be effective and safe, particularly if a patient is not transported to ED.

Few studies have investigated the modulation of pain for NTBP in ambulance care. Experiencing pain is always subjective and personal to the individual and it is understood that varying degrees of biological, psychological, and social factors

influence its perception (British Pain Society 2013). The pathophysiology of pain is a complex process that involves multiple systems in the body, including the nervous, immune, and endocrine systems (IASP 2020; British Pain Society 2013; Julius and Basbaum 2001). Pain can be divided into several stages: transduction, transmission, modulation, and perception. Many different types of pain were associated with NTBP. These included muscular strain or sprain; osteoarthritis, usually described as a deep ache and may be accompanied by stiffness, swelling or a grating sensation in the joints (Arthritis Foundation 2021); and fibromyalgia, which may be accompanied by fatigue, sleep disturbances or mood changes. Inflammatory conditions attributed to musculoskeletal presentations, such as dorsalgia, or the numerous infective and malignant diseases, suggest that inflammation was the most common cause of acute pain in this population. Pain management was found to be complex and subjective for ACs' management of NTBP (Deyo et al. 2014). This may have influenced the types of analgesia that were offered and administrated to patients.

There were 689 (29%) patients documented with a numeric pain score who were not transported to ED, and, from these, 397 (57.6%) had a pain score described as seven, indicating that they were in severe pain. This was an unexpected finding and was impossible to explain without further investigation. The description of severe pain resulted in the administration of more aggressive pain management for some of these patients. This included IV morphine (which was administered to 31 of these patients, and Entonox, which was administered to 183 but who were not conveyed to hospital). There is some evidence to suggest that the subjective reporting of pain may be influenced by various factors, including psychological and social factors (British Pain Society 2019). It is possible that these factors may have led to the over- or under-reporting pain suggested in the SAS data. Anxiety, depression, and a history of trauma were all possible examples of factors that may have influenced presentations of pain experienced by the SAS patients. These are the types of factors that are suggested to increase perceptions of pain, while social desirability bias, or a tendency to respond in a way that is viewed as socially acceptable rather than expressing true feelings or opinions, too can lead to the underreporting of pain (de Heer et al. 2014; Schreiber et al. 2013). The descriptive nature of the SAS data limited any further analysis of these findings but could be explored in a future study.

While it is always possible for patients to exaggerate their pain symptoms, ACS must approach such situations with a willingness to understand their perspective. The patient's reasons for the exaggeration of pain may vary and may include fear of being taken seriously, a desire for medication, or a lack of understanding about what constitutes severe pain. In one narrative review Henry et al. (2018) suggested that taking patient perceptions of pain seriously is important for effective pain management. Iqbal and Spaight (2015) argue that all health professionals should take all patient-reported pain seriously and work with the patient to manage their symptoms appropriately This suggests that promoting patient education for pain self-management for NTBP requires further study. There is some evidence that suggests that self-management can effectively reduce pain intensity, improve physical function, and enhance the quality of life (Du et al. 2017; Eccleston et al. 2014; McCracken et al. 2005). The documentation of non-pharmacological techniques to guide NTBP through various physical, psychological, and behavioural strategies was not recorded.

Kerns et al.'s (2022) article, 'Self-management for chronic pain', suggests the importance of some psychologically guided core competencies that can be used by healthcare professionals to facilitate analgesia. Kerns et al. (2022) highlight the importance of care provider empathy and clear communication in the management of chronic pain, and understanding the psychological obstacles that may prevent it. Thus, establishing strong, dynamic, collaborative connections between people with chronic pain and their healthcare professionals – relationships that place a priority on patient empowerment, activation, and self-efficacy and that can change over time – are the foundation for effective self-management of pain. This article demonstrates some of the challenges and limitations in managing patients with chronic pain that present to ACs. These may include exploring a patient's adherence to treatment and access to healthcare services, should they not be conveyed to the ED. Accessing additional care pathways can be highly challenging for ACs, as demonstrated in several studies (Porter et al. 2019; Blodgett et al. 2021; O'Hara et al. 2014).

Accessing care pathways is difficult due to various factors. These include limited access to patient information, inconsistencies in care pathways across different care regions, and a lack of clarity around which pathway to follow in certain situations. These were suggested to apply to NTBP. The perspective of managing the pain of NTBP and what

to do if a patient is not transported but is still in pain underscores the importance of ongoing training and education for ACs. They must have the knowledge and skills to make informed decisions. Developing a deeper clinical understanding of the causes of NTBP may therefore lead to improved pain management. This could be guided through the development of an effective definition of dorsalgia and include concepts such as promoting patient education for managing their condition with analgesia via pharmacological and non-pharmacological means. This would require the development of ACs' education and training for managing this condition.

A summary of this analysis found that how NTBP was managed varied per case. A lack of clear aetiology for the acute presentations of NTBP demonstrated by the many causes suggested why it was difficult to determine the best course of treatment per individual. A follow-up study that investigates patients diagnosed with dorsalgia may help to develop a better understanding.

5.5 Strengths of the study

Both advantages and challenges arose from analysing the SAS and ISD datasets in this study. A summary of the strengths of the analysis presented in this thesis, as presented in this section, demonstrates some of the positive aspects of using this retrospective research method (STROBE 2022; Hoppe et al. 2009). One of the main strengths of this analysis was that it enabled an investigation of a previously uncharted real-world population, describing their demographic and clinical characteristics. The large sample size strengthens the generalisability of the results, and, therefore, they are more likely to represent this population. As such, these results may help inform any future study of NTBP and its management from a prehospital perspective. The retrospective data improved the representativeness of the results for the adult population who called the SAS for assistance. The diversity in the data enabled a greater understanding of the demographic characteristics of these people and identified those most likely to need help from SAS.

The study was highly cost-effective, as the data were ready for analysis, and there was no need for a controlled study environment (STROBE 2022; Hoppe et al. 2009). The large sample size enabled the investigation of numerous clinical characteristics and the final clinical diagnosis of NTBP from linking the ED dataset with the SAS dataset. This

enabled an investigation and analysis of any unexpected outcomes and findings for NTBP. The ethical considerations were unproblematic, as the data already existed and did not involve any new interventions or exposures. The longitudinal data afforded the possibility to perform the analysis over a one-year period. This demonstrated how NTBP presented to SAS over a longer period of time. One example of this was the charting of repeat calls, which proved to be infrequent and the time between calls was longer than anticipated.

5.6 Limitations of the study

Highlighting the limitations of working with these retrospective data is essential to promote transparency and validity, to inform future research, foster collaboration, and enhance the project's credibility. As the retrospective data were descriptive, it was not possible to evaluate cause and effect, therefore, the results are limited by their observational nature (STROBE 2022; Hoppe et al. 2009; Vandenbroucke et al. 2007). The study was also limited in its generalisability to this specific population and setting. The results suggested that some of the themes identified here could be transferrable to other similar studies with the SAS.

The SAS is provided with a weekly update of its key performance statistics on their operations across Scotland (Scottish Ambulance Service 2021c; Scottish Ambulance Service 2022). The weekly report is exclusive to SAS activity and only considers new data over the past month. These data determine the trends in unscheduled care incidents, ambulance response times, conveyances to hospital and turnaround times (Scottish Ambulance Service 2021a; Scottish Ambulance Service 2022). The SAS data for this study was used predominantly for performance rather than describing a prehospital population for people with NTBP. For this reason, the presentation of the data was appalling for my research, and it proved very difficult to work. The SAS employs skilled data analysists for this purpose, and they have the time and skills to dedicate for this purpose. As clinical doctorate research student without any training as a data analyst whilst working full-time made this process at times feel insurmountable.

Ethnicity and race were not included in these data and were therefore not reported. In the UK, ethnicity is documented in the patients' confidential healthcare records (Raleigh and Goldblatt 2020; SMERHS 2019). These data help ambulance services monitor and

improve outcomes for different ethnic groups. However, the data relating to these variables were not requested, which is acknowledged as a limitation. Admittedly this was an oversight that happened during the research process and is not meant to be insensitive or offensive. A significant challenge of cleaning the datasets required an analysis of 65 independent variables. Some variables had two or more outcomes such as pain, NEWS scores and repeat doses of medications. All these variables had to be aligned into one document for the analysis of 8824 patient cases. Without this cleaning process there were over 19000 lines of data on one spread sheet. This is how the data was presented to me from SAS, across multiple books in one EXCEL document. As additional information was required for example any NEWS scores obtained during transport to ED they were provided in a separate EXCEL document. These had to be cleaned for duplicates and then merged into the master document. All the results had to be combined into one spreadsheet for analysis in the recommended SPSS software. It became apparent that an extensive working knowledge of EXCEL and its complex formulae would be required to interpret results if EXCEL was to be used for this process. There were no instructions how to achieve this objective which resulted in the whole process having to be learned through trial and error. This added significant stress and time for this study's completion. The data for ethnicity and race was missed during this process. It is acknowledged that we need more research on the health of ethnic minorities in Scotland (Raleigh and Goldblatt 2020; NHS Health Scotland 2014). The inclusion of minority groups is suggested important and should be included in any future study as it would improve the overall quality of the research.

Missing information was one of the most significant limitations. The retrospective data appears to be more beneficial to the SAS in informing its performance drivers. The data thus afford the organisation an understanding of its response times, care delivery to patients, efficiency and cost-effectiveness, satisfaction, staff well-being and public trust and confidence in the SAS (Scottish Ambulance Service 2021c). For the purposes of responding to the research questions in this study, the data required significant reworking and cleaning for the analysis of NTBP, including the final ED diagnosis.

Linked data had to be sought from ISD Scotland as SAS does not record ED diagnoses for its patients. The linked data and the SAS data sometimes had different information fields missing. This was true for demographic and clinical information and varied across

all the datasets. The missing data was problematic, and it was uncertain how this happened as data should have been identical. Working with the two datasets it was possible to merge documents which provided some areas where data was missing.

There were inconsistencies in the recording of clinical data by ACs, which were sometimes incomplete. It is possible that these could have been more accurately documented in ePRF data and that they had not successfully converted to the Microsoft Excel format. This suggested that a deeper analysis of the clinical data would require a review of each individual ePRF. This was not feasible for the size of this population study, as the ePRF data are recorded as live SAS data. Accessing them, therefore, would impact service performance in real-time. There was a significant challenge to converting all these results into one document so they could be used for analysis in the more user-friendly SPSS software. During this analysis, it was identified that data were missing and sometimes incomplete. Therefore, replicating this type of study would be incredibly time-consuming, as cleaning the data proved to be a monumental task. Without having an advanced knowledge of Microsoft Excel and an excellent understanding of IBM SPSS, significant time was added to the arrival at the analysis stage of the study. There were no shortcuts to this stage, demonstrating that allocating time and time management was difficult, especially with the commitments to full-time work in the SAS.This process had to be done to ensure that the results were as valid and as reliable as possible.

This data cleaning process was achieved more by trial and error than any instructions from textbooks, manuals, or YouTube videos on Excel and SPSS software. These resources rarely explained the process required to achieve the needed results. This required an incredible amount of additional work, which was often frustrating, demoralising and was more often solved through discussion with some colleagues, using abstract or lateral thinking.

5.7 Bias

It was acknowledged that is impossible to conduct research without some level of bias. As this was a descriptive observational study, working with limited available data, bias could have occurred at any phase of this research. To address this possibility, I tried to be mindful of my own expectations and beliefs and tried to limit any personal

prejudices when analysing data and reporting the results. As a paramedic working with this prehospital data, it was easy to visualise the data from my own clinical understanding and past patient experiences. It was acknowledged that the audience who may read my study may not exclusively be ACs. Objectively reporting demographic facts appeared to be more straightforward as they could be relatable to other health professionals. This was achievable with the statistical data provided in charts and diagrams (Porta 2014). Reporting the clinical information was more challenging (Shields 2021). Shields (2021) suggests that a writer should ask themself what am I trying to tell the reader? And how is it relevant to them? Time, therefore, was taken to minimise where possible any ambulance jargon or an assumption a reader knew how AC manage and treat patients with NTBP. This required some of the longer explanations provided for medications and treatments. This description aimed to provide the reader with as much information as possible to help them understand an ACs role. Reporting the clinical data required careful consideration to minimise any technical bias in my writing which may not have always been achieved.

Information bias is a type of error that occurs when key study variables are incorrectly measured or classified (Porta 2014). This was an area of my research, where my own unconscious bias may have occurred. As some of the demographic and clinical data sets were missing or incomplete great care had to be taken not make any assumptions based on my understanding of the findings (Porta 2014). An example of this could be the ACs on these occasions administered Entonox and morphine to the patient. Interpretively this meant that a paramedic had attended the patient as only paramedics or advanced practitioners can administer morphine in SAS (Brown et al. 2021). For a reader this may not have been apparent. The complexity of reporting all 8824 calls by grade of staff therefore determined it was better to report everyone as ACs. In the early stages of the study identification of each grade of staff that attended was experimented. With eight different categories this proved too complex and more than often disrupted the presentation of data and the mixing up of results.

To limit this information bias, I aimed to be considerate of data collection methods and sources from where they were collected. Data were obtained from the SAS and ISD Scotland for comparison without a reliance on one source. Following supervisory guidance to keep the statistical analysis descriptive, and reporting only what was found,

aimed to minimise biases in the interpretation of the results (Mitchell 2012). A limitation with this analysis meant that any comparisons between variables could not be realised. To help illustrate this point in the early design of the project, the aim was to examine the sensitivity and specificity of the aMPDS for detecting NTBP. To fully realise this, all 615,252 calls (inclusive of calls not diagnosed as 05 NTBP by ACs but received a final diagnosed by ED as NTBP) would have to have been analysed. This was simply too large a dataset to contend with. Without the objective eye and critical appraisal of supervisory support picking up on this, the omission of this information could have resulted in an enormously biased research question. Bias was catastrophically averted by guidance resulting in the reformulation of research questions two and three. This lesson demonstrated that being too close or too keen to find answers requires careful critical consideration. Without the provision of this guidance information bias would have been inevitable, demolishing any value presented to the keen-eyed reader. The challenge was attempting to remain subjective to facts and trying not to jump to conclusions.

5.8 Broader implications for practice, policy, and future research

Several key themes that may be useful for future research on the prehospital presentations of NTBP to SAS and other UK ambulance service trusts were identified. These outcomes would all benefit from conducting further research:

Women, particularly older ones, are the most likely to call an emergency ambulance for NTBP. This suggests that developing specific care pathways should consider their particular health needs.

Developing a multimodal approach to managing NTBP with partner healthcare agencies is essential. This should include advanced practitioners that offer greater access to urgent care pathways.

Dorsalgia was the favoured medical terminology for low back pain (non-traumatic). Defining this as a guideline may help inform the management of true NTBP.

5.9 Recommendations

This research may inform other similar studies to provide a more accurate prevalence for prehospital presentations of other non-traditional emergency calls. The following

recommendations, discussed below, relate to practice, policy, and education for managing and treating of NTBP based on the findings of this study.

5.9.1 Ambulance Pathways for Cauda Equina Syndrome

A rare condition associated with NTBP but usually asymptomatic is CES (Long et al. 2020). CES is rare but has been taken seriously enough to warrant its prehospital guideline criteria for UK ambulance services (Brown et al. 2021). Its diagnosis has become the focus of many acute hospital admissions for people symptomatic of NTBP presenting to ED (Long et al. 2020; Al-Nammari et al. 2020; Edlow 2015a). There are many causes for CES, with the recognition of some notable red flags signposted to ACs in JRCALC guidelines. The SAS has no direct access pathways to admit patients with possible CES to trauma and orthopaedic (T&O) services. These are located at dedicated trauma or satellite hospitals with radiology, T&O and Magnetic Resonant Imaging (MRI). The Major Trauma Centre (MTC) for the North of Scotland (NoS) is Aberdeen Royal Infirmary (ARI) for adults and the Royal Aberdeen Childrens Hospital (RACH) for children, the Royal Infirmary of Edinburgh, Ninewells Hospital in Dundee, and the new Southern General Queen Elizabeth Hospital in Glasgow (NHS Scotland North 2023; Royal College of Surgeons of Edinburgh 2014) with satellite hospitals such as Wishaw General in Lanarkshire situated across West, East and the North of Scotland. CES is impossible to diagnose without MRI, as history taking and physical examination have low sensitivity in confirming this condition (Long et al. 2020; Al-Nammari et al. 2020; Edlow 2015a).

The onset of symptoms for CES can be gradual or sudden in nature. Some patients experience NTBP, and others report no pain at all but have other associated neurological symptoms. These can include paraplegia, impotence in men, bladder dysfunction and urinary retention. Without immediate access to a diagnosis with MRI, the risks of permanent or chronic dysfunction for bladder, bowel, and general function are significant. CES has a poor prognosis and is associated with high morbidity. Any delays in its diagnosis there are suggested to have devastating life-changing consequences for patients. It is therefore a condition that, if detected, requires emergency referral and management and conveyance to the hospital (Long et al. 2020; Al-Nammari et al. 2020; Edlow 2015a).

Although there were no reported diagnoses of CES, it could not be confirmed whether any patients did not develop CES. It was determined that some patients who called the SAS for symptoms of NTBP were pain-free. Being in pain was thought to be synonymous with NTBP, but it became apparent that, for some people, this was not the reason they called the SAS. A review of the final ED diagnosis revealed some cases where patients had pathologies associated with this condition. Cervical disc disorders, spinal arthropathies, and neoplasms were examples observed in this population. Moreover, some patients diagnosed with ACs were pain-free, but were symptomatic of other clinical features associated with NTBP.

Scotland has a very diverse geography, with many people living in remote and rural areas. Accessing MRI services in these areas may delay assessment for patients who are symptomatic or asymptomatic of CES. According to The Royal College of Radiologists (2023), McNamee et al. 2013, Gardner et al. (2011), and Gitelman et al. (2008), these patients require immediate access to hospitals that have dedicated T&O centres with MRI onsite. MRI hours usually operate from 0830–2030, and conveying the patient to the right hospital could be a significant factor in ensuring a positive outcome.

For the SAS to transport any query CES to the most appropriate hospital, to the right team at the right time, could help significantly to accurately diagnose this patient population associated with NTBP. This could include the ability for a professional-to-professional telephone discussion with a T&O doctor. Since 2012, Primary Percutaneous Coronary Intervention (PPCI) for the treatment of acute myocardial infarction (heart attack) has been directly accessed by the SAS across six regional centres across Scotland (Scottish Government 2021b; Scottish Intercollegiate Guidelines Network (SIGN) 2016). These centres have saved many lives. Although further study would be required for developing equal access for patients detected with NTBP, developing guidelines for the recognition and diagnosis of CES by the SAS ACs may be beneficial.

5.9.2 Integrating Artificial Intelligence (AI)

Artificial intelligence (AI) mobile apps are increasingly being explored for use in the healthcare industry (Lee and Yoon 2021). The technology appears promising, offering to provide new ways to measure and monitor human health that may be used for

contributing to better patient outcomes. AI achieves this through its ability to analyse large amounts of data from various sources, such as medical records, and provide insights into an individual's health status, risk factors, and potential health outcomes (Lee and Yoon 2021). The aMPDS call triaging system for the cases of NTBP that were of a high acuity was found to have very low accuracy. Incorporating AI that could measure baseline observations and share them with aMPDS through an emergency app appears to have the potential to help to address this limitation.

AI is already integrated within healthcare as a tool for measuring human health through different means (Nomura et al. 2021). Diagnostically, AI is being used to help doctors make more accurate and timely diagnoses by analysing medical images, lab results and other patient data. For example, some research has demonstrated that machine learning AI can make accurate predictions based on human neural networks to identify skin cancer with an accuracy of 95%, compared to 86.4% for dermatologists (Esteva et al. 2018). AI and machine learning, along with predictive algorithms can also inform healthcare professionals about certain potential health conditions that may present in the future, based on a patient's medical history, lifestyle factors and genetics, and are used to identify patients at high risk for developing diseases such as heart disease or diabetes (Ellahham 2020; Nomura et al. 2021). Remote monitoring is another method that draws on AI systems and may be used to monitor and track patients with early warning signs of health problems, such as irregular heartbeats or changes in blood pressure. Several other mobile phone apps are available to manage various health conditions. Two studies have described the management of diabetes through remote AI technologies, and these have demonstrated that these have helped to improve patients' self-management of glycaemic control (Ellahham 2020; Nomura et al. 2021).

Personalised medicine is another adaptation possible with AI and may be used to analyse a patient's genetic data to identify the most effective medication or treatment for a particular condition (Alrefaei et al. 2022; Dias and Torkamani 2019). Some examples include those that provide personalised nutrition advice based on genetic testing, and those that monitor conditions such as diabetes or hypertension and provide tailored recommendations for managing these conditions.

Further research is required to validate the effectiveness of AI in clinical settings and to ensure their responsible and ethical use. These studies demonstrate the potential of AI to

improve the accuracy and efficiency of diagnosing human health conditions. This suggests the possibility that AI could provide baseline information that could be integrated into emergency call-taking processes in pre-hospital settings such as the SAS. This could enhance the detection of the acuity of calls from baseline observations measured by a mobile app. The technology for such systems already exists and is increasingly being used by NHS Scotland in other services. In developing these technologies for pre-hospital care, The design of an emergency app for patients accessing SAS should be based on the six physiological parameters of a NEWS score. Many existing apps, such as the track and trace system used during the COVID-19 pandemic, demonstrate how a system could work (O'Neill 2020). Developing any emergency app would require robust encryption algorithms, such as AES-256 or RSA-2048, to safeguard sensitive information from cyber threats (Chen and Zhu 2021). The final diagnoses data could be shared between the SAS, ED and the patient's GP. It has previously been suggested that these services should share emergency medical data between them (Grundy et al. 2019; Editorial Team 2022). This may help to facilitate instant access to medical information for SAS staff, and support the accurate prioritisation of emergency calls via telephone triage.

At least ten existing apps can measure essential baseline observations and these could be used to calculate a NEWS score that could be shared with aMPDS. A respiratory rate, measured by MD calc, is a system that uses the camera on the smartphone to measure a respiratory rate remotely. The user places the phone camera on their chest and the app, installed on the patient's phone, measures the respiratory rate by detecting chest movements. Healthcare providers gather the data by using the camera to collect the diagnostic information. An average respiratory rate over 30 seconds is then calculated. This measurement is essential for assessing breathing difficulties, which were identified in the call detriments as being the trigger for the escalation and higher prioritisation of emergency calls. As breathing difficulties are recognised as a predictor for cardiac arrest by call triage, this data could also help identify high acuity cases (Clawson et al. 2008). An examination of all the NEWS data in this study determined that respiratory rates were recorded by ACs in 7954 (90%) of cases. Of these, 7102 (80%) were found to be within an average adult range of 12–20 breaths per minute (Brown et al. 2021). A median respiratory rate of 18 breaths per minute was found in most patients, which is considered normal (Brown et al. 2021). There were 842 (9%) patients who had a higher

than average breathing rate, defined as ≥21 breaths (tachypnea) per minute, and 11 (0.12%) patients who had respirations that were considered abnormally low, at ≤8 breaths per minute. These are patients who would have been triaged as needing an immediate response if these data had been made available to call triage staff.

As breathing drives circulation, having an accurate measurement is arguably one of the most effective diagnostic measurements (Clawson et al. 2008). Further analysis of the data determined that these were the same patients who all had a pain score of ≥7 (severe) (Brown et al. 2021). For the patients who had abnormally slow respirations, their presentations of NTBP were consistent with metabolic imbalances associated with chronic conditions such as cardiac or respiratory illnesses (Brown et al. 2021). High respiratory rates may be caused by anxiety, fear, pain, illness and injury. This suggests that measuring all six baseline observations would be necessary to measure acute patients more accurately (Royal College of Physicians 2017).

The median heart rate for this population was 83 (83%) beats per minute and this was considered normal. The patients who were observed to have tachycardia (rapid heart rate) and bradycardia (a slow heart rate) were found to be consistent with the associated respiratory rates and were usually very unwell, following assessment by ACs. The AliveCor Kardia (2017) is an example of an app that lets users record their heart rhythm, providing an instant electrocardiogram (ECG) (Lane et al. 2020; Rizas et al. 2022). It achieves this by inviting the user to place their fingers on the device, enabling the app to provide an instant report on the user's condition. The Cardio-rhythm and Fibricheck apps use the phone camera to detect changes in physiology caused by blood flow, which helps to monitor heart rate and rhythm. Some acute cardiac conditions, such as atrial fibrillation (Afib), can be monitored by such apps. Afib is a condition that is not generally life-threatening and can produce the onset of acute breathlessness and palpitations. It increases the risk factors of transient ischaemic attack (TIA) or stroke by four to five times (British Heart Foundation 2023). Some studies suggest that medical apps can be effective for the self-monitoring and overall management of Afib (Guo et al. 2020). These apps demonstrate that obtaining remote measurements of vital baseline observations are possible. Cardio-rhythm and AliveKor suggest that blood oxygen saturations (SPO2) too are measurable by mobile apps. This app measures how much oxygen that red blood cells are carrying and the result is displayed as a percentage. A

reading of ≥94–100% is required for normal health and to meet metabolic function (Brown et al. 2021).

Any increase or decrease in metabolic effects alter the delivery and cellular demands of oxygen, making SPO2 an effective diagnostic tool for determining a patient's acuity. If these measurements are combined with the other baselines, they can also help to determine a patient's medical status. For NTBP, these readings ranged from 94–100% in 8225 cases. This demonstrated that most patients were in a stable condition and not of high acuity. It was found that 412 (4%) patients were severely hypoxic (SPO2 <85%), 136 (1%) were moderately hypoxic (SPO2 85–90%), and 1893 (20%) were mildly hypoxic (SPO2 90–93%). Other vital data included recording at least one systolic blood pressure with a median average of 110 mmHg within normal ranges. The mean body temperature was 37.1℃ and this was documented in 65% of cases. All of these measurements appear possible to measure via these medical apps.

A growing body of literature suggests that medical apps can improve health outcomes, promote patient engagement, and increase healthcare settings (Lane et al. 2020; Rizas et al. 2022). These studies present systematic reviews and meta-analyses of the available evidence, and their results suggests that using data gathered by apps to contribute to making informed decisions about the development of an emergency within the SAS is possible.

Admittedly there are many challenges to the widespread adoption of medical apps. Some of these may include issues of usability, maintaining privacy, and protection against cyber security attacks. The Wannacry ransomware attack on the NHS in 2017 affected devices running unpatched Microsoft Windows 7 software (Trautman and Ormerod 2019). A further attack on Advanced, a software supplier for NHS 111, raised concerns about patient data theft (Milmo and Campbell 2022). These attacks prompted the UK government to develop a strategy to protect the NHS from cyber attacks, including the securing of cyber resilience in healthcare sectors by 2030 (Markham 2023). The need to provide appropriate training and support for healthcare professionals and patients in the use of these apps must also be considered.

Any emergency medical app would require the software features discussed here to assess patient acuity. These would never substitute face-to-face examination, but could

become an essential component of call triage. A computer algorithm would interpret the patient's condition by adding baseline observations once these are shared by the patient. This would not require additional medical training for emergency dispatchers. The data could help to determine the determinants of identifying people at the most significant risk. Whether this could be integrated into the existing aMPDS system is unknown. Nevertheless, any costs could be justified by more lives being saved and ambulances being targeted more precisely to emergency calls. This may help the SAS with call prioritisation. Research has shown that older adults may face challenges in using medical apps, such as difficulty with using technology and having low digital literacy skills (Moorhead et al. 2013). Designing an app that could meet older people's needs and abilities, such as providing large font sizes, simplified navigation, and user-friendly interfaces, and possible inequalities that may exist for the minority of people who do not have access to the internet are some of the many challenges of developing such a proposal (NHS Digital 2023). It could be argued that the development of an emergency medical app considers the care provision of tomorrow and the future ageing population of Scotland, who will be highly media aware. The technology exists now, but SAS could use this to improve the identification of high-acuity calls and thus enhance call prioritisation of precious ambulance resources.

5.9.3 Reviewing possible causes of NTBP in a prehospital setting

Solid statistical evidence shows that a common cause of NTBP in females aged 16–54 is endometriosis (Endometriosis UK 2023; Rogers et al. 2009). This debilitating condition has been reported to have been poorly managed or not taken seriously by some health providers including one-fifth of GPs in the UK (Endometriosis UK 2023; Campbell 2021). It is not considered in JRCALC guidelines as a potential cause of NTBP. Endometriosis affects one in ten women, leaving them to manage severe and cycling pain, which may cause infertility. It is cited as taking an average of seven-and-a-half years to diagnose this condition in the UK (Pritchard et al. 2019). Recognising that endometriosis could be a potential cause of NTBP for women of childbearing age for any prehospital presentations is essential. This would require further study; however, it should be included as a possible cause of NTBP.

Woolf and Pfleger (2003) described four musculoskeletal conditions that are recognised by the World Health Organization (WHO) (2010) and the United Nations as being a

significant universal burden on health and social care systems. These are osteoarthritis (OA), rheumatoid arthritis (RA), osteoporosis, and low back pain. These conditions represent the most common musculoskeletal age and gender-specific conditions that can be symptomatic of acute back pain. They may be described as having mechanical, non-mechanical, and visceral causes (Hartvigsen et al. 2018; Walcott et al. 2011).

Osteoarthritis (OA), or *degenerative joint disease*, is an age-related form of arthritis commonly affecting the joints of the low back and neck (National Institute of Arthritis and Musculoskeletal and Skin Diseases 2019). It is a degenerative condition in which the cartilage that cushions the ends of bones within the joint gradually wears away, leading to pain, stiffness and swelling. The causes of OA are not fully understood, but it affects 9.6% of men and 18% of women who are aged ≥60 years (Woolf and Pfleger 2003). OA was not identified in the analysis in this study, but three cases (0.03%) of osteomyelitis were defined as an infection of the bone attributed to the staphylococcus aureus bacterium (Atlas and Deyo 2001). The patients were all women, with a mean age of 68.

Rheumatoid arthritis (RA) is a chronic autoimmune disorder in which the body's immune system attacks the synovial membrane that lines the joints. According to Woolf and Pfleger (2003), RA affects 0.3–1.0% of people and is more prevalent in women. The analysis found no incidences of RA that were suggested to be symptomatic of NTPB.

Osteoporosis is a condition in which the bones become weak and brittle, making them more prone to fractures. Osteoporosis is four times more common in women, affecting one in four women ≥50 years of age (Ratini 2022). This is considered to be one of the most detrimental fracture types and is associated with a 20% mortality (Woolf and Pfleger 2003). Associated injuries that may present as lower back pain include a fractured hip (neck of femur). Although there are no studies to provide exact patient numbers for the SAS, these types of injuries may be common reasons for making emergency calls for ambulances.

According to the NHS (2023) osteoporosis is more prevalent in older women because of diminished bone mineral density (BMD). With men, diminished BMD is associated with a loss of testosterone. Osteoporosis can affect younger women aged <45 years

(NHS 2023; University of Turku 2023). One reason for this has been linked to the onset of early menopause, usually between the age of 45 and 55 years (NHS 2023). Osteoporosis was diagnosed on 86 (0.97%) occasions, of which 58 (67%) were women, with an average age of 80 years, and 10 (11.6%) were men, with an average age of 82 years. Eighteen patients did not have their gender recorded. Despite being considered a possible cause for older people to call the SAS with NTBP, a diagnosis of osteoporosis was not found within the study population.

According to JRCALC, most presentations of low back pain are musculoskeletal in origin (Brown et al. 2021). This statement is not contested, yet the findings in this study determined NTBP was less likely to be caused by musculoskeletal conditions. The sample demonstrates that 93% of this population who called SAS had NTBP symptomatic of other conditions. Detecting potentially life-threatening and serious conditions symptomatic of NTBP, such as aortic aneurysm, aortic dissection, pancreatitis, ectopic pregnancy, and renal colic, is important (Brown et al. 2021). Very few of these conditions were presented in the sample. This finding reminds that how NTBP is diagnosed, documented, and recorded by ACs is important for developing their understanding of the patient's condition and any associated risks. Capsey et al. (2022) suggest that presentations of NTBP to ambulance services should have their own categorisation due to the non-traditional musculoskeletal causes. A wider UK ambulance study is therefore recommended to better understand this population.

5.9.4 ACs Developing Education and Training for NTBP

The JRCALC (2021) guidelines for low back pain (non-traumatic) demonstrate that ACs require a deeper understanding of these assessments and the knowledge to manage NTBP. This knowledge should be developed for all frontline staff. Emergency Medical Technicians (EMT) and Ambulance paramedics (senior clinicians) were the main groups who assessed and treated patients with NTBP. The different skill sets and medications for treating NTBP were accounted for in the analysis of these data. Although there are role differences, all frontline grades of staff in SAS are highly trained to deliver standardised immediate medical care in line with best UK practice (Brown et al. 2021; Resuscitation Council UK 2023; Scottish Ambulance Service 2023). Since 2020, paramedic education has been taught at five universities across Scotland. EMT education remains in-house within SAS, accredited by a vocational framework

equivalent to Scottish Qualifications Authority (2023) level 7 or the first year of university education (FutureQuals 2023).

These roles can work together in different combinations of two people per ambulance emergency unit (AEU) or as one paramedic or specialist advanced paramedic (PRU) in a response car. The PRU can offer additional support for the AEU and may assume clinical lead if required (Snooks et al. 2006). Due to the large dataset analysed in this study, separating each patient case by the grade of staff who attended them was not possible. Whether individual treatments of dorsalgia differed by grade could therefore not be determined.

The review of JRCALC for NTBP was vital as it recommends assessment skills that are not practised by all grades of staff in SAS, such as EMTs and some paramedics who have experienced different training and education routes before 2020. EMTs contribute significantly to frontline operations across Scotland. In their annual report for 2019–20, the SAS confirmed that 1426 (28%) of the frontline emergency staff were EMTs (Scottish Ambulance Service 2022). EMTs remained an essential part of the prehospital care system in Scotland and encountered and diagnosed many of the low acuity conditions of 05 NTBP. Although they have a broad range of skills closely aligned with paramedicine, their ability to diagnose low acuity conditions such as NTBP can be limited due to their scope of practice. As they are college educated to SQA level 7, the principles of advanced assessment, suggested by JRCALC, are not included in their college training programme. They are instead educated to the postgraduate level through various established university programmes such as the University of Stirling's Advanced Care Programme. This may suggest that presentations of dorsalgia may be more suitable for treatment provided by advanced urgent care paramedic specialists.

Developing educational support for frontline staff through continuous professional development (CPD), online learning, and *Learning in Practice* (LIP) is recommended for NTBP. Further study may be a helpful method to help analyse the effectiveness of the new guidelines. Using the retrospective data in this study could provide a comparison measured against assessment based on the latest guidelines. Without a more profound analysis, these outcomes cannot be determined.

5.9.5 Recording and documenting diagnosis

For ACs, NTBP was found to be more of an umbrella term. This medical condition does not have a single common category, such as Acute Coronary Syndromes or COPD, which can describe many presentations of cardiac and respiratory illnesses (Brown et al. 2021). The interpretation of NTBP, therefore, depended on its assessment. It was determined that ACs' descriptions of NTBP were based more on signs and symptoms of 304 final conditions diagnosed in ED. These data found that NTBP was not attributed to one specific cause. ACs' ability to accurately document their working diagnosis in SAS data determined a severe limitation with this process. The aMPDS system only allowed ACs to input one generic code, *05 back pain*, that was the only code available that best described the patient's condition at the closure of the job. It was this coding that defined these data. ACs record all their findings and treatments in an electronic Patient Report Form (ePRF) in a separate system. Therefore, it was impossible to record how many true NTBP (dorsalgia) cases were attended to and diagnosed by ACs. This finding illustrates how the documentation system may have prevented the obtaining of a more accurate understanding of how low acuity conditions such as NTBP (dorsalgia) present to the SAS.

5.9.6 Dorsalgia as a medical description of NTBP

Dorsalgia appeared to be the medical term of choice for describing NTBP. The ICD-10 code M54 referred to *dorsalgia* and was the medical terminology used to describe back pain in the ED data. Dorsalgia is classified into eight subcategories, depending on the location and nature of the pain. These range from M54.1 *Radiculopathy* pain, defined as pain radiating from the spine affecting the nerves of surrounding areas, to M54.9 *Dorsalgia*, which is unspecified (ICD-10 54 2023). Some researchers identify it as having three specific subdivisions, which are mechanical and structural, non-mechanical, or structural and visceral causes (Atlas and Deyo 2001). The definition of dorsalgia presented in the ICD-10 is consistent with the musculoskeletal presentations of NTBP diagnosed in ED across the country.

The JRCALC plus guidelines are titled *Low back pain (non-traumatic)* and provide ACs with a variety of causes and options for management (Brown et al. 2021). These include guidance for identifying red flag presentations such as cauda equina syndrome (CES) that are categorised as time-critical emergencies. The findings suggest that dorsalgia

may be the more accurate term for low back pain. Adopting this terminology for low back pain by the SAS could ensure consistency with ED and may help inform ACs of treatments or pathways that are more specific to it (Brown et al. 2021). Although this would require peer review and further study, it was suggested that providing a more precise definition of dorsalgia may help inform ambulance care.

5.9.7 Public attitudes for accessing emergency ambulances.

There appears to be a generational difference in attitudes toward calling ambulances (Fisher and Mason 2018). A mixed methods study found that people aged over 60 years perceive that ambulances should only be called for life-threatening conditions, such as MI, stroke, or cardiac arrest (Fisher and Mason 2018). In contrast, people aged 16–24 years considered ambulances to provide a more comprehensive skillset, and they would call them for more primary or secondary care presentations (Fisher and Mason 2018). Understanding these differences in public attitudes and why people call the SAS for conditions such as dorsalgia requires further study. In this study, the 628 people diagnosed with dorsalgia could be further investigated for this purpose.

Chapter 5 discussed the findings and offering an explanation and interpretation of these findings in relation to the broader research. Working with the large datasets was challenging and, reflectively, there are certain areas identified, such as inclusion of ethnicity in the analysis, that require more attention. Seven recommendations that were deducted from the findings. It is important to note that these are not exhaustive. The discussion highlighted that there are many areas that require further research for prehospital presentations of NTBP. In the next chapter, a conclusion to the study is presented.

Chapter 6: Conclusion

6.1 Overview of the chapter

The conclusion chapter serves as the final synthesis of findings of this study. My findings aim to contribute to developing practice education, policy, and future research for SAS for its assessment and management of NTBP. In summary, my study:

1. Established the patient demographic for NTBP 999 calls, including socioeconomic status (SIMD) with associated NEWS.
2. Analysed the positive predictive value (PPV) for ambulance clinicians' diagnoses of true NTBP and determined whether this differed by dispatch priority.
3. Determined the sensitivity and specificity, positive predictive value (PPV) and negative predictive value (NPV) of aMPDS on objective acuity, as measured by NEWS scores for calls coded 05 NTBP by ambulance clinicians.
4. Established what pre-hospital clinical interventions were used by ambulance clinicians to treat patients with NTBP.

6.2 Summary and Conclusions

In my review of the literature, I found that NTBP is a prevalent condition that can impact an individual's quality of life. Providing timely and appropriate interventions requires further analysis as the SAS delivers prehospital care for NTBP. A follow-up study based on recent 999 calls that have followed the latest JRCALC guidelines for low back pain (non-traumatic) could assess their effectiveness (Brown et al. 2021). The results of my study may provide a valuable comparison with those presented in this thesis. As the prehospital management of NTBP was demonstrated to be rarely straightforward, this may help inform improvements that could shape future ambulance care.

My project determined several key observations that could help to develop future ambulance care pathways and local policies. Women, particularly older ones, were the most significant service users for NTBP for SAS. Women also consistently made more ambulance calls in most age groups – those aged between 16 and 89 years. The presentations of NTPB to SAS were not found to be subjective to age or limited

exclusively to older people. This finding appeared to be more exclusive to NTBP, as a review of all the emergency calls demonstrated that neither men nor women made more calls than the other.The more prominent representation of women in the population for NTBP indicates that developing additional guidance or support should consider women's particular health needs. By gender, the causes of NTBP varied, suggesting that a one-size-fits-all strategy may not be efficient. When this project commenced, emergency presentations of NTBP were hypothesised as being more likely to be men. My own bias as a healthcare professional working in this practice area meant that I arrived at this research project with the assumption that an older generation of people working in manual occupations would be more likely to have NTBP. The findings did not diminish the need to review male patients and revealed that developing a global understanding of how the condition affects both genders is necessary. As women are more likely to suffer from health inequalities, their voices should be heard.

Examining socioeconomic status and linking it to age and gender determined some surprising findings. I had hypothesised that a lower SIMD status would result in more ambulance responses to areas of higher deprivation. The data revealed that SIMD did not make any difference in the presentations of NTBP. It was true that fewer people lived in SIMD 5 compared to SIMD 1, but, proportionally, NTBP affected all levels of this emergency population equally. This statistical finding still did not detract from the fact that more ambulances responded to calls made in SIMD 1 and SIMD 2. Lower socioeconomic status contributing to complex psychosocial reasons, including well-being and mental health, were deprivation-associated factors that may have influenced some calls. As these factors are usually more associated with areas of higher deprivation, they may account for why more ambulances respond to SIMD 1 and SIMD 2. Although plausible, this line of investigation was unproven, suggesting it could be worthy of further study. Societal challenges faced in modern Scottish society include health inequalities. NTBP appeared to be a relevant factor; therefore, further analysis of these ambulance data could help to develop local ambulance and NHS policies. Examining socioeconomic status from this perspective demonstrates a requirement for multi-agency pathways. Indicatively, some of this population called SAS for social help and support associated with NTBP. Therefore, ACs' ability to access mental and social health care services could be necessary for creating alternative care pathways for the treatment of NTBP.

My review of the NEWS scores pre- and post-assessment of NTBP for all the patients found that, in most cases, NTBP was a low to no acuity condition. A proportion of people had a moderate NEWS of 5–6, and, for some, a NEWS ≥7 demonstrated that ambulance presentations of NTBP were not always benign. Linking these findings to socioeconomic status confirmed that deprivation did not appear to influence the acuity of NTBP. People were as severely unwell in SIMD 1 as they were in SIMD 5. More people living in SIMD 1 were severely unwell, with the largest proportion being women. This was consistent throughout most of my findings.

I found that moderately to severely unwell people called the SAS with NTBP was unexpected. NTBP was frequently cited in the literature as a low acuity condition that was considered safe to treat and leave in the community. My observation resulted in a review of how NTBP is defined in practice. The analysis of this ambulance data found that NTBP was more often a description of signs and symptoms rather than a diagnosis. In ED data, dorsalgia was the medical terminology that officially diagnosed these patients with NTBP. How NTBP is described or diagnosed by the SAS may have hidden accurate presentations of dorsalgia. The sample included in this study presented 8824 patients who were diagnosed as 05 NTBP, of which only 628 people had dorsalgia or actual back pain. This suggests that is important to allow ACs to accurately record NTBP diagnoses in the ePR so that any underlying conditions are highlighted appropriately. Diagnosing NTBP may be challenging in a prehospital setting. This finding suggests that exploring the education, treatment, and diagnosis of NTBP requires development. The comprehensive JRCALC guidelines offer excellent guidance. If ACs are not trained or educated in the appropriate diagnosis and treatment of NTBP, a patient may be more likely to be transported to ED. Educationally, this suggests that more work is required to facilitate the professional development of ACs' practices in assessing and managing this condition.

If NTBP is a low acuity condition but challenging to manage, why would people make repeat calls to SAS? This hypothesis was tested to evaluate whether NTBP resulted in additional pressures for the SAS and, if so, to determine how these patients might be managed more effectively. NTBP was found to be unlikely to result in repeat calls. This supported the finding that most people who called SAS for NTBP required assistance

and were unlikely to make repeat emergency calls for help. The small number of repeat calls was scattered across the year with no consistency supported my observation.

My analysis of the diagnostic accuracy of ACs' ability to diagnose NTBP revealed that NTBP is more often a marker for complex chronic medical conditions. GPs were found to have greater accuracy in their diagnosis of dorsalgia. The diagnosis could only be recorded as 05 NTBP in both datasets. With the main emphasis of paramedic education and training being on recognising presentations of acute emergency presentations, it was not unexpected that NTBP would be challenging to diagnose. The ambulance profession is adapting to respond to more primary conditions using a triage system to identify people who are most likely to experience a cardiac arrest. The challenge for the SAS is in how to respond appropriately in order to provide society with an emergency service whilst at the same time being expected to deal with non-life-threatening conditions. Modern society has high expectations of the NHS and its services. UK ambulance services respond to many emergency calls that decades ago would not have been considered appropriate for an emergency ambulance service. This indicates a considerable societal shift in public attitudes and expectations of when to call 999 that presents multiple challenges to these services. This study found that 628 people were willing to call an emergency ambulance for dorsalgia, providing some validity to this assertion. The results of this study question whether the design of the aMPDS may be problematic, for example, has it been over-engineered and manipulated, making it less efficient and more likely to generate yellow calls? These questions are unknown and untested here, and in the literature. Examining whether the aMPDS could detect high acuity presentations of NTBP and finding that it could not, demonstrates the challenges presented by this algorithmic system. My findings in this study suggest that a deeper analysis of aMPDS triage to detect low acuity conditions such as NTBP, requires far more evidence-based research.

The management and treatment of NTBP by ACs of the SAS focused on administering analgesics. These were generic to ambulance care, of which Entonox, oral paracetamol and ibuprofen were administered by all grades of staff. Paramedics provided morphine for severe presentations of pain. A further ten drugs, which were all analgesics (opiate or non-steroidal anti-inflammatories or muscle relaxants), were administered by GPs. Whether these drugs were effective or appropriate for the presentation of NTBP

depended on the cause of the NTBP. Morphine and other opiates are not recommended for dorsalgia Most patients did not have dorsalgia. This demonstrated a limitation of working with descriptive data. A deeper analysis of the pharmacological interventions related with this sample would be required for this purpose. A key finding is the value of being able to record diagnoses more accurately. This would enable a greater understanding of the selection of pharmacology, which may have justified the use of opiates and to identify why a small portion of patients were left in the community following the administration of morphine.

Being in pain was not found to be a predictor for transport to ED. Alternatively, some patients had no pain but were still transported to ED. This suggests that the complexity of the presentations of NTBP could not be simplified, as being in pain alone was a reason to call SAS. The descriptive nature of the data did not afford further analysis, but invited further study on a complex issue. This supported the finding that how NTBP was recorded for greater accuracy requires further research.

Whether ACs provided or suggested non-pharmacological treatments was unknown. These factors were not considered in the guidelines available to ACs for 2018 (Brown et al. 2016a). A follow-up study could explore this avenue, as alternative treatments, exercises, and heat patches are now recommended in JRCALC (Brown et al. 2021). How these could be documented and recorded requires investigation, as these skills are perhaps more representative of those possessed by a primary health or urgent care provider, rather than professionals working in immediate care. The updated JRCALC guidelines assume that ACs are educated and trained to perform these assessments. This study found that additional knowledge and skills are required for this purpose. Developing further education and training around minor conditions for ACs is crucial but may need to include healthcare professionals as a whole, including primary care if more patients are to be managed in the community.

Drug safety and promoting analgesia to patients for NTBP who are not transported or referred to other health providers were elements of pre-hospital care that were not apparent in the data. Such comments were likely recorded in live datasets but, without access to these, this information could not be reviewed. The question of drug safety or suitability does require attention. If more patients are to be left in the community, questions relating to what analgesics could be beneficial, how long they could be safely

taken, and whether they would require a prescription, were highlighted. These avenues require investigation, considering the length of waiting times for seeing GPs in NHS Scotland. Conditions such as NTBP, which can usually be addressed in primary care, often become worse during the waiting time to attend the GP surgery. In an article published by the Royal College of Emergency Medicine (RCEM) (2021) there is evidence that long waiting GP times can lead to an increase in the number of people calling ambulances. Since the global pandemic and subsequent lockdown, most primary care services became virtual. This meant that people were forced to access their GP through online appointments, video calls and telephone consultations (RCEM 2021). There is an argument that some groups of people, such as older people, disabled people, people whose first language was not English, and those from deprived areas or with a low income, may have been excluded. The global pandemic has radically changed the way in which the public access primary and community healthcare (RCEM 2021). This could explain why ambulance services offer an alternative option for those in need. An unintended consequence of these changes is that patients who are affected by sinister underlying conditions such as malignancies may be referred to specialist services earlier by resorting to calling SAS.

The complexity of NTBP revealed in this thesis aligns with the broader literature that advocates for the importance of developing a multimodal approach to managing this condition. Physiotherapy services, for example, maybe the best fast-track route for making appropriate referrals for the SAS, rather than accessing GP services. Many GPs across Scotland self-refer patients to this service, providing them with a telephone contact. The geographic diversity of Scotland suggests that the SAS would be required to work with local health authorities to achieve a multi-disciplinary pathway. It is unlikely that a single national policy for managing NTBP would be possible.

It was found that, while NTBP is a complex and heterogeneous condition, there is a range of evidence-based strategies that ACs can use. It was identified that, in most cases, NTBP was symptomatic of other more complex conditions. This determined that clearly describing NTBP as dorsalgia, as defined in the ED data, may help clarify the accurate representation of this condition, compared to the people experiencing back pain as a symptom. A follow-up study investigating patients' experiences of dorsalgia with SAS may help clarify the effectiveness of treatments and interventions. It would be

necessary to explore ACs' experiences of managing dorsalgia and NTBP in order to determine the challenges of managing this condition in the prehospital setting.

The findings highlight several aspects that require attention and improvement in ambulance services. The first is the need for enhanced training and education for ACs. This should focus on the recognition, assessment, and treatment of NTBP. This would ensure that ACs possess the necessary knowledge and skills to provide optimal patient care. The challenges in accurately diagnosing the condition and the varied responses to its treatments were suggested in the data. In Scotland, this knowledge should be extended to EMTs. As the impact of NTBP extended beyond its physical symptoms and may have had significant psychological, social, and economic consequences for individuals and broader society, the findings of this study demonstrate that ambulance providers can contribute to managing this global problem.

The study revealed the importance of implementing evidence-based guidelines and protocols within SAS. Standardised protocols can guide ACs in making appropriate decisions regarding pain management and specialised care, but these may require local agreements across all regions of Scotland. Such protocols would promote consistency and efficiency for emergency care for time-critical presentations of CES and could benefit from a fast-track service via SAS. This identifies the significance of establishing effective communication and collaboration between SAS, primary health care providers, and hospitals. This is necessary to help reduce the reliance on ED transport, because NTBP was rarely a simple condition to manage in the prehospital setting in Scotland. Integrating electronic records, telemedicine technologies, and artificial intelligence apps may enhance real-time information sharing and remote consultations. These findings imply an urgent need for adopting a comprehensive and coordinated approach to NTBP. This should include the ambulance sector in a multimodal model.

More research evidence is needed to generate debate and discussion among researchers, ambulance clinicians, and other stakeholders. This could contribute to the development of new research collaborations and initiatives, as well as the identification of key research questions and priorities. This thesis emphasises that ongoing research and the evaluation of evidence-based studies to understand the underlying mechanisms of NTBP, the factors contributing to its persistence, and the effectiveness of different or alternative prehospital treatments are recommended. By developing and building on the

understanding of this and other studies collaboratively across healthcare disciplines, it is possible to improve patient care.

The value of the research undertaken in this thesis is that the findings may be used to help reduce unnecessary hospital attendances via ambulance transport, for NTBP, to emergency departments. This is a long-term aspiration. This study is a first step to help build an evidence base to facilitate meeting this goal. Developing this research may benefit the SAS for receiving acute services and, ultimately, for the out-of-hospital patient care management of NTBP. Strategically and organisationally, the SAS has committed itself to the NHS 20/30 vision to deliver, when possible, more care in the community. The findings and recommendations drawn from this study may be relevant and interesting to the SAS, patients, and acute hospital services.

From a patient and society perspective, identifying alternative ambulance clinician care pathways for more effective out-of-hospital assessment, management, and clinical treatment of NTBP, is desirable. Brown et al. (2022) indicate that ambulance clinicians can treat this condition effectively in the community. This would allow more patients to be treated in the comfort of their own homes (Scottish Ambulance Service 2017a). Developing this evidence base could save unnecessary ambulance transport to EDs, alleviating pressure on increasing ambulance demands, and potentially helping to address prolonged patient waiting times, which are also problematic in already hard-pressed in the acute hospital services.

From the ambulance clinicians' perspective, contributing to professional knowledge and enhancing the ability to treat NTBP could increase their effectiveness in assessing and treating minor injuries (Scottish Ambulance Service 2017b). This should be achieved by developing additional education and training for ACs in the assessment and management of NTBP. This research determines that promoting this development would involve a review and update of the latest available guidelines, which are comprehensive, but require more profound knowledge, particularly in relation to complex conditions such as NTBP (Brown et al. 2021).

The findings may contribute to developing a more explicit definition of true NTBP (dorsalgia) in making a diagnosis. The final ED medical diagnosis of dorsalgia may help SAS document low acuity cases of NTBP compared to conditions symptomatic of back

pain. If dorsalgia could be selected and recorded as a diagnosis in aMPDS data by ACs, ED clinicians may open alternative care pathways that are more suitable for these patients. Therefore, this research is relevant to ambulance clinician advisors based in ACC, allowing a chance to help dispatchers triage NTBP and help to identify the most appropriate ambulance response, thereby enhancing the existing aMPDS.

It is hoped that this research may contribute to the description of a sample population of people who present with NTBP to the SAS. Through time and future studies, this may help inform ambulance care and reduce unnecessary ED attendances, and, ultimately, improve the care experiences of people affected by NTBP.

Working full-time for the SAS and juggling a Clinical Doctorate was incredibly difficult. Stephen Tyler (1993) in his song *Amazing* from the Aerosmith album *Get a Grip* said:

> *The one last shot's a permanent vacation and how high can you fly with broken wings? Life's a journey, not a destination, and I just can't tell you what tomorrow brings.*

The lyrics in many ways reflect the experiences of my clinical doctorate journey. They summarise the magnitude of this level of study which were never taken lightly. But I also knew that I was never really alone either. There were always people there if I looked for them and without them I know that I would not have arrived at the end. Like many people, we all have our broken wings. When I started my studies, my life was so different, I had my mum, my wife and I had so much hope that we could have a family, but sometimes things are just not meant to be and the unexpected reminds me that tomorrow is never mine to own. Life is hard, its designed to be that way, but it is important that we never give up. Our wings can mend and if they don't work like they did they'll work in a different way.

I hope my contribution to the developing evidence base of prehospital care will be useful for others. And that it may lead to future studies that will help develop ambulance care.

References

Abdel Shaheed, C., Ferreira, G.E., Dmitritchenko, A., McLachlan, A.J., Day, R.O., Saragiotto, B., Lin, C., Langendyk, V., Stanaway, F., Latimer, J., Kamper, S., McLachlan, H., Ahedi, H. and Maher, C.G., (2021) The efficacy and safety of paracetamol for pain relief: an overview of systematic reviews. *Medical Journal of Australia*, 214 (7), pp. 324-331.

Abdelgawad, A.A. and Patel, N.J. (eds). (2014) *Pediatric orthopedics: a handbook for primary care physicians*. 2nd ed. Cham: Springer.

Abdelrahman, W. and Abdelmageed, A. (2014) Medical record keeping: clarity, accuracy, and timeliness are essential. *British Medical Journal*, 348, p. f7716.

Adams, R.J., Smart, P. and Huff, A.S. (2017) Shades of grey: guidelines for working with the grey literature in systematic reviews for management and organizational studies. *International Journal of Management Reviews*, 19 (4), pp. 432-454. https://doi.org/10.1111/ijmr.12102

Adler, N.E. and Newman, K. (2002) Socioeconomic disparities in health: pathways and policies. *Health Affairs*, 21 (2), pp. 60-76.

Al-Nammari, S.S., Gulati, A., Menon, K.V., Rossiter, N.D. (2020) Delay in management of cauda equina syndrome: causes and consequences. *Spine*, 45 (4), pp. E220-E226.

AliveCor Kardia (2017) User manual for Kardia Mobile by AliveCor. Available: www.alivecor.com [Accessed: 28 August 2023].

Alrefaei, A. F., Hawsawi, Y. M., Almaleki, D., Alafif, T., Alzahrani, F. A. and Bakhrebah, M.A. (2022) Genetic data sharing and artificial intelligence in the era of personalized medicine based on a cross-sectional analysis of the Saudi human genome program. *Scientific Reports*, 12 (1), pp. 1405. https://doi.org/10.1038/s41598-022-05296-7

Altman, D.G., Bland, J.M. (1994) Statistics notes: diagnostic tests 2: predictive values. *British Medical Journal*, 309 (6947), p. 102. https://doi.org/10.1136/bmj.309.6947.102

Ansdell, P., Thomas, K., Hicks, K.M., Hunter, S.K., Howatson, G. and Goodall, S. (2020) Physiological sex differences affect the integrative response to exercise: acute and chronic implications. *Experimental Physiology*, 105 (12), pp. 2007-2021.

Arksey, H. and O'Malley, L. (2005) Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology*, 8 (1), pp. 19-32. https://doi.org/10.1080/1364557032000119616

Aronson, J.K. (2016) Meyler's side effects of drugs. *The International Encyclopaedia of Adverse Drug Interactions*. 16th ed. Oxford: Elsevier.

Arthritis Foundation (2021) Chronic pain causes. Available: https://www.arthritis.org/health-wellness/healthy-living/managing-pain/pain-relief-solutions/chronic-pain-causes [Accessed 28 August 2023].

Association of Ambulance Chief Executives, Joint Royal Colleges Ambulance Liaison Committee (JRCALC) (2021) *JRCALC Clinical Guidelines 2021 Pocket Book.* Bridgwater: Class Professional Publishing.

Atlas, S.J. and Deyo, R.A. (2001) Evaluating and managing acute low back pain in the primary care setting. *Journal of General Internal Medicine*, 16, pp. 120-131.

Baxter, A.L., Thrasher, A., Etnoyer-Slaski, J.L. and Cohen, L.L. (2023) Multimodal mechanical stimulation reduces acute and chronic low back pain: pilot data from a HEAL phase 1 study. *Frontiers in Pain Research*, 4, p. 1114633.

BBC News (2021, January 9) *Ambulance delays: Increasing pressures on the NHS.* Available: https://www.bbc.com/news/uk-england-55544806 [Accessed: 28 August 2023].

Ben-Yishay, A. (2021) Back pain red-flags for emergency room vs. physician consults. *Spine Health*, 2 May. Available at: https://www.spine-health.com/conditions/lower-back-pain/back-pain-red-flags-emergency-room-vs-physician-consults [Accessed: 20 August 2023].

Bernell, S. and Howard, S.W. (2016) Use your words carefully: what is a chronic disease? *Frontiers in Public Health*, 4, p. 159.

Bhattacherjee, A. (2012) *Social science research: principles, methods, and practices*. Tampa: University of South Florida.

Biancuzzi, H., Dal Mas, F., Brescia, V., Campostrini, S., Cascella, M., Cuomo, A., Cobianchi, L., Dorken-Gallastegi, A., Gebran, A., Kaafarani, H.M., Marinangeli, F., Massaro, M., Renne, A., Scaioli, G., Bednarova, R., Vittori, A. and Miceli, L. (2022) Opioid misuse: a review of the main issues, challenges, and strategies. *International Journal of Environmental Research in Public Health*, 19 (18), p. 11754. https://doi.org/10.3390/ijerph191811754

Blackberry Clinic (2023). *How common is back pain in the UK?* Available: htttps://www.blackberryclinic.co.uk/articles/how-common-is-back-pain-in-the-uk/ [Accessed March 2024].

Blodgett, J.M., Robertson, D.J., Pennington, E., Ratcliffe, D. and Rockwood, K. (2021) Alternatives to direct emergency department conveyance of ambulance patients: a scoping review of the evidence. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, 29 (1), pp. 1-21. https://doi.org/10.1186/s13049-020-00821-x

Bloomberg, L., Meyers, J. and Braverman, M.T. (1994) The importance of social interaction: a new perspective on social epidemiology, social risk factors, and health. *Health Education Quarterly*, 21 (4), pp. 447-463. https://doi.org/10.1177/109019819402100407.

Blumberg, A.E. and Feigl, H. (1931) Logical positivism. *The Journal of Philosophy*, 28 (11), pp. 281-296.

Bohm, K. and Kurland, L. (2018) The accuracy of medical dispatch – a systematic review. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, 26 (94), pp. 1-10. https://doi.org/10.1186/s13049-018-0528-8

Booker, M.J., Shaw, A.R. and Purdy, S. (2015) Why do patients with 'primary care sensitive' problems access ambulance services? A systematic mapping review of the literature. *BMJ Open*, 5 (5), p. e007726. https://doi.org/10.1136/bmjopen-2015-007726

Bösner, S., Haasenritter, J., Hani, M.A., Keller, H., Sönnichsen, A.C., Karatolios, K., Schaefer, J.R., Baum, E. and Donner-Banzhoff, N. (2011) Gender bias revisited: new insights on the differential management of chest pain. *BMC Family Practice*, 12 (1), p. 45. https://doi.org/10.1186/1471-2296-12-45

British Heart Foundation (2019) *Bias and biology: how the gender gap in heart disease is costing women's lives*. British Heart Foundation. Available: https://www.bhf.org.uk/what-we-do/news-from-the-bhf/news-archive/2019/march/women-dying-needlessly-because-of-gender-inequalities [Accessed 27 August 2023].

British Heart Foundation (2023) *BHF UK Fact sheet*. British Heart Foundation. Available: https://www.bhf.org.uk/-/media/files/for-professionals/research/heart-statistics/bhf-cvd-statistics-uk-factsheet.pdf [Accessed 25 August 2023].

British National Formulary (2023a) *Entonox*. BNF. Available: https://bnf.nice.org.uk/drug/entonox.html [Accessed 25 August 2023].

British National Formulary (2023b) *Morphine*. BNF. Available: https://bnf.nice.org.uk/drug/morphine.html [Accessed 25 August 2023].

British National Formulary (2023c) *Gabapentin*. BNF. Available: https://bnf.nice.org.uk/drugs/gabapentin/ [Accessed 23 August 2023].

British Pain Society (2013) *Assessment of pain: A practical guide for clinicians*. British Pain Society. Available: https://www.britishpainsociety.org/static/uploads/resources/files/pain-assessment-practical-guide.pdf [Accessed 25 August 2023].

British Pain Society (2019) *Outcome Measures*. Available: https://www.britishpainsociety.org/static/uploads/resources/files/Outcome_Measures_January_2019.pdf [Accessed 17 August 2023].

British Pharmacological Society (2023) *What is pharmacology?* Available: https://www.bps.ac.uk/public-resources/what-is-pharmacology [Accessed 23 August 2023].

Brown, C.W. and Macleod, M.J.B. (2018) The positive predictive value of an ambulance prealert for stroke and transient ischaemic attack. *European Journal of Emergency Medicine* 25 (6), pp. 411-415. https://doi.org/10.1097/MEJ.0000000000000475

Brown, S.L., Lewis, M. and Morrow, D.R. (2016b) Endovascular repair of ruptured popliteal artery aneurysms: a case report and review of the literature. *EJVES Short Reports*, 32, pp. 24-28.

Brown, S.N., Kumar, D.S., James, C. and Mark, J. (eds.) (2021) *JRCALC clinical guidelines 2021*. Bridgwater: Class Professional Publishing.

Brown, S.N., Kumar, D.S., Mullins, M. and Mark, J. (eds.) (2016a) *JRCALC clinical guidelines 2016*. Bridgwater: Class Professional Publishing.

Brown, S.N., Walker, A., James, C. and Wrigley, F. (eds.) (2022) *JRCALC clinical guidelines 2022*. Bridgwater: Class Professional Publishing.

Buchbinder, R., van Tulder, M., Öberg, B., Costa, L.M., Woolf, A., Schoene, M., Croft, P., Hartvigsen, J., Cherkin, D., Foster, N.E. and Maher, C.G. (2018) Low back pain: a call for action. *The Lancet*, 391 (10137), pp. 2384-2388.

Caldwell, K., Henshaw, L. and Taylor, G. (2011) Developing a framework for critiquing health research: an early evaluation. *Nurse Education Today*, 31 (8), pp. e1-e7.

Campbell, J. L., Ramsay, J. and Green, J. (2001) Age, gender, socioeconomic, and ethnic differences in patients' assessments of primary health care. *Quality in Health Care*, 10 (2), pp. 90-95. https://doi.org/10.1136/qhc.10.2.90

Campbell, J. L., Ramsay, J. and Green, J. (2001) Age, gender, socioeconomic, and ethnic differences in patients' assessments of primary health care. *Quality in Health Care*, 10 (2), pp. 90-95.

Campbell, S. (2021) *Endometriosis: how new treatment 'changed my life'*. BBC News. Available: https://www.bbc.com/news/health-56245521 [Accessed: 28 August 2023].

Capsey, M., Ryan, C., Alexanders, J. and Martin, D. (2022) Ambulance service use by patients with lower back pain an observational study. *British Paramedic Journal*, 6 (4), pp. 11-17.

Ceklic, E., Tohira, H., Ball, S., Brown, E., Brink, D., Bailey, P., Brits, R. and Finn, J. (2022) A predictive ambulance dispatch algorithm to the scene of a motor vehicle crash: the search for optimal over and under triage rates. *BMC Emergency Medicine*, 22 (1), pp. 1-11. https://doi.org/10.1186/s12873-022-00609-5

Charlton, K., Limmer, M. and Moore, H. (2020) Intravenous versus oral paracetamol in a UK ambulance study: a case-control study. *British Paramedic Journal*, 5 (1), pp. 1-6.

Chartered Society of Physiotherapy (2023) *Outcome and experience measures*. The Chartered Society of Physiotherapy. Available: https://www.csp.org.uk/professional-clinical/research-evaluation/outcome-experience-measures [Accessed: 21 August 2023].

Chen, H. and Zhu, S. (2021) Cybersecurity in healthcare: a review. *Journal of Biomedical Informatics*, 120, p. 103838.

Chiarotto, A., Maxwell, L.J., Ostelo, R.W., Boers, M., Tugwell, P. and Terwee, C.B. (2019) Measurement properties of visual analogue scale, numeric rating scale, and pain severity subscale of the Brief Pain Inventory in patients with low back pain: a systematic review. *Journal of Pain*, (3), pp. 245-263. https://doi.org/10.1016/j.jpain.2018.07.009

Choke, E., Vijaynagar, B., Thompson, J., Nasim, A., Bown, M.J. and Sayers, R.D. (2012) Changing epidemiology of abdominal aortic aneurysms in England and Wales: older and more benign? *Circulation*, 125 (13), pp. 1617-1625.

Chou, R., Turner, J.A., Devine, E.B., Hansen, R.N., Sullivan, S.D., Blazina, I., Dana, T., Bougatsos, C. and Deyo, R.A. (2015) The effectiveness and risks of long-term

opioid therapy for chronic pain: a systematic review for a National Institutes of Health Pathways to Prevention Workshop. *Annals of Internal Medicine*, 162 (4), pp. 276-286.

Cianfrini, L.R., Richardson, E.J. and Doleys, D., (2021) *Pain psychology for clinicians: a practical guide for the non-psychologist managing patients with chronic pain*. Oxford: Oxford University Press.

Claridge, F. and Parry, A. (2021) Ambulance service pressures need a whole-system response. NHS Confederation. Available: https://www.nhsconfed.org/articles/ambulance-service-pressures-need-whole-system-response [Accessed: 24 August 2023].

Clawson, J., Olola, C., Heward, A., Patterson, B. and Scott, G. (2008) The Medical Priority Dispatch System's ability to predict cardiac arrest outcomes and high acuity pre-hospital alerts in chest pain patients presenting to 9-9-9. *Resuscitation*, 78 (3), pp. 298-306. https://doi.org/10.1016/j.resuscitation.2008.03.229

Clawson, J., Olola, C.H., Heward, A., Scott, G. and Patterson, B. (2007) Accuracy of emergency medical dispatchers' subjective ability to identify when higher dispatch levels are warranted over a Medical Priority Dispatch System automated protocol's recommended coding based on paramedic outcome data. Emergency Medical Journal, 24 (8), pp. 560-563. https://doi.org/10.1136/emj.2007.047928

College of Paramedics (2023) Overview of the paramedic profession. Available: https://www.collegeofparamedics.co.uk/what-is-a-paramedic [Accessed 27 August 2023].

Corp, N., Mansell, G., Stynes, S., Wynne-Jones, G., Morsø, L., Hill, J.C. and van der Windt, D.A. (2021) Evidence-based treatment recommendations for neck and low back pain across Europe: a systematic review of guidelines. *European Journal of Pain*, 25 (2), pp. 275-295.

Cosio, D. (2020) The perseverance loop: the psychology of pain and factors in pain perception. *Practical Pain Management*, 20 (1).

Crimmins, E.M., Shim, H., Zhang, Y.S. and Kim, J.K. (2019) Differences between men and women in mortality and the health dimensions of the morbidity process. *Clinical Chemistry*, 65 (1), pp. 135-145. https://doi.org/10.1373/clinchem.2018.288332

Critical Appraisal Skills Programme (CASP) UK (2018) CASP Systematic review checklist. Oxford: CASP UK. Available: https://casp-uk.net [Accessed 27 August 2023].

Critical Appraisal Skills Programme (CASP) UK (2023) CASP Systematic review checklist. Oxford: CASP UK. Available: https://casp-uk.net [Accessed 27 August 2023].

Crombez, G., Eccleston, C., Van Damme, S., Vlaeyen, J.W. and Karoly, P. (2012) Fear-avoidance model of chronic pain: the next generation. *The Clinical Journal of Pain*, 28 (6), pp. 475-483.

Dancey, C.P. and Reidy, J. (2017) *Statistics without maths for psychology*. 8th ed. Pearson International.

Datapharm (2022) Datapharm website. Available: www.datapharm.com [Accessed 27 August 2023].

Davies, C. and Davies, A. (2013) *The trigger point therapy workbook: your self-treatment guide for pain relief*. New Harbinger Publications.

Davis, D.P., Graydon, C., Stein, R., Wilson, S., Buesch, B., Berthiaume, S., Lee, D.M., Rivas, J., Vilke, G.M. and Leahy, D.R. (2007) The positive predictive value of paramedic versus emergency physician interpretation of the prehospital 12-lead electrocardiogram. *Prehospital Emergency Care*, 11 (4), pp. 399-402.

Dawes, J. (2008) Do data characteristics change according to the number of scale points used? An experiment using 5-point, 7-point and 10-point scales. *International Journal of Market Research*, 50 (1), pp. 61-77.

de Heer, E.W., Gerrits, M.M.J.G., Beekman, A.T.F., Dekker, J., van Marwijk, H.W.J., de Waal, M.W.M., Spinhoven, P., Penninx, B.W.J.H. and van der Feltz-Cornelis, C.M.

(2014) The association of depression and anxiety with pain: a study from NESDA. *PLoS ONE*, 9 (10), p. e106907. https://doi.org/10.1371/journal.pone.0106907

Deakin, C.D., Sherwood, D.M., Smith, A. and Cassidy, M. (2006) Does telephone triage of emergency (999) calls using advanced medical priority dispatch (AMPDS) with Department of Health (DH) call prioritisation effectively identify patients with an acute coronary syndrome? An audit of 42,657 emergency calls to Hampshire Ambulance Service NHS Trust. *Emergency Medicine Journal*, 23 (9), pp. 700-704.

DePalma, M.G. (2020) Red flags of low back pain. *Journal of the American Academy of Physician Assistants*, 33 (8), pp. 8-11.

Department of Health (2002) *Improvement, expansion and reform: the next 3 years' priorities and planning framework, 2003–2006*. Appendix B. London: Department of Health.

Department of Health (2005) *Summary statistics of emergency calls to ambulance services and patient journeys, England 1993–94 to 2003–04*. Available: http://www.publications.doh.gov.uk/public/sb0411.htm [Accessed: 27 August 2023].

Devlin, R.A. and Barham, V. (2011) Comparative efficiency assessment of primary care service delivery models using data envelopment analysis. *Canadian Public Policy*, 37 (1), pp. 85-109.

Deyo, R.A., Jarvik, J.G. and Chou, R. (2014) Low back pain in primary care. British Medical Journal, 16, (349), p. g4266. https://doi.org/10.1136/bmj.g4266

Deyo, R.A., Mirza, S.K., Turner, J.A., and Martin, B.I. (2015) Overtreating chronic back pain: time to back off? *Journal of the American Board of Family Medicine*, 28 (3), pp. 313-316.

Dias, R. and Torkamani, A. (2019) Artificial intelligence in clinical and genomic diagnostics. *Genome Medicine*, 11 (70). https://doi.org/10.1186/s13073-019-0689-8

Dickson, J.M., Jacques, R., Reuber, M., Hick, J., Campbell, M.J., Morley, R. and Grünewald, R.A. (2018) Emergency hospital care for adults with suspected seizures in the NHS in England 2007–2013: a cross-sectional study. *BMJ Open*, 8 (10), p. e023352.

Dionne, C.E., Dunn, K.M., Croft, P.R., Nachemson, A.L., Buchbinder, R., Walker, B.F., Wyatt, M., Cassidy, J.D., Rossignol, M., Leboeuf-Yde, C., Hartvigsen, J., Leino-Arjas, P., Latza, U., Reis, S., Gil Del Real, M.T., Kovacs, F.M., Oberg, B., Cedraschi, C., Bouter, L.M., Koes, B.W., Picavet, H.S., van Tulder, M.W., Burton, K., Foster, N.E., Macfarlane, G.J., Thomas, E., Underwood, M., Waddell, G., Shekelle, P., Volinn, E. and Von Korff, M. (2008) A consensus approach toward the standardization of back pain definitions for use in prevalence studies. *Spine*, 33 (1), pp. 95-103. https://doi.org/10.1097/BRS.0b013e31815e7f94

Douglas, E., Bell, D., Eadie, D., McGeechan, G., McGregor, A., Phillips, J., Robertson, T. and Rutherford, A. (2017) *Healthy ageing in Scotland: the pilot survey*. Stirling: University of Stirling.

Downey, C.L., Tahir, W., Randell, R., Brown, J.M. and Jayne, D.G. (2017) Strengths and limitations of early warning scores: a systematic review and narrative synthesis. *International Journal of Nursing Studies*, 76, pp. 106-119.

Du, S., Yuan, C., Xiao, X., Chu, J., Qiu, Y., Qian, H. and Zhang, K. (2017) Self-management programs for chronic musculoskeletal pain conditions: a systematic review and meta-analysis. *Patient Education and Counselling*, 100 (11), pp. 2122-2133.

Duderstadt, K.G. (2019) *Pediatric physical examination: an illustrated handbook*. 3rd ed. St. Louis: Elsevier.

Duncan, E. A. S., & Fitzpatrick, D. (2016). Role and prevalence of impaired awareness of hypoglycaemia in ambulance service attendances to people who have had a severe hypoglycaemic emergency: A mixed-methods study. Diabetes Care, 39(3) pages33-34.

Durcan, M. (2020). *Emergency services expenditure*. In J. Smith (Ed.), *Healthcare Economics* (pp. 12–25). London: King's Fund

Eaton, G., Wong, G., Tierney, S., Roberts, N., Williams, V. and Mahtani, K.R. (2021) Understanding the role of the paramedic in primary care: a realist review. *BMC Medicine*, 19 (145). https://doi.org/10.1186/s12916-021-02019-z

Eaton, J.C. (2000) *Essentials of immediate medical care*. Churchill-Livingstone.

Ebell, M.H. (2019) Gabapentin and Pregabalin not effective for low back pain with or without radiculopathy. *American Family Physician*, 99 (6).

Eccleston, C., Fisher, E., Craig, L., Duggan, G. B., Rosser, B. A. and Keogh, E. (2014) Psychological therapies (internet-delivered) for the management of chronic pain in adults. *Cochrane Database of Systematic Reviews*, 2, CD010152. https://doi.org/10.1002/14651858.CD010152.pub2

Edlow, J.A. (2015a) Managing nontraumatic back pain. *Annals of Emergency Medicine*, 66 (2). https://doi.org/10.1016/j.annemergmed.2014.11.011

Edlow, J.A. (2015b) Cauda equina syndrome: diagnosis, treatment, and outcome—evaluation of a case series. Journal of Emergency Medicine, 48 (5), pp. 573-580. https://doi.org/10.1016/j.jemermed.2014.12.002

Edwards M.J., Bassett G., Sinden L. and Fothergill, R.T. (2015) Frequent callers to the ambulance service: patient profiling and impact on case management on patient utilisation of the ambulance service. *Emergency Medicine Journal*, 32, pp. 392-396. https://doi.org/10.1136/emermed.2013.203352

Ellahham, S. (2020) Artificial intelligence: the future for diabetes care. *The American Journal of Medicine*, 133 (8), pp. 895-900. https://doi.org/10.1016/j.amjmed.2020.03.0331

Endometriosis UK (2023) *What is endometriosis?* Available: https://www.endometriosis-uk.org/understanding-endometriosis [Accessed 28 August 2023].

Esteva, A., Kuprel, B., Novoa, R.A., Ko, J., Swetter, S.M., Blau, H.M. and Thrun, S. (2018) Dermatologist-level classification of skin cancer with deep neural networks. *Nature*, 542 (7639), pp. 115-118. https://doi.org/10.1038/nature21056

Fawcett, T. (2006) An introduction to ROC analysis. *Pattern Recognition Letters*, 27 (8), pp. 861-874.

Feldman, M.J., Verbeek, P.R., Lyons, D.G., Chad, S.J., Craig, A.M. and Schwartz, B. (2006) Comparison of the medical priority dispatch system to an out-of-hospital patient acuity score. *Academic Emergency Medicine*, 13 (9), pp. 954-960.

Fink, R. (2000) Pain assessment: the cornerstone to optimal pain management. *Baylor University Medical Center Proceedings,* 13 (3), pp. 236-239. http://doi.org/10.1080/08998280.2000.11927681

Fisher, J. and Mason, S. (2018) Is ambulance use increasing or decreasing in England? A mixed methods study. *BMC Health Services Research*, 18 (1), p. 299. https://doi.org/10.1186/s12913-018-3123-3

Flemming, K. and Noyes, J. (2021) Qualitative evidence synthesis: where are we at? *International Journal of Qualitative Methods,* 20. https://doi.org/10.1177/1609406921993276

Ford-Jones, P.C. and Chaufan, C. (2017) A critical analysis of debates around mental health calls in the prehospital setting. *Inquiry*, 54. https://doi.org/10.1177/0046958017704608

Foucquier, J. and Guedj, M. (2015) Analysis of drug combinations: current methodological landscape. *Journal of Pharmacology and Experimental Therapeutics*, 353 (2), pp. 371-384. https://doi.org/10.1124/jpet.114.221358

Fuller, J.M., Barenfeld, E. and Ekman, I., (2021) Why do patients struggle with their medicines?—A phenomenological hermeneutical study of how patients experience medicines in their everyday lives. *PLOS ONE*, 16 (8), p. e0255478.

FutureQuals (2023) FutureQuals website. Available: www.futurequals.com [Accessed 28 August 2023].

Gardner, A., Gardner, E. and Morley, T. (2011) Cauda equina syndrome: a review of the current clinical and medico-legal position. *European Spine Journal*, 20 (5), pp. 690-697.

Geeky Medics (2023) *Sensitivity, specificity, PPV and NPV.* Available: https://geekymedics.com/sensitivity-specificity-ppv-and-npv/ [Accessed: 21 August 2023].

Giagoudakis, G. and Markantonis, S.L. (2005) Relationships between the concentrations of prostaglandins and the nonsteroidal anti-inflammatory drugs indomethacin, diclofenac, and ibuprofen. *Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy*, 25 (1), pp. 18-25.

Giordano, J., Abramson, K. and Boswell, M.V. (2010) Pain assessment: subjectivity, objectivity, and the use of neurotechnology part one: practical and ethical Issues. *Pain Physician*, 13 (4), pp. 305-315.

Giorgi, A. and Giorgi, B. (2003) Phenomenology. In: J.A. Smith, eds. *Qualitative Psychology: A Practical Guide to Research Methods*. London: Sage Publications.

Gitelman, A., Hishmeh, S., Morelli, B.N., Joseph Jr., S.A., Casden, A., Kuflik, P., Neuwirth, M. and Stephen, M. (2008) Cauda equina syndrome: a comprehensive review. *American Journal of Orthopedics*, 37 (11), pp. 556-562.

Global Burden of Disease (GBD) (2019) *Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019.* Available: https://vizhub.healthdata.org/gbd-results/ [Accessed: 28 August 2023].

Global Burden of Disease (GBD) Low Back Pain Collaborators (2021) Global, regional, and national burden of low back pain, 1990–2020, its attributable risk factors, and projections to 2050: a systematic analysis of the Global Burden of Disease Study 2021. *The Lancet Rheumatology*, 5 (6).

Grant, M.J. and Booth, A. (2009) A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Information & Libraries Journal*, 26 (2), pp. 91-108.

Greenhalgh, J. and Meadows, K. (2015) An introduction to patient-reported outcome measures (PROMs) in physiotherapy. *Physiotherapy*, 101 (2), pp. 119-125.

Greenhalgh, S., Truman, C., Webster, V. and Selfe, J., (2016). Development of a toolkit for early identification of cauda equina syndrome. *Primary Health Care Research & Development*, 17 (6), pp. 559-56

Greenwood, B., Lichtman, J.H., Dreyer, R.P., Spertus, J.A., Reid, K.J., Garavalia, B., Parashar, S., Vaccarino, V., Krumholz, H.M. and Lorenze, N.P. (2018) Sex differences in young patients with acute myocardial infarction: a VIRGO Study analysis. *European Heart Journal: Acute Cardiovascular Care*, 7 (2), pp. 111-121.

Grundy, Q., Chiu, K., Held, F., Continella, A., Bero, L. and Holz, R. (2019) Data sharing practices of medicines related apps and the mobile ecosystem: traffic, content, and network analysis. *British Medical Journal*, 364, l920. https://doi.org/10.1136/bmj.l920

Guo, Y., Lane, D.A., Wang, L., Zhang, H., Wang, H., Zhang, W., Wen, J., Xing, Y., Wu, F., Xia, Y., Liu, T., Wu, F., Liang, Z., Liu, F., Zhao, Y., Li, R., Li, X., Zhang, L., Guo, J., Burnside, G., Chen, Y., Lip, G.Y.H. and the mAF-App II Trial Investigators (2020) Mobile health technology to improve care for patients with atrial fibrillation. *Journal of the American College of Cardiology*, 75 (13), pp. 1523-1534. https://doi.org/10.1016/j.jacc.2020.01.052

Harbison, J., Hossain, O., Jenkinson, D., Davis, J., Louw, S.J. and Ford, G.A. (2003) Diagnostic accuracy of stroke referrals from primary care, emergency room physicians, and ambulance staff using the face arm speech test. *Stroke*, 34 (1), pp. 71-76.

Hartvigsen, J., Hancock, M.J., Kongsted, A., Louw, Q., Ferreira, M.L., Genevay, S., Hoy, D., Karppinen, J., Pransky, G., Sieper, J., Smeets, R.J., Underwood, M. and The Lancet Low Back Pain Series Working Group (2018) What low back pain is and why we need to pay attention. *The Lancet*, 391 (10137), pp. 2356-2367.

Hay, O., Dar, G., Abbas, J., Stein, D., May, H., Masharawi, Y., Peled, N. and Hershkovitz, I. (2015) The lumbar lordosis in males and females, revisited. *PLOS ONE*, 10 (8), p. e0133685. https://doi.org/10.1371/journal.pone.0133685

Health and Care Professions Council (HCPC) (2014) *Standards of proficiency – Paramedics*. London: HCPC.

Health and Care Professions Council (HCPC) (2017) *Standards of proficiency: Paramedics*. Available: https://www.hcpc-uk.org/globalassets/resources/standards/standards-of-proficiency-paramedics.pdf [Accessed 27 August 2023].

Health and Care Professions Council (HCPC) (2021) Scope of practice. Available: https://www.hcpc-uk.org/standards/meeting-our-standards/scope-of-practice/ [Accessed 27 August 2023].

Health Financial Management Association (HFMA) (2023) The NHS in Scotland. In: *HFMA introductory guide to NHS finance*. Available: www.hfma.org.uk [Accessed: 21 August 2023].

Healthcare Business Today (2023) What is a healthcare data sharing system? Available: https://www.healthcarebusinesstoday.com/what-is-a-healthcare-data-sharing-system/ [Accessed: 28 August 2023].

Herkes, G., Algie, C., Cameron, P. and Smith, K. (2019) Pain relief administration to patients in the prehospital setting by paramedics using methoxyflurane (Penthrox®): a prospective, observational, cohort study. *Emergency Medicine Journal*, 36 (7), pp. 398-402.

Heydari, F., Jafari, H., Zarei, S. and Hejrati, S. (2019) Comparison of the effectiveness of inhaled methoxyflurane (Penthrox) with intravenous fentanyl in reducing pain associated with renal colic: A double-blind, randomized, controlled trial. *Advanced Biomedical Research*, 8, 22.

Hill, J.C., Dunn, K.M., Lewis, M., Mullis, R., Main, C.J., Foster, N.E., and Hay, E.M. (2008) A primary care back pain screening tool: identifying patient subgroups for initial treatment. *Arthritis Care & Research*, 59 (5), pp. 632-641.

Hinchey, P., Myers, B., Zalkin, J., Lewis, R. and Garner Jr., D. (2007) Low acuity EMS dispatch criteria can reliably identify patients without high-acuity illness or injury. *Prehospital Emergency Care*, 11 (1), pp. 42-48.

Hoikka, M., Länkimäki, S., Silfvast, T. and Ala-Kokko, T.I. (2017) Medical priority dispatch codes—comparison with National Early Warning Score. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, 25 (1), p. 1.

Hoppe, D.J., Schemitsch, E.H., Morshed, S., Tornetta, P. III, Bhandari, M. (2009) Hierarchy of evidence: where observational studies fit in and why we need them. *Journal of Bone & Joint Surgery*, 91 (Suppl 3), pp. 2-9 .

Ikeda, T., Sugiyama, K., Aida, J., Tsuboya, T., Watabiki, N., Kondo, K. and Osaka, K. (2019) Socioeconomic inequalities in low back pain among older people: the JAGES cross-sectional study. *International Journal for Equity in Health*, 18 (1), pp. 1-11. https://doi.org/10.1186/s12939-019-0918-1

International Academies of Emergency Dispatch (IAED) (2018) *Medical Priority Dispatch System*. Salt Lake City, UT: Priority Dispatch Corporation.

International Academies of Emergency Dispatch (IAED) (2023) About the IAED. Available: https://www.emergencydispatch.org/who-we-are/about-the-iaed [Accessed: 27 August 2023].

International Association for the Study of Pain (2020) *IASP taxonomy*. Available: https://www.iasp-pain.org/resources/terminology [Accessed: 28 August 2023].

International Institute for Health and Care Research (IHRI) (2022) About us. Available: https://ihri.eu/ [Accessed 27 August 2023].

Iqbal, M. and Spaight, P. A. (2015) Patients and emergency clinicians' perceptions of improving prehospital pain management: a qualitative study. *Emergency Medicine Journal*, 32 (4), pp. 288-292. https://doi.org/10.1136/emermed-2014-20365

Julius, D. and Basbaum, A.I. (2001) Molecular mechanisms of nociception. *Nature*, 413 (6852), pp. 203-210.

Kahere, M. and Ginindza, T. (2020) Mapping evidence on the prevalence, incidence, risk factors and cost associated with chronic low back pain among adults in Sub-Saharan Africa: a systematic scoping review protocol. Systematic Reviews, 9 (57). https://doi.org/10.1186/s13643-020-01321-w

Kamper, S.J., Apeldoorn, A.T., Chiarotto, A., Smeets, R.J., Ostelo, R.W., Guzman, J. and van Tulder, M. (2015) Multidisciplinary biopsychosocial rehabilitation for chronic low back pain: Cochrane systematic review and meta-analysis. *British Medical Journal*, 350, h444. https://doi.org/10.1136/bmj.h444

Karcioglu, O., Topacoglu, H., Dikme, O. and Dikme, O. (2018) A systematic review of the pain scales in adults: which to use? *The American Journal of Emergency Medicine*, 36 (4), pp. 707-714.

Karstens, S., Joos, S., Hill, J.C., Krug, K., Szecsenyi, J. and Steinhäuser, J. (2015) General practitioners' views of implementing a stratified treatment approach for low back pain in Germany: a qualitative study. *PLOS One*, 10 (8), p. e0136119.

Katz, J.N. (2006) Lumbar disc disorders and low-back pain: socioeconomic factors and consequences. *Journal of Bone & Joint Surgery*, 88 (suppl 2), pp. 21-24.

Kerns, R.D., Burgess, D.J., Coleman, B.C., Cook, C.E., Farrokhi, S., Fritz, J.M., Goertz, C., Heapy, A., Lisi, A.J., Rhon, D.I. and Vining, R. (2022) Self-management of chronic pain: psychologically guided core competencies for providers. *Pain Medicine*, 23 (11), pp.1815-1819.

Kherad, M., Rosengren, B.E., Hasserius, R., Nilsson, J.-Å., Redlund-Johnell, I., Ohlsson, C., Mellström, D., Lorentzon, M., Ljunggren, Ö. and Karlsson, M.K. (2017) Risk factors for low back pain and sciatica in elderly men—the MrOS Sweden study. *Age and Ageing*, 46 (1), pp. 64-71. https://doi.org/10.1093/ageing/afw152

Kliegman, R.M., St Geme, J.W., Blum, N.J., Shah, S.S., Tasker, R.C., Wilson, K.M. (eds). (2021) *Nelson textbook of pediatrics*. 21st ed. Philadelphia: Elsevier.

Klineberg, E., Mazanec, D., Orr, D., Demicco, R., Bell, G. and McLain, R. (2007) Masquerade: medical causes of back pain. *Cleveland Clinic Journal of Medicine*, 74 (12), pp. 905-913.

Knezevic, N.N., Yekkirala, A.S. and Yaksh, T.L. (2021) Basic mechanisms of pain pathways: from peripheral nociception to central nervous system plasticity. *Journal of Pain Research*, 14, pp. 3217-3228. https://doi.org/10.2147/JPR.S279624

Knottnerus, J.A. and Muris, J.W. (2003) Assessment of the accuracy of diagnostic tests: the cross-sectional study. *Journal of Clinical Epidemiology*, 56 (11), pp. 1118-1128.

Koivulahti, O., Tommila, M. and Haavisto, E. (2020) The accuracy of preliminary diagnoses made by paramedics–a cross-sectional comparative study. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, 28 (1), pp. 1-7.

Kraus, S., Breier, M., Lim, W.M., Dabić, M., Kumar, S., Kanbach, D., Mukherjee, D., Corvello, V., Piñeiro-Chousa, J., Liguori, E. and Palacios-Marqués, D. (2022) Literature reviews as independent studies: guidelines for academic practice. *Review of Managerial Science*, 16 (8), pp. 2577-2595. https://doi.org/10.1007/s11846-022-00588-8

Krupski, T.L., Dahm, P., Fesperman, S.F. and Schardt, C.M. (2008) How to perform a literature search. *The Journal of Urology*, 179 (4), pp. 1264-1270.

Kuehl, A.E. (ed.) (2002) *Prehospital Systems and Medical Oversight.* National Association of EMS Physicians. Kendall/Hunt Publishing Company.

Lalkhen, A.G. and McCluskey, A. (2008) Clinical tests: sensitivity and specificity. *Continuing Education in Anaesthesia, Critical Care & Pain*, 8 (6), pp. 221-223.

Lane, D.A., McMahon, N., Gibson, J., Weldon, J. C., Farkowski, M. M., Lenarczyk, R., Watkins, C. L., Dilaveris, P., Caiani, E.G. and Potpara, T.S. (2020) Mobile health applications for managing atrial fibrillation for healthcare professionals and patients: a systematic review. *EP Europace*, 22 (10), pp. 1567-1578. https://doi.org/10.1093/europace/euaa2691

Larsen, E.R. (2012) The chemistry of modern inhalation anesthetics. In: M.B. Chenoweth, ed. *Modern Inhalation Anesthetics*. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 4-32.

Lassiter, W. and Allam, A.E. (2022) Inflammatory back pain. In: *StatPearls*. Treasure Island, FL: StatPearls Publishing. Available: https://www.ncbi.nlm.nih.gov/books/NBK539753/ [Accessed: 26 August 2023].

Leboeuf-Yde, C., Fejer, R., Nielsen, J., Kyvik, K.O. and Hartvigsen, J. (2011) Consequences of spinal pain: do age and gender matter? A Danish cross-sectional

population-based study of 34,902 individuals 20-71 years of age. *BMC Musculoskelet Disorders* 12 (39), pp. 1-13.

Lee, D. and Yoon, S.N. (2021) Application of artificial intelligence-based technologies in the healthcare industry: opportunities and challenges. *International Journal of Environmental Research and Public Health*, 18 (1), p. 271. https://doi.org/10.3390/ijerph18010271

Licciardone, J.C. (2004) Low back pain: pathophysiology and management. *Journal of the American Osteopathic Association*, 104 (3), pp. 107-113.

Linton, S.J. and Shaw, W.S. (2011) Impact of psychological factors in the experience of pain. *Physical Therapy*, 91 (5), pp. 700–711. https://doi.org/10.2522/ptj.20100330

Liverpool Medical Institution. (n.d.) History of the ambulance. Available: https://www.lmi.org.uk/history-of-the-ambulance [Accessed 16 August 2023].

Long, B., Koyfman, A. and Gottlieb, M. (2020) Evaluation and management of cauda equina syndrome in the emergency department. *The American Journal of Emergency Medicine*, 38 (1), pp. 143-148.

Luciano, M.M., Aloia, T.A. and Brett, J.F. (2019) 4 Ways to make evidence-based practice the norm in health care. Harvard Business Review. Available: https://hbr.org/2019/08/4-ways-to-make-evidence-based-practice-the-norm-in-health-care [Accessed: 28 August 2023].

Macfarlane, G.J., Beasley, M., Jones, E.A., Prescott, G.J., Docking, R., Keeley, P., McBeth, J. and Jones, G.T. (2012) The prevalence and management of low back pain across adulthood: results from a population-based cross-sectional study (the MUSICIAN study). *Pain*, 153 (1), pp. 27-32. https://doi.org/10.1016/j.pain.2011.08.005

Machado, G.C., Maher, C.G., Ferreira, P.H., Pinheiro, M.B., Lin, C.-W. C., Day, R.O., McLachlan, A.J. and Ferreira, M.L. (2017) Efficacy and safety of paracetamol for spinal pain and osteoarthritis: systematic review and meta-analysis of randomised placebo controlled trials. *British Medical Journal*, 357, p. j1805. https://doi.org/10.1136/bmj.j1805

Machado, G.C., Maher, C.G., Ferreira, P.H., Pinheiro, M.B., Lin, C.W.C., Day, R.O., McLachlan, A.J. and Ferreira, M.L. (2015) Efficacy and safety of paracetamol for spinal pain and osteoarthritis: systematic review and meta-analysis of randomised placebo controlled trials. *British Medical Journal*, 350, p. h1225.

Malton Museum (2021) *The Roman Army Medical Service*. Available at: https://www.maltonmuseum.co.uk/ [Accessed: 20 August 2023].

Manna, A., Sarkar, S.K. and Khanra, L.K. (2015) PA1 An internal audit into the adequacy of pain assessment in a hospice setting. *BMJ Supportive & Palliative Care*, 5 (Suppl. 1). http://dx.doi.org/10.1136/bmjspcare-2015-000906.61

Marin, T.J., Van Eerd, D., Irvin, E., Couban, R., Koes, B.W., Malmivaara, A., van Tulder, M.W. and Kamper, S.J. (2017) Multidisciplinary biopsychosocial rehabilitation for subacute low back pain. *Cochrane Database of Systematic Reviews*, 6, CD002193.

Markham, Lord N.F. (2023) *A cyber resilient health and adult social care system in England: cyber security strategy to 2030*. Policy paper. UK Government, Department of Health and Social Care. Available: https://www.gov.uk/government/publications/cyber-security-strategy-for-health-and-social-care-2023-to-2030/a-cyber-resilient-health-and-adult-social-care-system-in-england-cyber-security-strategy-to-2030#contents [Accessed 25 August 2023].

Marmot, M. (2005) Social determinants of health inequalities. *The Lancet*, 365 (9464), pp. 1099-1104.

Massé-Alarie, H. and Schneider, C. (2016) Revisiting the corticomotor plasticity in low back pain: challenges and perspectives. *Healthcare*, 4 (3), p. 67. https://doi.org/10.3390/healthcare4030067

Maxwell, E. and Lamont, T. (2023) *Improving care by using patient feedback.* The National Institute for Health and Care Research (NIHR) Dissemination Centre https.//doi.org.10.3310/themedview.04237

McClelland, G., Flynn, D., Rodgers, H. and Price, C. (2020) Positive predictive value of stroke identification by ambulance clinicians in North East England: a service

evaluation. *Emergency Medical Journal*, 37 (8), pp. 474-479. https://emj.bmj.com/content/37/8/474

McCracken, L.M., Vowles, K.E. and Eccleston, C. (2005) Acceptance-based treatment for persons with complex, long standing chronic pain: a preliminary analysis of treatment outcome in comparison to a waiting phase. *Behaviour Research and Therapy*, 43, pp. 1335-1346. https://doi.org/10.1016/j.brat.2004.10.003

McGrath, P. A. (1994) Psychological aspects of pain perception. *Archives of Oral Biology*, 39, pp. S55-S62.

McNamara, L.A. and Martin, S.W. (2023) Principles of epidemiology and public health. In: D. Kimberlin, M.Fischer, S.S. Long and C.G. Prober, eds. *Principles and Practice of Paediatric Infectious Disease*, 6th ed. Elsevier, pp. 1-10.

McNamee, J., Flynn, P., O'Leary, S., Love, M. and Kelly, B. (2013) Imaging in cauda equina syndrome — a pictorial review. *Ulster Medical Journal*, 82 (2), pp. 100-108.

Medical News Today (2023) *Back pain: can ice or heat therapy help?* Available: https://www.medicalnewstoday.com/articles/ice-or-heat-for-back-pain [Accessed: 28 August 2023].

Medicines and Healthcare Products Regulatory Agency (MHRA) (2023) Guidance on adverse drug reactions. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/949130/Guidance_on_adverse_drug_reactions.pdf [Accessed: 23 August 2023].

Mengist, W., Soromessa, T., Legese, G. (2020) Method for conducting a systematic literature review and meta-analysis for environmental science research. *MethodsX*, 7, 100777, https://doi.org/10.1016/j.mex.2019.100777

Meroni, R., Piscitelli, D., Ravasio, C., Vanti, C., Bertozzi, L., De Vito, G., Perin, C., Guccione, A.A,. Cerri, C.G. and Pillastrini, P. (2021) Evidence for managing chronic low back pain in primary care: a review of recommendations from high-quality clinical

practice guidelines. *Disability and Rehabilitation*, 43 (7), pp. 1029-1043. https://doi.org/10.1080/09638288.2019.1645888

Milmo, D. and Campbell, D. (2022) Fears for patient data after ransomware attack on NHS software supplier. *The Guardian*, 11 August. Available at: https://www.theguardian.com/society/2022/aug/11/fears-patient-data-ransomware-attack-nhs-software-supplier [Accessed: 28 August 2023].

Ministry of Health, Scottish Home and Health Department (1966) *Report by the Working Party on Ambulance Training and Equipment*. London: Her Majesty's Stationery Office.

Mitchell, A. (2012) *A quick guide to report writing*. SAGE Publications Inc.

Molinaro, A.M. (2015) Diagnostic tests: how to estimate the positive predictive value. *Neuro-Oncology Practice*, 2 (4), pp. 162-166.

Moorhead, S.A., Hazlett, D.E., Harrison, L., Carroll, J.K., Irwin, A. and Hoving, C. (2013) A new dimension of health care: systematic review of the uses, benefits, and limitations of social media for health communication. Journal of Medical Internet Research, 15 (4), p. e85. https://doi.org/10.2196/jmir.1933

Munn, Z., Peters, M.D., Stern, C., Tufanaru, C., McArthur, A. and Aromataris, E (2018) Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Medical Research Methodology*, 18, pp. 1-7.

National Health Service Act 1946. Available: https://www.legislation.gov.uk/ukpga/1946/81/pdfs/ukpga_19460081_en.pdf [Accessed: 28 August 2023].

National Institute for Health and Clinical Excellence (NICE) (2020) *Low back pain and sciatica in over 16s: assessment and management*. NICE Clinical Guideline [NG59]. London: National Institute for Health and Clinical Excellence.

National Institute for Health and Clinical Excellence (NICE) (2022) *Artificial intelligence for analysing chest X-ray images*. Medtech innovation briefing [MIB292]. Available at: https://www.nice.org.uk/advice/mib292 [Accessed: 28 August 2023].

National Institute of Arthritis and Musculoskeletal and Skin Diseases (2019) *Osteoarthritis*. Available: https://www.niams.nih.gov/health-topics/osteoarthritis [Accessed: 28 August 2023].

National Records of Scotland (2021) *Scotland's population: The Registrar General's annual review of demographic trends 2020*. Edinburgh: NRS. Available: https://www.nrscotland.gov.uk/statistics-and-data/statistics/stats-at-a-glance/registrar-generals-annual-review/2020 [Accessed 27 August 2023].

National Records of Scotland (2023) *Population statistics.* Edinburgh: NRS. Available: https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/population/population-statistics [Accessed 21 August 2023].

NHS (2023) *Overview: osteoporosis.* NHS Health A–Z. Available: https://www.nhs.uk/conditions/osteoporosis/ [Accessed: 28 August 2023].

NHS Digital (2005). *Emergency Ambulance Services: England 2004-2005.* Retrieved from NHS Digital. https://digital.nhs.uk/data-and-information/publications/statisitcal/ambulance-services/ambulance-services,England-2004-05-NHS England Digital. [Accessed March 2024].

NHS Digital (2023) *Why digital inclusion matters to health and social care*. Available: https://digital.nhs.uk/about-nhs-digital/corporate-information-and-documents/digital-inclusion/digital-inclusion-in-health-and-social-care [Accessed: 28 August 2023].

NHS England (2017) *New ambulance service standards announced.* Available: https://www.england.nhs.uk/2017/07/new-ambulance-service-standards-announced/ [Accessed 20 Aug 2023].

NHS England (2021) *Deprivation*. Available: https://www.england.nhs.uk/about/equality/equality-hub/national-healthcare-

inequalities-improvement-programme/what-are-healthcare-inequalities/deprivation/ [Accessed 12 August 2023].

NHS Health Scotland (2014) *Scottish Migrant and Ethnic Health Research Strategy Group (SMEHRS) combined report 2013 and strategy 2014–2019*. Available: https://www.healthscotland.scot/media/1843/scottish-migrant-and-ethnic-health-research-strategy-group-smehrs-report.pdf [Accessed August 28 2023].

NHS Scotland North (2023) Major Trauma Centre website. Available: https://www.nhsscotlandnorth.scot/networks/trauma/major-trauma-centre [Accessed 18 August 2023].

Nikolakopoulos, G., Kounnis, V., Tzatzarakis, M.N., Tsakalof, A.K., Vakonaki, E. and Tsatsakis, A. (2020) Acetaminophen (paracetamol) pharmacokinetics: a concise overview. *Toxicology Reports*, 7, pp. 438-450.

Nomura, A., Noguchi, M., Kometani, M., Furukawa, K. and Yoneda, T. (2021) Artificial intelligence in current diabetes management and prediction. *Current Diabetes Reports*, 21 (12), p. 61. https://doi.org/10.1007/s11892-021-01423-2

Nwachuku, A. (2020) 4 big reasons why back pain is hard to diagnose. *Spine-Health*, 28th February 2020. Available: www.spine-health.com/blog/4-big-reasons-why-back-pain-hard-diagnose [Accessed: 28 August 2023].

O'Brien, K., Colquhoun, H, Levac, D., Baxter, L., Tricco, A., Straus, S., Wickerson, L., Nayar, A., Moher, D. and O'Malley, L. (2016) Advancing scoping study methodology: a web-based survey and consultation of perceptions on terminology, definition and methodological steps. *BMC Health Services Research*, 16 (305). http://doi.org/10.1186/s12913-016-1579-z

O'Cathain, A., Simpson, R., Phillips, M. and Knowles, E. (2022) Tendency to call an ambulance or attend an emergency department for minor or non-urgent problems: a vignette-based population survey in Britain. *Emergency Medical Journal*, 39 (6), pp. 436-442. https://doi.org/10.1136/emermed-2020-210271

O'Hara, R., Johnson, M., Hirst, E., Weyman, A., Shaw, D., Mortimer, P., Newman, C., Storey, M., Turner, J., Mason, S., Quinn, T., Shewan, J. and Siriwardena A.N. (2014) A qualitative study of decision-making and safety in ambulance service transitions. *Health Services and Delivery Research*, 2 (56).

O'Neill, P.H. (2020) Coronavirus tracing apps can save lives even with low adoption rates. *MIT Technology Review*, September 2. Available: https://www.technologyreview.com/2020/09/02/1007936/coronavirus-tracing-apps-can-save-lives-even-with-low-adoption-rates/ [Accessed 23 August 2023].

Office for Health Improvement and Disparities (2022) Health disparities and health inequalities. Available: https://www.gov.uk/government/publications/all-our-health/health-disparities-and-health-inequalities [Accessed 27 August 2023].

Office for National Statistics (2022) *Scotland population mid-year estimate 2019*. Available: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/timeseries/scpop/pop [Accessed: 26 August 2023].

Paez A. (2017) Grey literature: an important resource in systematic reviews. Journal of Evidence Based Medicine, 10 (3), pp. 233-240. https://doi.org/10.1111/jebm.12265

Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. (2020) The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

Pallant, J. (2017) *SPSS survival manual*. 6th ed. London: Routledge.

Palmer, B. and Rolewicz, L. (2022) *Peak leaving? A spotlight on nurse leaver rates in the UK*. Nuffield Trust. Available: https://www.nuffieldtrust.org.uk/resource/peak-leaving-a-spotlight-on-nurse-leaver-rates-in-the-uk [Accessed: 28 August 2023].

Park, Y.S, Konge, L., and Artino, A.R. Jr (2020) The positivism paradigm of research. *Academic Medicine*, 95 (5), pp. 690-694. https://doi.org/10.1097/ACM.0000000000003093

Patton, G.S. Jr. (1947) *War as I knew it*. Boston: Houghton Mifflin Co.

Peacock, P.J. and Peacock, J.L. (2006) Emergency call work-load, deprivation and population density: an investigation into ambulance services across England. *Journal of Public Health*, 28 (2), pp. 111–115. https://doi.org/10.1093/pubmed/fdi079

Peters, M.D., Marnie, C., Colquhoun, H., Garritty, C.M., Hempel, S., Horsley, T., Langlois, E.V., Lillie, E., O'Brien, K.K., Tunçalp, Ö. and Wilson, M.G. (2021) Scoping reviews: reinforcing and advancing the methodology and application. *Systematic Reviews*, 10 (263). https://doi.org/10.1186/s13643-021-01821-3

Petty, R.E., Laxer, R.M., Lindsley, C.B., Wedderburn, L.R. (eds). (2016) *Pediatric rheumatology in clinical practice*. 2nd edn. Cham: Springer.

Pham, M.T., Rajić, A., Greig, J.D., Sargeant, J.M., Papadopoulos, A. and McEwen, S.A. (2014) A scoping review of scoping reviews: advancing the approach and enhancing the consistency. *Research Synthesis Methods*, 5 (4), pp. 371-385. https://doi.org/10.1002/jrsm.1123

Plana, D., Palmer, A.C. and Sorger, P.K. (2022) Independent drug action in combination therapy: implications for precision oncology. *Cancer Discovery*, 12 (3), pp. 606-624. https://doi.org/10.1158/2159-8290.CD-21-0212

Pollock, D., Davies, E.L., Peters, M.D., Tricco, A.C., Alexander, L., McInerney, P., Godfrey, C.M., Khalil, H. and Munn, Z. (2021) Undertaking a scoping review: a practical guide for nursing and midwifery students, clinicians, researchers, and academics. *Journal of Advanced Nursing*, 77 (4), pp. 2102-2113. https://doi.org/10.1111/jan.14743

Porta, M. (2014) *A dictionary of epidemiology*. 6th ed. Oxford: Oxford University Press.

Porter, J.E., Monuteaux, M.C., Stack, A.M. and Fleegler, E.W. (2019) Emergency medical services and sepsis care: a survey of emergency medical services medical directors. *Journal of Emergency Medicine*, 57 (2), pp. 236-243.

Porter, K.M., Stenhouse, C. and Healey, F. (2013) An evaluation of the Scottish Ambulance Service's clinical prioritisation model for unscheduled care. *Emergency Medical Journal*, 30 (12), pp. 1033-1037.

Powell, J.T., Hinchliffe, R.J,, Thompson, M.M., Sweeting, M.J., Ashleigh, R., Bell, R., Gomes, M., Greenhalgh, R.M., Grieve, R.J., Heatley, F., Thompson, S.G. and Ulug, P. (2014) Observations from the IMPROVE trial concerning the clinical care of patients with ruptured abdominal aortic aneurysm. *Journal of British Surgery*, 101 (3), pp. 216-224.

Pritchard, C., Brown, B., Khawaja, A., Gatenby, A. and Diu, N.L. (2019) Endometriosis: the condition that can take over seven years to diagnose. BBC News. Available: https://www.bbc.co.uk/news/av/stories-49925760 [Accessed: 28 August 2023].

Public Health England (2017) *Chapter 5: inequality in health*. Gov.uk. Available: https://www.gov.uk/government/publications/health-profile-for-england/chapter-5-inequality-in-health [Accessed 12 August 2023].

Public Health Scotland (2020) *Unscheduled Care Data Mart (UCDM)*. Edinburgh: Public Health Scotland.

Public Health Scotland (2023) *Scottish Index of Multiple Deprivation*. Available: https://www.publichealthscotland.scot/our-areas-of-work/inequalities/scottish-index-of-multiple-deprivation/ [Accessed: 28 August 2023].

Pullen, I. and Loudon, J. (2006) Improving standards in clinical record-keeping. *Advances in Psychiatric Treatment*, 12 (4), pp. 280-286.

Purcell, D. and Cooper, M. (2016) *Minor Injuries: a clinical guide*. 2nd ed. London: Churchill Livingstone.

Qaseem, A., Wilt, T.J., McLean, R.M. and Forciea, M.A. (2017) Non-invasive treatments for acute, subacute, and chronic low back pain: a clinical practice guideline from the American College of Physicians. *Annals of Internal Medicine*, 166 (7), pp. 514-530. https://doi.org/10.7326/M16-2367

Qureshi, N., Ali, R., Azam, F., Ullah, W., Qadir, M.I. and Hussain, S. (2019) Efficacy and safety of diclofenac in musculoskeletal injuries: a meta-analysis of randomised controlled trials. *Journal of Orthopaedic Surgery and Research*, 14 (1), p. 126.

Raja, S.N., Carr, D.B., Cohen, M., Finnerup, N.B., Flor, H., Gibson, S., Keefe, F., Mogil, J.S., Ringkamp, M., Sluka, K.A. and Song, X.J. (2020) The revised IASP definition of pain: concepts, challenges, and compromises. *Pain*, 161 (9), p. 1976.

Raleigh, V. and Goldblatt, P. (2020) *Ethnicity coding in health records*. The King's Fund. Available: https://www.kingsfund.org.uk/publications/ethnicity-coding-health-records [Accessed: 18 August 2023].

Rasmussen-Barr, E., Lindqvist, C., Östhols, S. and Boström, C. (2021) Are patient reported outcome measures (PROMs) useful in low back pain? Experiences of physiotherapists in primary health care in Sweden. *Musculoskeletal Science and Practice*, 55, p. 102414. https://doi.org/10.1016/j.msksp.2021.102414

Rathbone, T., Truong, C., Haldenby, H., Riazi, S., Kendall, M., Cimek, T. and Macedo, L.G. (2020) Sex and gender considerations in low back pain clinical practice guidelines: a scoping review. *BMJ Open Sport & Exercise Medicine*, 6 (1), p.e000972.

Ratini, M. (2021) *What is osteopenia?* WebMD. Available at: https://www.webmd.com/osteoporosis/osteopenia-early-signs-of-bone-loss [Accessed: 28 August 2023].

Resuscitation Council UK (2021) *Resuscitation Guidelines 2021*. Available: https://www.resus.org.uk/resuscitation-guidelines/ [Accessed: 28 August 2023].

Resuscitation Council UK (2023) *Resuscitation Guidelines Clinical Library & Quality Standards Courses for Professionals*. Available: www.resus.org.uk [Accessed: 28 August 2023].

Rizas, K.D., Freyer, L., Sappler, N., von Stülpnagel, L., Spielbichler, P., Krasniqi, A., Schreinlechner, M., Wenner, F.N., Theurl, F., Behroz, A., Eiffener, E., Klemm, M.P., Schneidewind, A., Zens, M., Dolejsi, T., Mansmann, U., Massberg, S. and Bauer, A. (2022) Smartphone-based screening for atrial fibrillation: a pragmatic randomized

clinical trial. *Nature Medicine*, 28, pp. 1823–1830. https://doi.org/10.1038/s41591-022-01979-w

Rizzardo, A., Miceli, L., Bednarova, R., Guadagnin, G.M., Sbrojavacca, R. and Della Rocca, G. (2016) Low-back pain at the emergency department: still not being managed? *Therapeutics and Clinical Risk Management*, 12, pp. 183-187.

Roberts, S.B., Calligeros, K. and Tsirikos, A.I. (2019) Evaluation and management of paediatric and adolescent back pain: epidemiology, presentation, investigation, and clinical management: a narrative review. *Journal of Back and Musculoskeletal Rehabilitation*, 32 (6), pp. 955-988.

Robinson, L., Dapaah, J. and Walker, A. (2004) *Could ambulance clinicians manage acute low back pain according to the Royal College of General Practitioners Guidelines?* West Yorkshire Metropolitan Ambulance Service. AMBEX abstracts 999 EMS Research Forum. Available: www.emjonline [Accessed: 28 August 2023].

Rogers, P.A., D'Hooghe, T.M., Fazleabas, A., Gargett, C.E., Giudice, L.C., Montgomery, G.W., Rombauts, L., Salamonsen, L.A. and Zondervan, K.T. (2009) Priorities for endometriosis research: recommendations from an international consensus workshop. *Reproductive Sciences*, 16, pp. 335-346.

Royal College of Nursing (RCN) (2022) About us. RCN. Available: https://www.rcn.org.uk/ [Accessed: 27 August 2023].

Royal College of General Practitioners (RCGP 2015). GP Updated hand-book Low Back Pain Management. http://www.rcgp.org.uk/clinspec/guidelines/backpain/ [Accessed March 2024].

Royal College of Physicians (2017) National Early Warning Score (NEWS) 2: standardising the assessment of acute-illness severity in the NHS. Updated report of a working party. Available: https://www.rcplondon.ac.uk/projects/outputs/national-early-warning-score-news-2 [Accessed: 28 August 2023].

Royal College of Radiologists (2023) *MRI provision for cauda equina syndrome.* Available: https://www.rcr.ac.uk/publication/mri-provision-cauda-equina-syndrome [Accessed: 28 August 2023].

Royal College of Surgeons of Edinburgh (2014) *Trauma care in Scotland: A report by the Trauma Working Group of the Royal College of Surgeons of Edinburgh*. Available: https://www.rcsed.ac.uk/media/4089/web_trauma-care-report-2012.pdf [Accessed 18 August 2023].

Ryan, R. (2013) Data synthesis and analyses. Cochrane Consumers and Communication Review Group. Available: http://cccrg.cochrane.org [Accessed: 28 August 2023].

Sarsfield, K. and Boyle, A. (2021) *What's behind the increase in demand in emergency departments?* RCEM Acute Insight Series. Royal College of Emergency Medicine. Available: https://rcem.ac.uk/wp-content/uploads/2021/10/Whats_Behind_The_Increase_In_Demand_In_EDs.pdf [Accessed: 28 August 2023].

Schick-Makaroff, K., MacDonald, M., Plummer, M., Burgess, J. and Neander, W. (2016) What synthesis methodology should I use? A review and analysis of approaches to research synthesis. *AIMS Public Health*, 3 (1), pp. 172-215. https://doi.org/10.3934/publichealth.2016.1.172

Schreiber, K.L., Martel, M.O., Shnol, H., Shaffer, J.R., Greco, C., Viray, N., Taylor, L.N., McLaughlin, M., Brufsky, A., Ahrendt, G., Bovbjerg, D., Edwards, R.R. and Belfer, I. (2013) Persistent pain in postmastectomy patients: comparison of psychophysical, medical, surgical, and psychosocial characteristics between patients with and without pain. *Pain*, 154 (5), pp. 660-668. https://doi.org/10.1016/j.pain.2012.11.015

Schwandt, T.A. (1994) Constructivist, interpretivist approaches to human inquiry. In: N.K. Denzin and Y.S. Lincoln, eds. *The Sage Handbook of Qualitative Research*. London: Sage, pp. 118-137.

Schwartz-Shea, P. and Yanow, D. (2013) *Interpretive Research Design: Concepts and processes*. London: Routledge.

Scottish Ambulance Service (2009) *Scottish Ambulance Service Annual Report and Accounts 2008/2009*. Edinburgh: Scottish Ambulance Service. Available: http://scottishambulanceservice.co,/TheService/annualreport.aspx [Accessed: 28 August 2023].

Scottish Ambulance Service (2017a) Technician and paramedic re-banding announced, Thursday 24th August 2017. *Scottish Ambulance Service-News*. Available: www.scottishambulance.com [Accessed: 28 August 2023].

Scottish Ambulance Service (2017b) *Improving Care, reducing costs.* Edinburgh: Scottish Ambulance Service. Available: www.scottishambulance.com/.../file/.../PTS-more-than-patient-transport-hight-res.pdf [Accessed: 28 August 2023].

Scottish Ambulance Service (2018) *Towards 2020: Taking Care to the Patient, 2015–2020*. Edinburgh: Scottish Ambulance Service.

Scottish Ambulance Service (2019) *Clinical Governance Framework 2019-2022*. Edinburgh: Scottish Ambulance Service. Available: https://www.scottishambulance.com/media/5629/clinical-governance-framework-2019-22.pdf [Accessed: 28 August 2023].

Scottish Ambulance Service (2020) *Annual Report and Accounts 2019-2020*. Available: https://www.scottishambulance.com/publications/annual-report-and-accounts/ [Accessed 18 August 2023].

Scottish Ambulance Service (2021a) *About us: our funding*. Edinburgh: Scottish Ambulance Service. Available: https://www.scottishambulance.com/About-Us/Our-Funding.aspx [Accessed: 28 August 2023].

Scottish Ambulance Service (2021b) *Clinical Practice Guidelines 2021*. Edinburgh: Scottish Ambulance Service. Available: https://www.scottishambulance.com/What-We-Do/clinical-practice-guidelines-2021.aspx Accessed: 28 August 2023].

Scottish Ambulance Service (2021c) *Board Quality Indicators Performance Report*. Edinburgh: Scottish Ambulance Service.

Scottish Ambulance Service (2022) *Annual Report and Accounts 2021-2022.* Available: https://www.scottishambulance.com/publications/annual-report-and-accounts/ [Accessed 18 August 2023].

Scottish Ambulance Service (2023a) *About us.* Edinburgh: Scottish Ambulance Service. Available: https://www.scottishambulance.com/ [Accessed: 28 August 2023].

Scottish Ambulance Service (2023b) *Our 2030 Strategy*. Available: https://www.scottishambulance.com/media/3gsf0jbh/our-2030-strategy-final.pdf [Accessed 28 August 2023].

Scottish Government (2020) *Scottish Index of Multiple Deprivation 2020: A National Statistics Publication for Scotland*. Available: https://www.gov.scot/collections/scottish-index-of-multiple-deprivation-2020/ [Accessed 28 August 2023].

Scottish Government (2021a) *Women's Health Plan: A plan for 2021–2024*. Edinburgh: Scottish Government. Available: https://www.gov.scot/publications/womens-health-plan/ [Accessed 28 August 2023].

Scottish Government (2021b) Heart disease: action plan. Edinburgh: Scottish Government. Available: https://www.gov.scot/publications/heart-disease-action-plan/ [Accessed 27 August 2023].

Scottish Government (2023) Scottish Index of Multiple Deprivation. Available: https://www.gov.scot/collections/scottish-index-of-multiple-deprivation-2020/ [Accessed 27 August 2023].

Scottish Intercollegiate Guidelines Network (SIGN) (2016) *Management of acute coronary syndrome*. Available: https://www.sign.ac.uk/media/1090/sign148.pdf [Accessed: 28 August 2023].

Scottish Office (1994) *The Scottish Ambulance Service National Health Service Trust Order 1994*. Edinburgh: HMSO.

Scottish Qualifications Authority (2023) *About SQA.* Available: https://www.sqa.org.uk/sqa/409.html [Accessed: 28 August 2023].

Sedgwick, P. (2014) Cross sectional studies: Advantages and disadvantages. *British Medical Journal*, 348, g2276.

Sethi, G.K., Hughes, R.K. and Takaro, T. (1974) Dissecting aortic aneurysms. *The Annals of Thoracic Surgery*, 18 (2), pp. 201-215.

Shaheed, C.A., Maher, C.G., Williams, K.A., Day, R., McLachlan, A.J. and Nicholson, M. (2017) Efficacy, tolerability, and dose-dependent effects of opioid analgesics for low back pain: a systematic review and meta-analysis. *JAMA Internal Medicine,* 177 (3), pp. 380-387.

Shea, B.J., Reeves, B.C., Wells, G., Thuku, M., Hamel, C., Moran, J., Moher, D., Tugwell, P., Welch, V., Kristjansson, E. and Henry, D.A. (2017) AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *British Medical Journal*, 358, j4008.

Sheard L., Marsh C., Mills T., Peacock R., Langley J., Partridge R., Gwilt, I. and Lawton, R. (2019) Using patient experience data to develop a patient experience toolkit to improve hospital care: a mixed-methods study. *Health Service Delivery Research,* 7 (36).

Shields, K. (2021) *Methods to explain technical ideas to non-technical people*. Forbes. Available: https://www.forbes.com/sites/theyec/2021/10/29/methods-to-explain-technical-ideas-to-non-technical-people/ [Accessed 18 August 2023].

Sieper, J. and Poddubnyy, D. (2017) Axial spondyloarthritis. *The Lancet*, 390 (10089), pp. 73-84. https://doi.org/10.1016/S0140-6736(16)31591-4

Singh, J. (2013) Critical Appraisal Skills Programme. CASP Appraisal Tools. *Journal of Pharmacology and Pharmacotherapeutics*, 4 (76). http://doi.org/10.4103/0976-500X.107697

Siriwardena, A.N., Smith, M.D., Rowan, E. and Spaight, R. (2021) Clinical effectiveness and costs of pre-hospital inhaled methoxyflurane for acute pain in trauma in adults: non-randomised control group study. *British Paramedic Journal*, 5 (4), pp. 66-67.

Smith, J. (2018) Cauda equina syndrome: a diagnostic and surgical emergency. *Journal of Neurosurgery*, 129 (3), pp. 567-578.

Snooks, H.A., Halter, M., Close, J.C., Cheung, W.Y., Moore, F. and Roberts, S.E. (2006) Emergency care of older people who fall: a missed opportunity. *BMJ Quality & Safety*, 15 (6), pp. 390-392.

Snyder, H. (2019) Literature review as a research methodology: an overview and guidelines. *Journal of Business Research*, 104, pp. 333-339.

Soldin, O.P. and Mattison, D.R. (2009) Sex differences in pharmacokinetics and pharmacodynamics. *Clinical Pharmacokinetics*, 48 (3), pp. 143-157.

Sommer, T.G., Frost, P. and Svendsen, S.W. (2015) Combined musculoskeletal pain in the upper and lower body: associations with occupational mechanical and psychosocial exposures. *International Archives of Occupational and Environmental Health*, 88, pp. 1099-1110.

Stafford, V. Greenhalgh, S., Davidson, I. (2014). *Why do patients with Simple Mechanical Back Pain seek Urgent Care?* Physiotherapy 100 (2014) 66-72. Elsevier. http://dx.doi.org/10.1016/j.physio.2013.08.001 [Accessed March 2024].

St Andrew's Ambulance Association (1983) *The history of St. Andrew's Ambulance Association, 1882–1982*. Glasgow: St Andrew's Ambulance Association.

STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) (2022) STROBE Checklist: cohort studies. Available: www.strobe-statement.org [Accessed 23 August 2023].

Sweeting, M.J., Ulug, P., Powell, J.T., Desgranges, P., Balm, R. and Trialists, R.A. (2015) Ruptured aneurysm trials: the importance of longer-term outcomes and meta-analysis for 1-year mortality. *European Journal of Vascular and Endovascular Surgery*, 50 (3), pp. 297-302.

Taylor, C.A., Bell, J.M., Breiding, M.J. and Xu, L. (2017) Traumatic brain injury–related emergency department visits, hospitalizations, and deaths—United States, 2007 and 2013. *MMWR Surveillance Summaries*, 66 (9), p. 1.

Tetzlaff, J., Page, M. and Moher, D. (2020) PNS154 the PRISMA 2020 statement: development of and key changes in an updated guideline for reporting systematic reviews and meta-analyses. *Value in Health*, 23, S312-S313.

Toloo, S., Fitzgerald, G., Rego, J., Tippett, V. and Quinn, J. (2010) *Age and gender differences in ambulance utilisation in Queensland*. In: ACEM 27th Annual Scientific Meeting, 21 November.

Tortora, G.J. and Derrickson, B.H. (2020) *Principles of Anatomy and Physiology*. 16th ed. London: Wiley.

Trautman, L.J. and Ormerod, P. (2019) Wannacry, ransomware, and the emerging threat to corporations. *Tennessee Law Review*, 86, pp. 503-556.

Trevethan, R. (2017) Sensitivity, specificity, and predictive values: foundations, liabilities and pitfalls in research and practice. Perspective article. *Frontiers in Public Health*, 5. https://doi.org/10.3389/fpubh.2017.00307

Tricco, A.C., Lillie, E., Zarin, W., O'Brien, K., Colquhoun, H., Kastner, M., Levac, D., Ng, C., Sharpe, J.P., Wilson, K., Kenny, M., Warren, R., Wilson, C., Stelfox, H.T. and Straus, S.E. (2016) A scoping review on the conduct and reporting of scoping reviews. *BMC Medical Research Methodology*, 16 (1), p. 15. https://doi.org/10.1186/s12874-016-0116-4

Tricco, A.C., Lillie, E., Zarin, W., O'Brien, K.K., Colquhoun, H., Levac, D., Moher, D., Peters, M.D., Horsley, T., Weeks, L. and Hempel, S. (2018) PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Annals of Internal Medicine*, 169 (7), pp. 467-473. https://doi.org/10.7326/M18-0850

Turner, J., O'Cathain, A., Knowles, E., Nicholl, J. and Coster, J. (2019) Impact of the urgent care telephone service NHS 111 pilot sites: a controlled before and after study. *BMJ Open*, 9 (8), p. e028736.

Tyler, S. and Supa, R. (1993) Amazing. [Song recorded by Aerosmith]. On *Get a Grip*. Geffen.

UC Berkeley News (2020) Lack of females in drug dose trials leads to overmedicated women. Available: https://news.berkeley.edu/2020/08/12/lack-of-females-in-drug-dose-trials-leads-to-overmedicated-women/ [Accessed: 28 August 2023].

Udry, J.R. (1998) Why are males injured more than females? *Injury Prevention*, 4, pp. 94-95.

University of Turku (2023) New study offers information on bone regeneration and osteoporosis in the light of evolution. *Medical Xpress*, 17 August.

Urology Foundation (2023) *Prostate cancer*. Available: https://www.theurologyfoundation.org/urology-health/prostate-cancer [Accessed: 27 August 2023].

Vandenbroucke, J.P., von Elm, E., Altman, D.G., Gøtzsche, P.C., Mulrow, C.D., Pocock, S.J., Poole, C., Schlesselman, J.J. and Egger, M. (2007) Strengthening the reporting of observational studies in epidemiology (STROBE): explanation and elaboration. *Epidemiology*, 18 (6), pp. 805-835.

Vandvik, P.O., Brandt, L., Alonso-Coello, P., Treweek, S., Akl, E.A., Kristiansen, A., Fog-Heen, A., Agoritsas, T., Montori, V.M. and Guyatt, G. (2013) Creating clinical practice guidelines we can trust, use, and share: a new era is imminent. *Chest*, 144 (2), pp. 381-389. https://doi.org/10.1378/chest.13-0746

VanMeter, K.C. and Hubert, R.J. (2022) *Gould's Pathophysiology for the Health Professions.* 7th ed. Elsevier Health Sciences.

Vella, S.P., Chen, Q., Maher, C., Simpson, P., Swain. M.S. and Machado, G.C. (2022) *Paramedic care for back pain: a review of Australian and New Zealand clinical practice guidelines*. *Australasian Emergency Care*, 25(4), pp. 354-360.

Walcott, B., Coumans, J. and Kahle, K. (2011) Diagnostic pitfalls in spine surgery: masqueraders of surgical spine disease. *Neurosurgical Focus*, 31(4).

Wang, X. and Cheng, Z. (2020) Cross-sectional studies: strengths, weaknesses, and recommendations. *Chest*, 158 (1S), pp. S65-S71.

Wáng, Y.X.J. (2018) Senile osteoporosis is associated with disc degeneration. *Quantitative Imaging in Medicine and Surgery*, 8 (6), pp. 551-556. https://doi.org/10.21037/qims.2018.07.04

Waterman, B.R., Belmont, P.J. Jr, Schoenfeld, A.J. (2012) Low back pain in the United States: incidence and risk factors for presentation in the emergency setting. *Spine*, 12 (1), pp. 63-70. https://doi.org/10.1016/j.spinee.2011.09.002

Williams, C.M., Maher, C.G., Latimer, J., McLachlan, A.J., Hancock, M.J., Day, R.O. and Lin, C.W.C. (2014) Efficacy of paracetamol for acute low-back pain: a double-blind, randomised controlled trial. *The Lancet*, 384 (9954), pp. 1586-1596.

Wilson, L.A.B and Nakagawa, S. (2022) Women are 50–75% more likely to have adverse drug reactions. *The Conversation*. Available: https://theconversation.com/women-are-50-75-more-likely-to-have-adverse-drug-reactions-a-new-mouse-study-finally-helps-explain-why-195358 [Accessed: 23 August 2023].

Woolf, A.D. and Pfleger, B. (2003) Burden of major musculoskeletal conditions. *Bulletin of the World Health Organization*, 81 (9), pp. 646-656.

World Health Organization (2010) *ICD-10: International Statistical Classification of Diseases and Related Health Problems: Tenth Revision*, 3rd ed. World Health Organization.

World Health Organization (2019a) *International Classification of Disease ICD-10 code M54.5*. Available: https://icd.who.int/browse10/2019/en#M51 [Accessed: 28 August 2023].

World Health Organization (2019b) *WHO Model List of Essential Medicines*, 21st list. Geneva: World Health Organization.

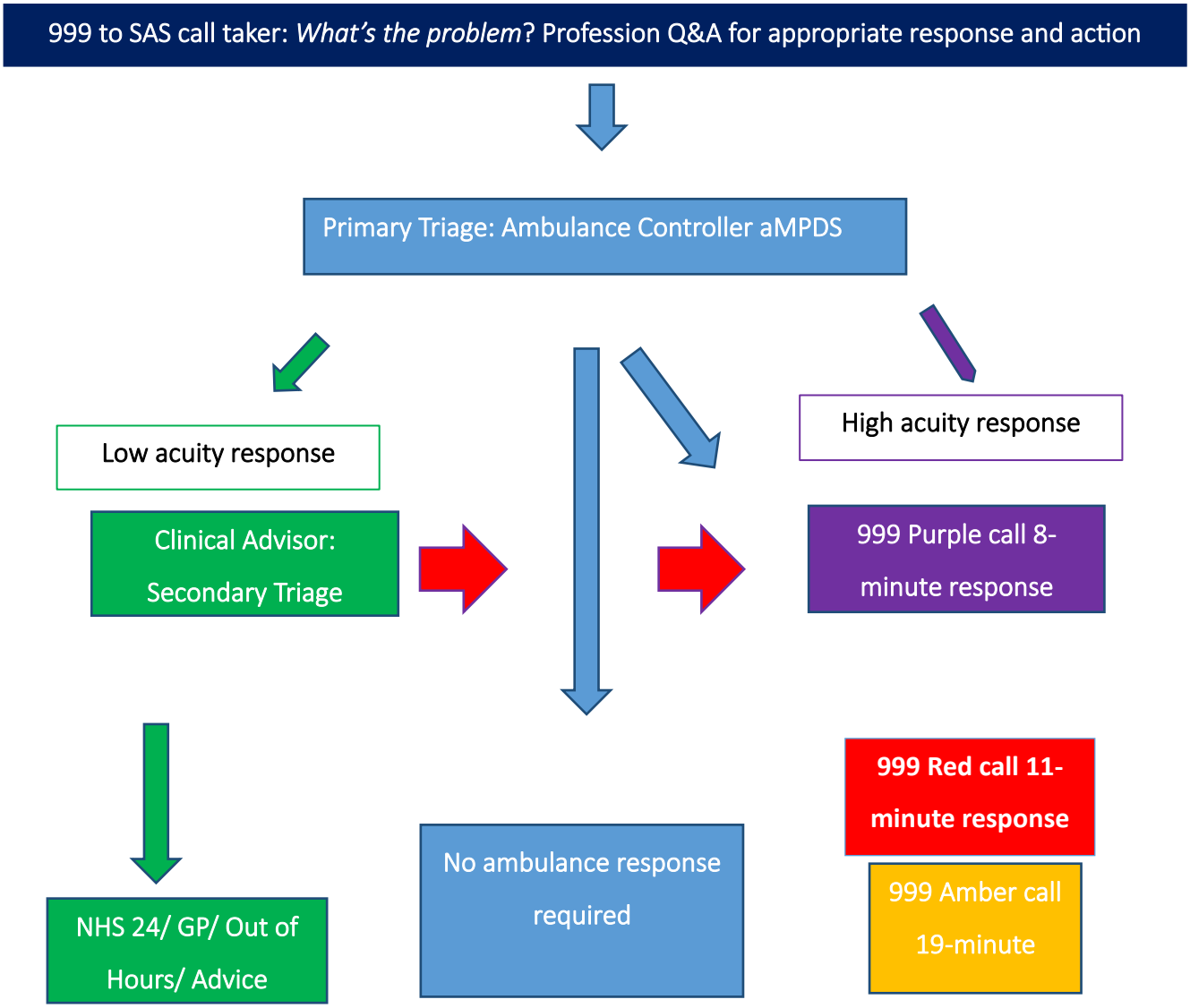
Worsham, C. and Jena, A.B. (2019) *The art of evidence-based medicine*. Harvard Business Review. Available: https://hbr.org/2019/01/the-art-of-evidence-based-medicine [Accessed 28 August 2023].

Wynne-Jones, G., Cowen, J., Jordan, J.L., Uthman, O., Main, C.J., Glozier, N. and van der Windt, D. (2014) Absence from work and return to work in people with back pain: a systematic review and meta-analysis. *Occupational and Environmental Medicine*, 71 (6), pp. 448-456.

Zheng, A., Bharmal, A., Rajabali, F., Turcotte, K., Thomas, L., Garis, L. and Pike, I. (2022) Risk of non-medical drug overdose following prescription of opioids post-injury: a retrospective cohort study. *Health Reports*, 33 (7), pp. 3-12.

Zucker, I. and Prendergast, B.J. (2020) Sex differences in pharmacokinetics predict adverse drug reactions in women. *Biology of Sex Differences*, 11 (1), pp. 1-14.

Appendix 1: Patient Flow Chart SAS aMPDS Triage System Future Model of Care



Colour coding key:

Appendix 2: Ethics Approval

JE/KH

4th March 2019

Christopher Aitchison
Faculty of Health Sciences & Sport
University of Stirling
FK9 4LA

UNIVERSITY of STIRLING

NHS, Invasive or Clinical Research (NICR) Committee

Room G10
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Stirling FK9 4LA

Tel: +44 (0) 1786 467390
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Dear Christopher,

A retrospective cohort study of the population that make emergency calls for non-traumatic back pain attended by ambulance clinicians of the Scottish Ambulance Service NICR 18/19 – Paper No. 002

Thank you for your email of 20th February 2019 which included the following attachments:

- Cover Letter
- NICR Ethical Approval Cover Sheet
- Scottish Ambulance Service Approval Letter

I am pleased to advise that your study has now been granted approval, and wish you and your team all the best.

May I remind you of the need to inform NICR (nicr@stir.ac.uk) prior to making any amendments to this protocol, or any changes to the duration of the project and provide notification of study completion. A site file of all documents related to the research should be maintained throughout the life of the project, and kept up to date at all times. The site file template can be found on the NICR webpage at:
http://www.stir.ac.uk/research/integritygovernanceethics/researchethics/formsandguidance/

Please bear in mind that your study could be audited for adherence to research governance and research ethics protocols.

NICR 18/19 – Paper No 002
Please quote this number on all correspondence

Yours sincerely

Dr Josie Evans
(Depute Chair)

Appendix 3: Proposed Publication for the Emergency Medical Journal (EMJ)

An observational study to describe the clinical and demographic characteristics of adult patients requiring ambulance care for Non-Traumatic Back Pain (NTBP) in Scotland.

Abstract title

Christopher Aitchison[1], Kathleen Stoddart; Josie Evans; David Fitzpatrick and Tony Robertson[2]. *[1]Scottish Ambulance Service, Scotland UK; [2] University of Stirling, Scotland UK.*

Background:
Non-Traumatic Back Pain (NTBP) is perceived as a common low acuity condition presenting to UK ambulance services. Recent evidence suggests that NTBP may be safely treated in an out-of-hospital setting, avoiding Emergency Departments. Little published evidence is available on this patient population's demographic and clinical characteristics, essential to inform future clinical guidelines. This study sought to i) establish the demographic and clinical characteristics of patients presenting to the Ambulance Service with NTPB; ii) determine the positive predictive value (PPV) for ambulance clinicians' diagnosis of true NTBP (dorsalgia); iii) identify common pain relief measures used to treat these patients.

Methods:
An observational study of all calls made to SAS in 2018-19.

Results:
There were 8824 patients included in this study. More females (55.8%, 4927) made calls for NTBP than males (44.2%, 3897). The median age of all patients was 60 years (range 43-77). Ten percent (882) of patients made more than one call for NTBP within the same 12-month period. Fifty percent of patients (4303) lived in the most deprived areas of Scotland (SIMD 1 and 2). Clinically, 8542 patients had a complete first NEWS recorded: 49% (4215) with a score of 0, 35% (2940) NEWS of 1-6, and 16% (1403) with a NEWS $\geq$ 7. The PPV for ambulance clinicians' diagnosis of dorsalgia was 20.4%. Common pain relief methods recorded included Entonox 54% (2409), morphine 24% (1055), paracetamol 13% (568), and ibuprofen 6% (286).

Conclusion:

Calls for NTBP span all age groups in the adult population, proportionately more females required SAS support. Medium to high clinical risk was reported in one-third of patients suggesting not all NTBP were low acuity. In this study ambulance clinician's ability to diagnose true NTBP (dorsalgia) was determined. This identified some priority areas for further research.