August 2021

An Exploratory Analysis of the Nurse Dependency of Patients with Burn Injuries Using Data Collected in a National Burn Injury Database

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS OF BIRMINGHAM CITY UNIVERSITY FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

JANE LEAVER

BIRMINGHAM CITY UNIVERSITY,
FACULTY OF HEALTH, EDUCATION AND LIFE SCIENCES

Abstract

<u>An Exploratory Analysis of the Nurse Dependency of Patients with Burn Injuries Using Data Collected in a National Burn Injury Database</u>

It has long been recognized that poor nurse staffing levels can have a detrimental effect on patient care and outcomes. Yet there is a lack of validated UK nurse dependency tools available to predict or support staffing levels and none specifically related to burn care. The international Burn Injury Database (iBID) has been collecting data on the nurse dependency of patients with a burn injury alongside information on their burn injury from specialised burn services in England and Wales.

The aim of this research was to "explore the nurse dependency data contained within iBID; to gain an increased understanding of nurse dependency in relation to burn injuries and to assess if iBID contained information that could be used to predict nurse dependency of acute burn inpatients and help with nursing staff planning".

An observational exploratory study approach was undertaken. First, to ascertain whether the iBID nurse dependency tool measured nurse dependency it was compared to the Safer Nursing Care Tool (SNCT) tool, the most commonly used nurse dependency tool in the UK. Nurses in three burn services scored the nurse dependency of their burn-injured patients daily using both nurse dependency tools as well as fictional case studies to assess inter-rater reliability. The results were analysed using Spearman correlation and Krippendorff alpha. Secondly, the nurse dependency data from iBID was analysed. Multiple regression was used to build a predictive nurse dependency model and the nurse dependency trajectories were plotted to understand how staffing levels are influenced by the recovery pathway a patient may be on.

This research has shown a correlation between the iBID nurse dependency tool and the SNCT scores suggesting that the iBID nurse dependency tool does indeed measure aspects of nurse dependency. There is a positive relationship between nursing dependency and burn severity. In particular, the size of the burn has been shown to have an influence on the nursing dependency trajectory over a patients' stay. Moving forward this may be used to help predict nursing workload for a group of patients in advance and whether the individual patient's stay is likely to be longer than 1 day/percentage burn. The regression modelling has highlighted several variables that have predictive properties. The variables that had some clinical judgement associated with them appear to be better predictors than pure objective variables, thus giving weight to the argument that ND tools should be used alongside professional judgement.

Dedication

This thesis is dedicated to my mum for her continual encouragement and support and my Dad who would have been so proud.

Acknowledgements

The completion of this thesis would not have happened without the help and support of many people; who all have my sincere thanks and gratitude. I particularly need to thank all the participants and the burns services that participated in this research, without which the research would not have been as successful. Ken Dunn, Medical Director of iBID, for first suggesting the topic, enabling me to access the relevant data from iBID, and supporting this PhD journey. My supervisors for their guidance throughout this journey. Especially Rob Cook, without whose statistics expertise I would not have got this far.

Special thanks to my family and friends for their help and encouragement. In particular my parents, Bill and Pat Howard, for their unwavering support, faith and pride in me throughout my life enabling me to strive to achieve dreams and ambitions. My nephew, Lewis, who motivated me into making the final decision to embark on the PhD journey. My niece, Katrina, for diligently reading and insightfully commenting on my thesis. Lastly, but certainly not least, my husband, Ian, for his patience, forbearance, and support during this time. I will have to relearn how to do the household chores again now.

Contents

List of Tables

List of Figures

Abbreviations

ADL- Activities of Daily Living

ASBI – Abbreviated Burn Severity Index

AUKUH - Association UK University Hospitals

BBA – British Burn Association

BC – Burn centre

BCU – Birmingham City University

BOBI - Belgian Outcome of Burn Injury

BF – Burn facility

BHDU – Burn high dependency unit

BICU – Burn intensive care unit

BU – burn unit

CCPD - Critical Care Patient Dependency System

CHPPD – Care Hours Per Patient Day

CI – Confidence intervals

CNIS – Comprehensive Nursing Intervention

ES - Effect Size

FTDD – Full-thickness/Deep-dermal

GCS – Glasgow Coma Scale

GDPR – General data protection regulations

HDU – High dependency unit

HELS – Health, Education and Life Sciences

HRA – Health Research Authority

iBID – international Burn Injury Database

ICU – Intensive care unit

IT – information technology

LOS – length of stay

NASA_TLX – National aeronautics and space administration task load index

NAS – Nursing Activities Score

NICE - National Institute for Health and Care Excellence

ND – Nurse dependency

NEMS – Nine Equivalents of Nursing Manpower

NHPPD - nurse hours per patient day

NHS – National Health Service

NIHR - National Institute of Health Research

NQB – National Quality Board

NMC – Nursing and Midwifery Council

NSI - Nurse sensitive indicators

OAT – Oncology Acuity Tool

OPC – Oulu Patient Classification

PAONCIL - Professional Assessment of Optimal Nursing Care Intensity Level

PARENT - European cross border **Pa**tient **Re**gistries I**n**i**t**iative

PedAAT - Pediatric Ambulatory Acuity Tool

PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyses

RCN – Royal College of Nursing

RN – Registered Nurse

SD – Standard deviation

SE – Standard error

SNCT – Safer Nursing Care Tool

SUHT - Southampton University Hospitals NHS Trust

TBSA – Total burned surface area

TEN - Toxic Epidermal Necrolysis

TISS - Therapeutic Intervention Scoring System

UK - United Kingdom

USA – United States of America

VIF – Variance inflation factor

WHO – World Health Organisation

WMSN - Workload Management System for Nurses

WTE - whole time equivalent

Chapter 1 Introduction

1.1 Introduction

In the last decade, nurse staffing levels, particularly in relation to the quality of care, in the UK were brought to the forefront of the media and public minds following the 'Mid Staffordshire Hospital scandal'. The subsequent inquiry (Francis, 2013) highlighted inadequate staffing levels as one of the contributing factors to the many failings of care provided. It is perhaps not surprising that poor staffing levels had a detrimental effect on patient care and outcomes as there is a growing body of research emerging that shows links between nurse staffing levels and quality of care. Several papers have highlighted a link between lower levels of nurse staffing and an increase in patient mortality (Aiken et al., 2002; Aiken et al., 2014; Ball et al., 2018; Musy et al., 2021; West et al., 2014) whereas others have shown associations with quality, adverse events, missed care and poorer outcomes (Bettencourt et al., 2020; Duffield et al., 2011; Griffiths et al., 2018; Kane et al., 2007; Needleman et al., 2002; Patrician et al., 2011). In 1998 Blegen (1998) showed that the higher the Registered Nurse (RN) skill mix the less adverse patient care incidences occur. She suggested that as far back as 1958, nurses were concerned about nurse staffing levels and links with the quality of patient care. Whereas, Cheung et al. (2008) suggested that the link goes back still further and that even Florence Nightingale recognised the link between trained nurses and improved patient outcomes.

The Royal College of Nursing (RCN) has been campaigning for adequate nurse staffing for many years and has published several reports on the issues of inadequate nurse staffing (RCN, 2010; RCN, 2019; Scott, 2003). Yet it still remains an issue, perhaps because there is limited evidence to suggest that one system for determining required staffing is better or more cost-effective than others (Griffiths et al., 2020$_b$; RCN, 2010).

This is an issue across all specialities including the researcher's specialist area of burn care. The importance of adequate nurse staffing levels in burn care is also recognised by the British Burn Association (BBA) and specifically addressed in one of their burn care standards B.19:

> "the nursing establishment is based on bed capacity and the dependency of the patients managed in the service. The service has the capability to adjust the skill mix and numbers of Registered Nurses to reflect the changes in complexity of the patients cared for"
>
> (Burn Standards Review Group, 2018: 20).

The evidence expected for this standard is nurse dependency (ND) data to show that the staffing levels are adjusted according to the patient's dependency. However, there is one flaw in this, in that there is no validated way of measuring ND explicitly in burn care in the UK.

Moving forward, the next couple of sections of this chapter explain how, from this contextual background, the research problem was identified and how the researcher's research philosophy influenced the methodological approach and resulting research questions.

1.2 Research Problem

In 2003, the international Burn Injury Database (iBID) was set up in the UK, following the recommendations of the National Burn Care Review (British Burn Association 2001), to collect data on all burn injuries from specialised burn services in England and Wales. Since 2012, data related to the ND requirements of patients has also been collected from the burn services but never analysed or routinely used to aid workforce planning. With the pressures on the health service to ensure adequate staffing, it seems pertinent that this data be examined to see if it can be used to aid workload planning and consequently improve burn patient care. Otherwise, the collection of this data is a pointless, time consuming exercise if it is not going to be used in any meaningful way. Moreover, exploration of the iBID dependency data is in line with Griffiths et al.'s (2020_b) view that rather than inventing new dependency tools, a closer look at those already in use is needed.

Therefore, when it was suggested at a burns conference (Dunn, 2014) that the ND data in iBID needed investigating, it stirred the researcher's interest; especially as the researcher is a Burns Specialist Nurse, passionate about patient safety and promoting excellence in caring for patients with a burn injury. Also, having been a ward manager of a burn unit in the past, she is well aware that, more and more in this current economic climate, nurses are having to justify their staffing requirements as budgets are squeezed (Ball et al., 2019; Robertson et al., 2017).

As discussed earlier, the evidence suggests that if nurse staffing levels are inadequate patient outcomes and mortality can be affected. Yet, there is no gold standard model for correct nurse staffing levels, nor ND requirements of burn patients. National Health Service (NHS) policy documents and reports refer to 'safe staffing levels' but do not uniformly define what this means (Ball et al., 2019). Consequently, if information about burn patients' ND requirements and possible predictive signs for increased ND needs could be established it would help to justify changes to burn nurse staffing requirements and thus ultimately improve burn care and burn patient outcomes.

Furthermore, the dependency data being collected in iBID was through a ND tool that had not been externally validated and the tool and subsequent data were not routinely being used by burn services. Therefore, there was also a need to confirm that the iBID ND tool did measure ND and to then disseminate this information. In other words, there was a need to mobilise the ND knowledge found in iBID or as Ward (2016: 477) put it “moving knowledge to where it is most useful.”

1.3 Research Philosophy

A research philosophy is a belief about the ways in which data, about a phenomenon, should be collected, analysed, and used. For any researcher, it is important that they have an understanding of their own research philosophy, or their ‘worldview’ as Creswell and Plano Clark (2011) put it, in order to appreciate how this may guide their research and thinking. The worldview or paradigm is a pattern or frame of beliefs and assumptions shared by groups of researchers (Creswell and Plano Clark, 2011) about how knowledge is developed, which will underpin and shape the research process (Saunders et al., 2012). In particular, Weaver and Olson (2006) see paradigms as a lens through which to view and interpret the research. These paradigms are made up of a perception about reality (ontology), how knowledge is formed (epistemology) and the research process (methodology) (Houghton et al., 2012), along with the underpinning values (axiology) and language used (rhetoric) (Creswell, 2014).

The researcher is a nurse and senior lecturer practitioner in the field of burns and plastic surgery nursing. She has worked in burns and plastic surgery nursing for over thirty years both in the UK and abroad. She was a ward manager on a burns and plastic surgery ward and therefore understands the practical difficulties of nurse staffing and the importance of getting nurse staffing levels right to help safeguard patients and to promote good care and patient outcomes. She also understands the needs of burn patients and the nuances of their care, such as wound management, that will differ between burn patients and non-burn patients. As a nurse, her values can be summed up by the importance of the underpinning medical scientific evidence that directs the patients' treatment (biomedical) and the compassionate caring role of nursing, seeing the patient as an individual and being their advocate (humanistic). These values are all encompassed by the Nursing and Midwifery Council's (NMC) Code that sets out the professional standards registered nurses must uphold (NMC, 2018).

There has been debate in the literature as to which of the many philosophical stances is best, particularly between the qualitative and quantitative traditions (Robson and McCartan, 2016). Yet, the correct approach will depend on what the aim of the research is and the research questions as to which is the most appropriate, alongside the researcher's values, that will also influence this. Research paradigms can be seen as a continuum, with one end being embedded in the objective, quantitative and 'scientific' view of the more traditional *positivist* and the other end in the more subjective, qualitative and 'socially' constructed view of the *Interpretivist* (Randall and Mello, 2012; Saunders et al., 2012). However, it is not as simple as taking a position somewhere on this continuum and 'staying' there. The world is a complex place and there are many ways of interpreting it depending on one's position at the time. Therefore, the research question and the best way of answering it should determine the philosophical position. This is very much in line with the *pragmatic* paradigm which is often seen as synonymous with mixed methods research (Robson and McCartan, 2016). That the best methodological approach is the one that works for the research problem rather than being situated in one particular philosophical domain. Morgan (2014) argues that pragmatism is a paradigm in its own right, regardless of the methodology. He contends that pragmatism recognises the value of different philosophical approaches that guide the choices of 'inquiry' and informs practice. Leading to the importance of researchers articulating why they have made a choice of an action and the impact of this rather than just framing their actions in an abstract set of philosophical beliefs.

As a nurse, the pragmatic paradigm resonates strongly. Over time, many nursing theorists, such as Henderson, Orem and Casey, have attempted to define nursing (Snowden et al., 2010) but each definition has been limited due to the diverse nature of what nurses do. Nursing has also taken from many disciplines (medicine, sociology, psychology to name but a few) in order to meet the holistic needs of the patient (Gerrish and Lacey, 2015). All these disciplines see the world from a different viewpoint; therefore, it is difficult to put nursing philosophy squarely into one box or another. Historically medicine with its scientific positivist quantitative methods was seen as the 'correct' research stance to take. As qualitative research developed and other paradigms were articulated, much of nursing research shifted into this direction; as it was argued that these fitted the 'person-centred' side of nursing that recognised that there is a social and human context that cannot be measured in the same way as traditional science. Qualitative research was then seen as more appropriate. Nonetheless, that does not mean that either stance is better than the other. It really comes down to what is being studied and the best way to do this or the 'what works' pragmatic view. Houghton et al. (2012) would agree and argues that the specific paradigm chosen does not matter, it is the transparency and the consistency in relating to the research paradigm/worldview throughout the research process that is important to ensure rigour and quality of the research.

So, in line with the pragmatic paradigm and nursing's holistic stance, it was important to consider the research problem in context and the best methodology to answer the emerging questions. As the purpose of this research was to statistically explore a burn injury database and investigate the possibility of predictive relationships between ND scores and other variables, it is argued that it fits into the quantitative end of the research paradigm continuum. The raw data is numerical, can be analysed statistically and the aim is to examine and quantify the relationship between variables.

This fits the quantitative approach as opposed to the qualitative approach that aims to explore and understand the underlying meanings attributed to the situation (Creswell, 2014).

In taking a quantitative approach an assumption is made that there is an 'objective' reality that can be observed and tested, which therefore fits with the 'Positivist View' (Polit and Beck, 2009; Robson and McCartan, 2016). However, this is not the whole picture. The statistical analysis of the ND data may be objective in nature, in that the data can be seen as observable, measurable concrete facts/reality independent of experience (Crotty, 1998; Robson and McCartan, 2016), but there is likely to be some form of subjectivism to the data depending on the scorer's interpretation of the situation at the time. Hence, it is not possible to approach this research purely from a 'positivist' position. The 'Post Positivist' argument recognises that observations do not occur in isolation and although the findings are probably true (Denzin and Lincoln, 2011) there may be some bias due to the values of the observer and observed. Both the 'positivist' and the 'post-positivist' aim to establish objectivity (free from bias), reliability (consistency in measurement) and validity (the research measures what it purports to) (Taylor and Medina, 2013) in order to assure confidence in the finding. The 'post-positivist' on the other hand, acknowledges that when dealing with individuals it is not possible to be absolutely certain about any claims of knowledge that are made (Creswell, 2014). Therefore, they take the stance that hypotheses, rather than being verified as true, are checked for falsification as advocated by Karl Popper (Crotty, 1998). If it is shown not to be false, then the findings are probably true (Denzin and Lincoln, 2011).

At the opposite end of the paradigm continuum is the qualitative paradigms that use research methods such as grounded theory, ethnography and phenomenology. These come from a social research background and focus more on socially constructed human interactions and meanings and tend to collect non-numeric data (Creswell, 2014). Qualitative research paradigms tend to be more subjective in their approach as the researcher is more immersed in the collection and interpreting of the data (Gerrish and Lathlean, 2015). Meaning that the researcher has to demonstrate reflexivity and be clear about their values and potential impact to demonstrate rigour and trustworthiness (Taylor and Medina, 2013). Whereas with quantitative research, a greater value is placed on the objectiveness and scientific detachment in the collection of numerical data to show reliability and validity.

Subsequently, regardless of which approach is taken, it is important that the researcher ensures that a transparent, systematic and rigorous approach is used (Gerrish and Lathlean, 2015; Tashakkori and Teddlie, 2010) that is consistent with the research and their values. Using a methodology that appropriately fits with the subject being researched and method of data collection and clearly documenting the process, consistent with the pragmatic paradigm discussed above. Hence, a post-positive quantitative approach will be taken as that fits with statistical analysis methodology and allows for the recognition that the collected data may have some subjective bias.

1.4 Research Aims and Objectives

As mentioned previously iBID contains a wealth of information about burn patients and ND that has yet to be scrutinised in detail. Thus, the overarching aim of this research was to:

> Explore the nurse dependency data contained within iBID; to gain an increased understanding of nurse dependency in relation to burn injuries and to assess if iBID contained information that could be used to predict nurse dependency of acute burn inpatients and help with nursing staff planning.

Following a preliminary review of the data the following research objectives were identified:

1. To evaluate the quality of the nurse dependency data in iBID.
2. To establish whether the iBID nurse dependency tool did indeed measure nurse dependency.
3. To analyse the nurse dependency data from iBID to ascertain if
   - any relationships between nurse dependency and burn severity existed
   - a predictive model for burn nurse dependency could be derived from the data

The above research aims and objectives then informed the following research questions that this study set out to answer.

1. Does the iBID nurse dependency tool measure nurse dependency compared to another nurse dependency tool?
2. Do burn nurses score nurse dependency consistently?
3. Which burn severity/demographic variables show signals of a relationship with the iBID nurse dependency scores?
4. Can the iBID nurse dependency scores be predicted for adult inpatients with acute burns?

1.5 Thesis Outline

This introduction chapter has given an overview of the research problem and the aims and objectives deriving from this. Also, the research philosophy underpinning this study and where the researcher sits within this has been discussed. Chapter two, in order to set the scene for the context of this thesis, gives the background to some of the significant topics related to this research, such as an overview of burn care and iBID, as well as defining some key terms such as dependency and acuity. A review of the literature on ND tools is then discussed in chapter three, with a particular focus on burn ND tools and the Safer Nursing Care Tool (SNCT) as the only ND tool recognised by the National Institute for Health and Care Excellence (NICE) (2014). Chapter four then discusses the research methodology and the rationale behind it, the ethical considerations, and the main statistical tests that were undertaken. It outlines how this research was undertaken in three parts, which when combined answered the research questions. The first part of this research compared the iBID ND tool to a recognised UK validated ND tool, the SNCT, with the intention of answering the first two research questions. The second part of this research analysed a sample of data from iBID in order to begin to discover answers to the second two research questions. Finally, the third part tested any clinically relevant results and hypotheses formed from the first two parts on the whole database to confirm the findings.

The results of the research are reported in chapters five, six and seven. Chapter five presents the findings of the first part of the research which related to objective two, verifying that the iBID ND dependency tool did measure ND, which also answered the first two research questions (does the iBID nurse dependency tool measure nurse dependency compared to another nurse dependency tool and do burn nurses score nurse dependency consistently?) In chapter six, the results of the exploratory statistical analysis of a sample of data from iBID are presented. These relate to objective three, which was to identify any relationships between ND and burn severity and to identify any predictive signals of ND that may exist and thus starting to answer the third and fourth research questions (Which burn severity/demographic variables show signals of a relationship with the iBID ND scores and whether the iBID ND scores could be predicted for adult inpatients' with acute burns). The third part of this research was, to test the findings and hypotheses derived from chapters five and six on the whole iBID database, to ascertain whether the findings could be generalised to the wider burns community. The results of this testing of hypotheses and cross-validation of the regression models is presented in chapter seven alongside a narrative data quality evaluation of iBID. Therefore, answering research question four (Can the iBID nurse dependency scores be predicted for inpatients with acute burns) and meeting objectives one (To evaluate the quality of the nurse dependency data in iBID) and concluding objective three.

Chapter eight, the discussion chapter, then brings together all the findings of the preceding chapters, to discuss as a whole, in relation to the research questions, aims and objectives and wider literature. In the final chapter, chapter nine, the contribution to knowledge that this research has made, along with the strengths, limitations, and challenges of this study are discussed. It concludes with the recommendations for practice, iBID design, and future research derived from this research.

1.6 Summary

This chapter has outlined the research problem and the purpose of the research. It has also expounded the researcher's underpinning values and research philosophy that have shaped this research. The next chapter sets out the background and overview of some of the key themes that this research is related to.

Chapter 2 Background

2.1 Introduction

The aim of this chapter is to give background information on the key topics that are discussed in this research. Firstly, it starts with an overview of burn care which includes a definition of a burn injury, classification of burn size and depth, treatment complexities, and the strategic set up of burn services in the UK. Next, the international Burn Injury Database (iBID) is described along with where it fits within health informatics and medical registries. Thirdly, this chapter briefly discusses nursing workload to give the context of some of the issues in this area and where the iBID nurse dependency (ND) tool may fit within the workload methods. Finally, it finishes by discussing the difference between dependency and acuity and the definitions that will be used in this thesis.

2.2 Burn Overview

A burn is a cutaneous injury, where some or all of the skin is destroyed either by heat, cold, electricity, chemicals or radiation. In England and Wales, approximately 120,000 burn injuries occur each year with 20% requiring hospitalisation (iBID, 2021). These burn injuries can have a huge impact on the individual and their family due to the initial pathophysiological response of the injury and later from disfigurement, disability, and psychological trauma (Leaver and Thomas, 2012); an impact that will be with them for the rest of their lives.

There is a large variation in the causes and severity of burns (Smolle et al., 2017; Stylianou et al., 2015; Whitaker et al., 2019). Some burns may be very small and can be treated at home while others are complex and may be life-threatening requiring specialist treatment. In children and older adults, scalds are the most common cause of burn injuries, while flame burns are the most common cause in younger adults. The most likely place to be burned is in the home (Brusselaers et al., 2010; Stylianou et al., 2015). Not all burns occur due to accidents; some are caused by deliberate self-harm/suicide attempts and some from deliberate acts of harm by others which adds another dimension to the care required for these patients, particularly in the context of differing cultures (Nisavic, 2017; Peck, 2012).

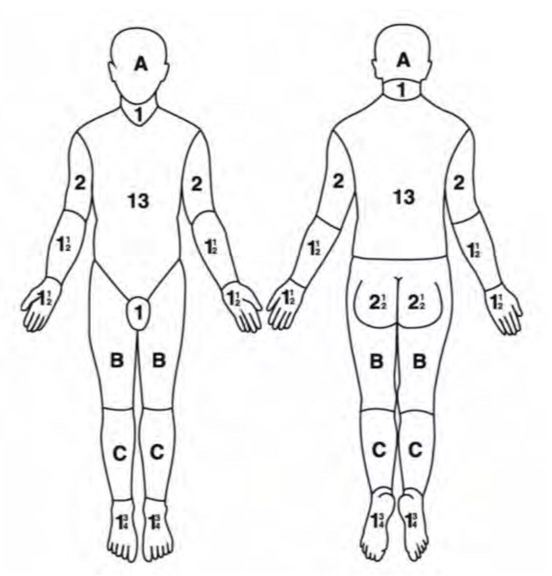
The majority of burns are non-complex, impacting less than 5% of the body area (iBID, 2021). These burns often do not require admitting to a hospital unless there are associated injuries or complications.

2.2.1 Burn size classification

Burns are described by depth and size. The size of a burn, otherwise known as the total burned surface area (TBSA), is expressed as the percentage of the body that is burned which is usually calculated using the Lund and Browder chart (Lund and Browder, 1944), as shown in Figure 2.1. On the whole, the larger the burn size the more severe the burn is and the higher the risk of death. This is further compounded by age at either end of the spectrum and/or the presence of an inhalation injury from the burn. Meaning that a small burn of 4% may range from being minor (for example, if it was on the back of a healthy adult) to severe and life-threatening (for example, if it was on the face and involving smoke inhalation) (National Burn Care Review Committee, 2001). Thus, it is not just the size of the burn that dictates the severity and workload but other factors, (such as co-morbidities and the individual patient's mobility and self-care ability) and treatment plan (for example, conservative management, surgical management, comfort care if treatment is deemed futile).

Burn size does not just indicate the possible severity, it is also a key component of the various burn mortality prediction models, such as the

Revised Baux score (Osler et al., 2010), Belgian Outcome of Burn Injury (BOBI) (Belgian Outcome in Burn Injury Study Group, 2009) and Abbreviated Burn Severity Index (ABSI) (Tobiasen et al., 1982). These all utilise the TBSA along with age and the presence of inhalation injury to give a predictive mortality score (Halgas et al., 2018). A British mortality predictive model has also been developed using UK data from iBID (Stylianou et al., 2014). This iBID mortality predictor model takes into consideration injury type and the patient's existing disorders as well as TBSA, age and inhalation injury for its calculations. It is also the mortality predictor model that is used in the NHS England specialised burn Quality Dashboard to identify expected and unexpected deaths/survival of patients with a burn injury.



Area / Age	A = ½ of the head (front or back)	B = ½ of one thigh (front or back)	C = ½ of one calf (front or back)
0	9.5	2.75	2.5
1	8.5	3.25	2.5
5	6.5	4	2.75
10	5.5	4.25	3
15	4.5	4.5	3.25
adult	3.5	4.75	3.5

Figure 2.1 The Lund and Browder chart. Used to calculate the total burned surface area (TBSA). The burned areas are shaded in on the body and then the percentage for each area burned is calculated using the table. All the area percentages are added up to give a total percentage that is the TBSA.

The size of the burn also determines whether fluid resuscitation is required to ensure adequate tissue perfusion. In burns, of >10% in children and >15% in adults, extra fluids (calculated to the TBSA and weight) are given to replace fluid lost through the burn wound and leakage into the extravascular space due to the inflammatory response that occurs following a burn injury. In a burn of >20-30% this vascular permeability will affect the whole body leading to generalised oedema and if not managed adequately hypovolemic shock (The education committee of the Australian and New Zealand Burn Association, 2012).

The TBSA is also seen as an outcome measurement to predict how long a patient with a burn injury may be in hospital for. One day per TBSA per cent (1 day/TBSA) is seen as a good outcome to aim for. If a patient had a 30% burn then it could be expected that they would be discharged around the 30-day mark, whereas for a 50% burn they may be in for 50 days. This outcome was first suggested in 1987, following a roundtable discussion with eminent burn surgeons of that time (Gillespie et al., 1987), and is still widely used today (Dolp et al., 2018). Since then, there has been debate about the accuracy of this outcome and various papers have been written to try to analyse more accurately the predicted length of stay and factors that may affect it (Caton et al., 2014; Dolp et al., 2018; Taylor et al., 2017). Sahin et al. (2011) suggested that two days per TBSA may be a more conservative estimate, however, they were considering their calculations from a cost-effectiveness view rather than a quality outcome measure. The literature is in agreement that there are certain factors that are likely to increase the length of stay. These include inhalation injury, sepsis and other complications, which some of the suggested 1 day/TBSA revisions attempt to take into account (Dolp et al., 2018; Taylor et al., 2017). Another big cause of the delay in discharge is social factors rather than a medical issue (Challis et al., 2014). Nevertheless, 1day/TBSA is still a reasonable starting point for predicting length of stay.

2.2.2 Burn depth classification

The depth of the burn is classified in relation to the anatomy of the skin and will direct the wound management. Figure 2.2 shows the different burn depths and Table 2.1 summarises the characteristics of these different burn depths.

The depth of the burn will determine the treatment plan. If a patient has a full-thickness burn then early surgery is highly likely to be required to debride the dead tissue and to get coverage with a skin graft (Herndon, 2018). In large burns over 50%, it can be difficult to achieve full skin coverage all at once with a skin graft, as there is not enough unburned skin to use. In this case, further surgery will be required a few weeks later when the donor sites have healed. In the meantime, an alternative dressing or skin substitute will be necessary (Rowan et al., 2015), requiring skilled nursing input for wound management. For some patients with full-thickness burns, it may not be appropriate for surgery to be undertaken due to underlying comorbidities. In which case, depending on the size of the burn, it may take months for healing to occur increasing the risk of sepsis and other complications.

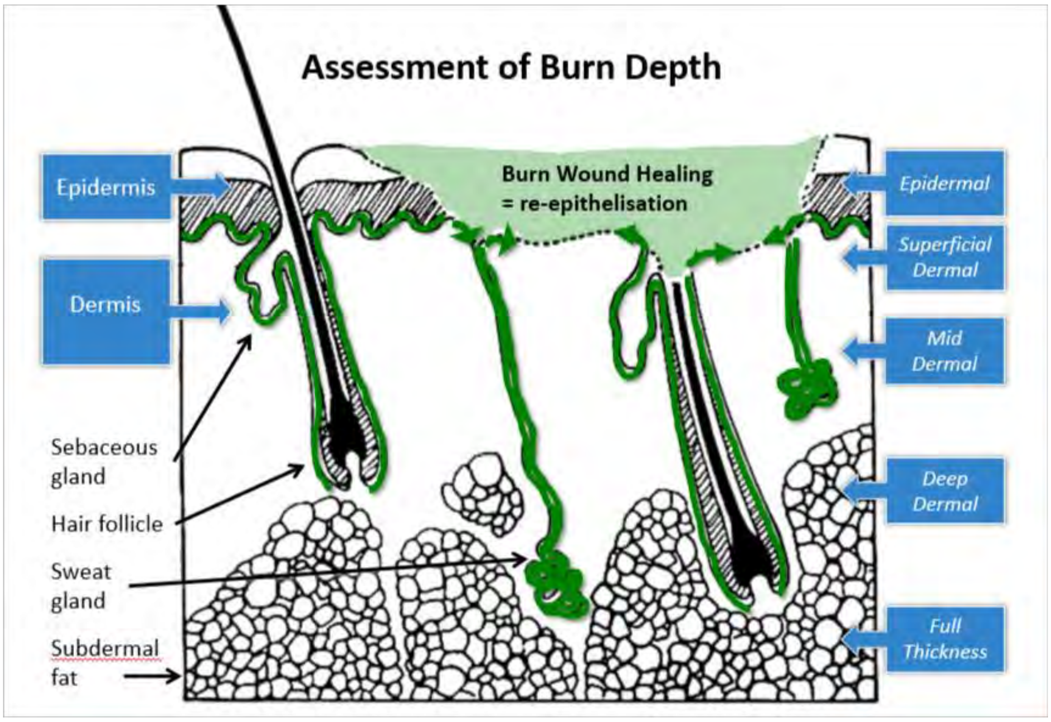


Figure 2.2 Diagram showing the layers of the skin and different burn depth (adapted from the education committee of the Australian and New Zealand Burn Association (2012: 41) UK Emergency Management of Severe Burns course manual)

If the burn is partial-thickness in-depth then surgery may not be required and the burn will usually heal within two weeks with regular dressing changes (Herndon, 2012). Burn dressing changes can be extremely painful due to exposed nerve endings, the inflammatory response and the size of the burn (Richardson and Mustard, 2009). For some patients, oral analgesia or Entonox may not be enough to control the pain and they will require some form of sedation for the dressing change (Pardesi and Fuzaylov, 2017). Thus, increasing nursing workload more than would normally be expected with dressing changes in other specialities. Normal burn wound management involves thoroughly cleaning the burn wound and removing any debris before applying an appropriate dressing. Depending on the size of the burn the dressing procedure is likely to take more than half an hour and often several hours. The larger burn dressings may even require two nurses and if the patient requires sedation for the dressing change the involvement of an anaesthetist.

Table 2.1 Classification of burn depths and their characteristics. (Herndon, 2018)

Burn depth classification (other classification terminology in the brackets)	**Physical characteristics**	**Area affected**	**Time to heal**
Epidermal (superficial/ 1st degree)	Bright pink/red No blisters Brisk capillary refill Very painful	Part of the epidermis	Usually heals within 3-7 days
Superficial dermal (superficial partial thickness/ 2nd degree)	Red or pink Wet or blistered Brisk Capillary refill Very painful	Epidermis and part of the papillary dermis	Usually heals within 2 weeks

Deep dermal (deep partial thickness/ 2nd degree)	Pale /blotchy red Dry Fixed staining from the coagulation of haemoglobin Sluggish capillary refill Painful/reduced sensation	Epidermis, papillary dermis and part of the reticular dermis	Usually takes over 2 weeks to heal
Full-thickness *(3rd degree)*	Charred or waxy white No blisters no capillary refill no sensation as nerve endings destroyed	All of the epidermis and dermis and may involve underlying tissues as well	Unless a very small area will take many weeks to heal so usually requires skin grafting

2.2.3 Organisation of burn care in the UK

Prior to 2002 the organisation and provision of burn care in the UK varied considerably (National Burn Care Review Committee, 2001). Some burn services would see a large number of burn patients whereas others would only see large and complex burns occasionally. Following the recommendations of the National Burn Care Review (National Burn Care Review Committee, 2001) four burn care networks in England and Wales were set up as shown in Figure 2.3. Due to devolved Healthcare Scotland already had its own burn care network at this time and was not included in the burn care structure in England and Wales following the burn care review. The burn services in these four networks were designated into Burn Facility (BF) - a specific plastic surgery ward that cares for small non-complex burns, Burn Unit (BU) - a specialist burn ward caring for burns of moderate complexity and Burn Centre (BC) – which cares all burns including the large complex burns. By reducing the number of burn services and only having a few designated burn centres the aim was to build up expertise and improve burn patient care. The national burn care referral guidelines (National Network for Burn Care, 2012) set out criteria for BF, BU and BC burn patients. A summary of the adult referral guidance can be found in Appendix A.

In addition, to burn patients, BU and BC also treat patients with Vesiculobullous disorders such as Steven Johnson Syndrome and Toxic Epidermal Necrolysis (TEN), where, due to a drug reaction, the epidermis blisters and peels away leaving large painful raw areas (Creamer et al., 2016). These patients are treated in burn services due to the expertise of the burn services' in caring for patients with large amounts of skin loss. Although, in many respects, there are similarities in the care of burn and TEN patients (with regards to dressings and fluid management), the disease management and treatment pathway is different. Therefore, these patients were not included in this research study.

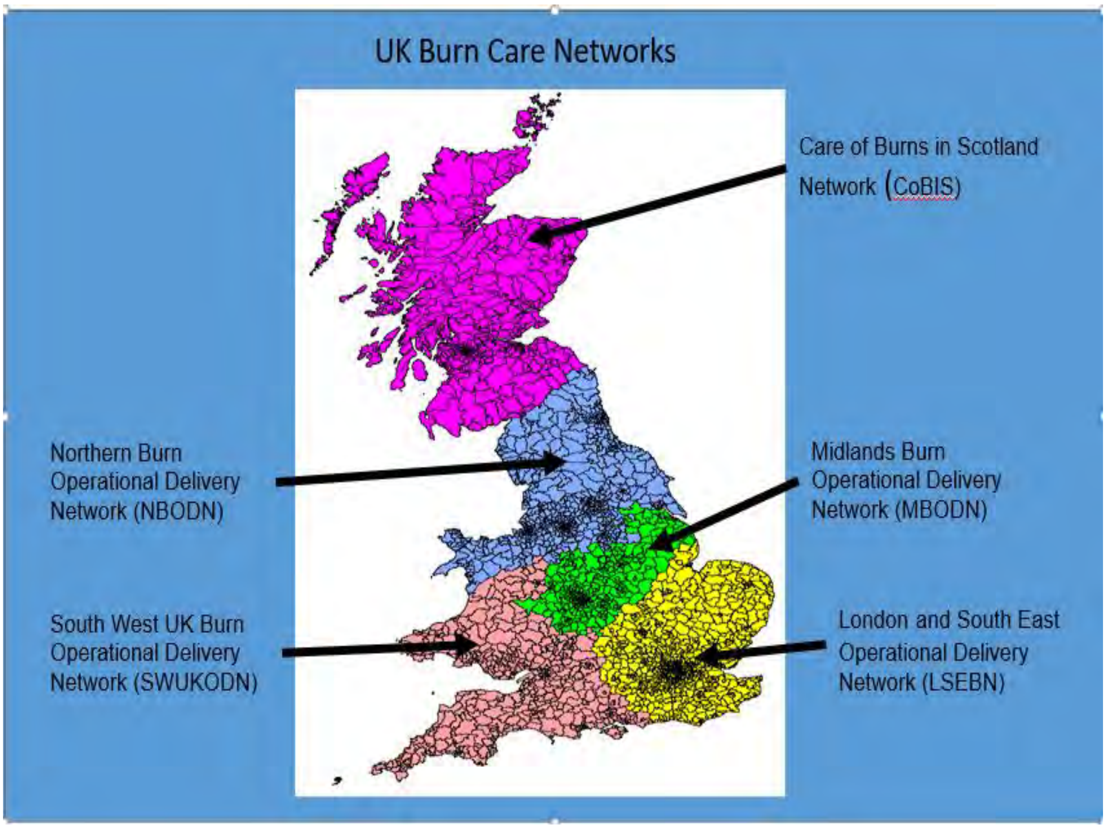


Figure 2.3 UK Burn Care Networks

2.3 The international Burn Injury Database (iBID)

IBID is a UK based national burn registry that collects data on patients with a burn injury admitted to the burn services in England and Wales (international Burn Injury Database, 2019). This section will discuss iBID, what it is and what it includes. First, it will look at where iBID fits in the field of health informatics, specifically the area of data registries. Then it will explain how iBID developed, how it functions and how it is linked to ND.

2.3.1 Health Informatics

Healthcare informatics is an area that has been growing since the introduction of the first electronic health records in the 1960s and the advent of computers which has meant large amounts of information could be collected and stored for analysis. However, the collection and use of patient statistics to improve healthcare was not new even then. Hippocrates in the 5th century BC recorded medical data and Florence Nightingale in the Victorian era has been heralded as the first informatics nurse with her meticulous record-keeping that she used to improve healthcare (Sengstack and Boicey, 2015).

There is no standard definition of health informatics but, in essence, it is the use of information technology (IT) in healthcare (Braunstein, 2015). It encompasses many different IT-based innovations ranging from the storage of information in medical registries to telemedicine and health sensors (Nelson and Staggers, 2018). For this research, it is the generation and storage of patient data and the use of this in relation to ND that is of particular interest.

Health informatics incorporates many underpinning theories and models from a range of disciplines, such as systems and information theories (Nelson and

Staggers, 2018). Two theories that are of particular relevance to this study and the use of iBID are the Shannon Weaver Information Communication Model (Shannon and Weaver, 1949) and the Nelson data to Wisdom continuum (Nelson, 2002). These two theories can help to give an overview of how the data collected in the registry can be transformed into knowledge that can be used and applied in practice, as well as how the information communication process can aid or hinder this.

The Shannon and Weaver Information Communication Model explains how data is transmitted from one entity to another through potential noise sources that may affect the message. It can be used as a framework to understand the communication and transfer of information from medical registries as well as considering the effectiveness of this (Nelson and Staggers, 2018). Based on the Shannon Weaver Information- Communication Model, Figure 2.4 is a diagrammatic representation of how the communication of ND information is transmitted and received via iBID. Although in the original model, Shannon and Weaver picture the noise (anything that disrupts the message) between the transmitter and receiver, in practice the noise can appear anywhere between the information source and destination, potentially resulting in the degradation of the message.

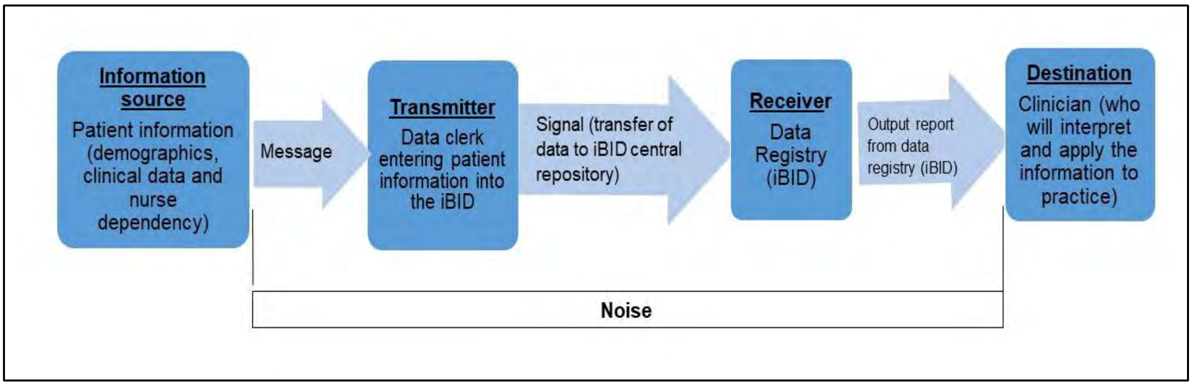


Figure 2.4 Information communication model for iBID based on Shannon and Weavers information communication model (Shannon and Weaver, 1949).

The ‘Nelson data to Wisdom continuum’ (see Figure 2.5) was developed from Blum’s original three concepts of Data (un-interpreted facts), Information (data that has been processed to give more meaning) and Knowledge (occurs when the relationship between the data and information is formalised), with the addition of Wisdom (the appropriate use of the knowledge) as a fourth dimension (Nelson and Staggers, 2018). It builds upon the communication model by demonstrating how the initial data can be changed into something that can be applied constructively in practice to improve patient care. It starts with the patient data (the information source) that is transmitted to iBID (receiver) where it is organised into potentially meaningful information. The output from iBID then reaches the clinician (destination) who then interprets the information turning it into knowledge that can then be applied and used.

Part of the aim of this research was to gain an increased understanding of nurse dependency in relation to patients with a burn injury. Using Nelson’s model, this would equate to the knowledge level of their continuum; where the initial data and information that comes from iBID is analysed and interpreted in light of wider knowledge and understanding, to give further knowledge. The wisdom level would then come at the end following any practice recommendations and as the new knowledge is integrated into practice.

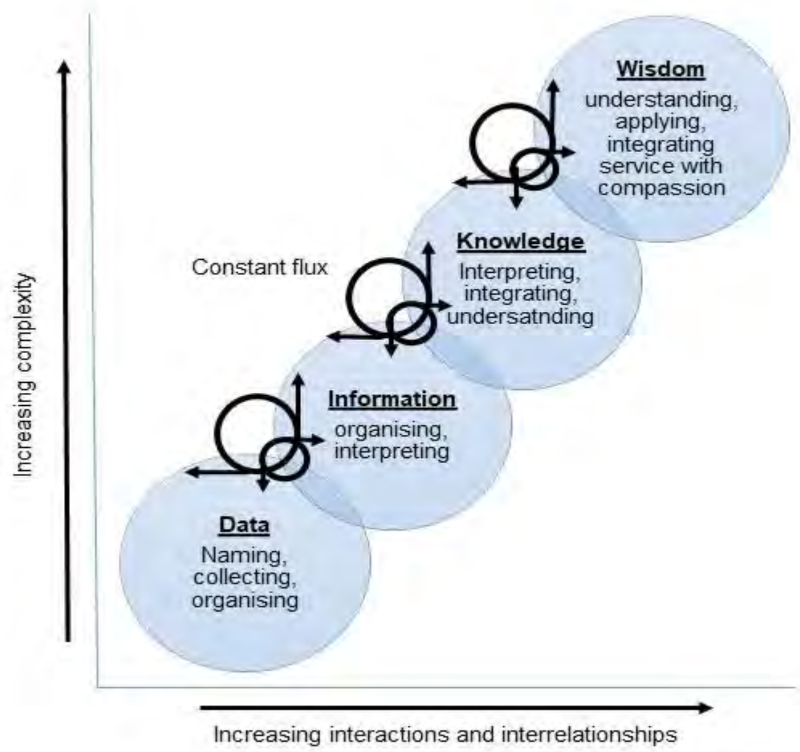


Figure 2.5 Nelson Data to Wisdom Continuum Model (Nelson, 2020)

2.3.2 Medical registries

As mentioned previously, the need for keeping records and pooling information has long been recognised as a benefit to improving the quality of care; however, it was not until the advent of computers that a wider record could be kept (Nwomeh et al., 2006). Medical registries have various names (such as databases, clinical audit register, quality registries) but in essence, they all collect and store standardised patient data for analysis and reporting from multiple sites (Blumenthal, 2019; Nelson et al., 2016). The purpose of these registries is to enable the comparison of outcomes with the ultimate aim of improving patient care. The European cross border Patient Registries Initiative (PARENT) specifically defines a registry and its purpose as “an organized system that collects, analyses, and disseminates the data and information on a group of people defined by a particular disease, condition, exposure, or health-related service, and that serves a predetermined scientific, clinical or/and public health (policy) purposes” (Zaletel and Kralj, 2015, 15). Registries may be locally based or like iBID, more centrally based, collecting information from a large number of services.

Data for medical registries can be collected in several ways - unstructured (free text) semi-structured (a flexible framework for collecting data) or structured (defined and fixed numeric values or text) (Salati et al., 2011). Like most medical registries, iBID collects large volumes of data in a structured manner that is easily usable for statistical analysis. Data registries are increasingly being used for health research. Lefering (2014) suggests that the use of medical registries in research fits between prospective and retrospective observational studies in the hierarchy of evidence. Registries produce a much larger sample size than clinical trials, which can be beneficial, but data completeness and data correctness can be lower leading to potential problems in analysis. Additionally, although subcategories can be compared, there is a risk of bias as true randomisation is not possible (Lefering, 2014). Lefering’s positioning of data registries with observational studies fits well with this study design as an exploratory analysis is being undertaken and not an experimental investigation.

As alluded to in the previous paragraph, it is not only the sample size that causes problems with analysis but the quality of the data itself. If the data quality is poor, questionable or unknown then there will be little confidence in the outcomes and potential for benchmarking (O'Reilly et al., 2016). Throughout the literature, several frameworks for assessing data quality have been developed (O'Reilly et al., 2016; Pipino et al., 2002; Sariyar et al., 2013; Williams and Karpelowsky, 2019) yet there does not appear to be a universal gold standard definition of data quality.

The PARENT guidelines break the quality dimensions required for medical registries into four dimensions (governance, data quality, information quality and ethical issues) as shown in Figure 2.6 (Zaletel and Kralj, 2015). These four dimensions encompass the main aspects of data quality discussed in the literature so will be used as a framework later in this study to evaluate the quality of iBID.

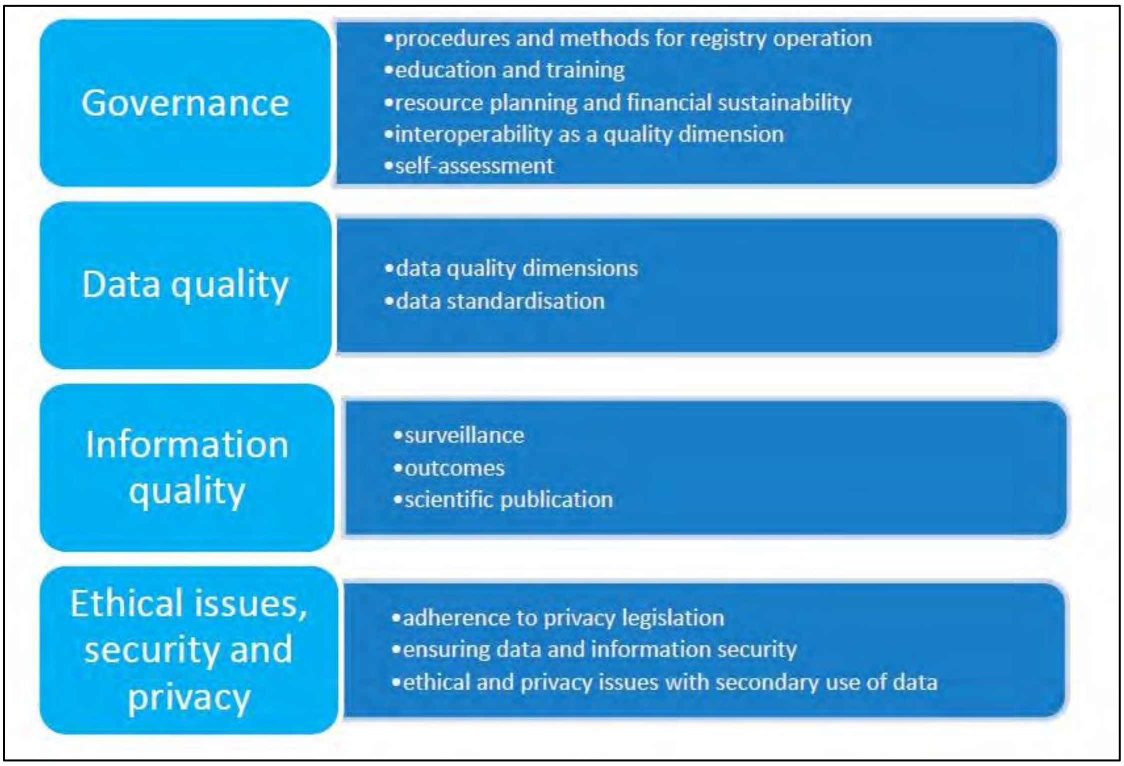


Figure 2.6 European cross-border Patient Registries Initiative's Quality Dimensions of Registries diagram (Zaletel and Kralj, 2015, 59)

2.3.3 IBID development

One of the first burn databases identified in the literature was the National Burn Information Exchange that developed from a local database in Michigan to a national database in 1964 following a research grant (Feller et al., 1980). Data from this database went on to show differences in care and survival across hospitals (Feller et al., 1976) which prompted Davenport at a BBA conference in 1978 to call for a similar UK version (iBID, 2019). There continued to be calls for a UK burns database and in 1995 funding was secured and the BBA gave a remit for one to be developed as other UK databases were not found to meet the requirements for burn care. The iBID was one of the first English speaking national burn registries alongside the American National Burn Repository and the Burns Registry of Australia and New Zealand.

The iBID aims are multifaceted, though principally its purpose is to;

"Store detailed information about burn injuries, requiring treatment by specialist burn services, in a large enough volume to enable advances to be made in:

- Burn prevention
- Service provision monitoring and Quality Assurance
- Planning and modelling changes in burn service provision
- Service accreditation
- Audit and support of Clinical Governance
- Burn outcome assessment
- Epidemiological research
- Design of multi-centred clinical research"

(iBID, 2019)

This is similar to the aspirations of other national burn databases (Cleland et al., 2016; Feller et al., 1980; Peck et al., 2016). More recently, the World Health Organisation (WHO) has launched a global burn registry to get an increased understanding of the risk factors and risk groups to better inform worldwide burn prevention programmes (WHO, 2018), along with a greater knowledge of worldwide burn care practices across both low and high-income countries (Peck et al., 2016).

The iBID has been developed over time and had several software updates and additions to the data set as clinical requirements changed. An initial version of the software with a minimum dataset was launched in 1998 but there was no funding for centralisation and data analysis (international Burn

Injury Database, 2019). Around this time a National Burn Care Review was undertaken which recognised the need for a burn database to aid burn prevention and quality assurance and recommended the continuing development of “a clinical specialist database for burn injury” (National Burn Care Review Committee, 2001, 15). In 2004, the first UK version of national burn care standards was published that included a standard for burn services to contribute to a national burn injury database (National Burn Care Group, 2004). At the same time, funding was made available and redeveloped iBID software was launched in April 2005. Supported by NHS commissioners, all specialised burn centres and units in England and Wales started to input data prospectively and retrospectively going back to 2003. A new version of the iBID software was released in 2012 which included a section on ‘levels of care dependency’ (iBID, 2019) which to date has not been formally analysed. This ‘levels of care’ data set, contains data on aspects of nursing care required to give a nursing dependency score as well as nursing skill required, therapy and medical input.

The iBID was designed to record both the causation of the burn injury and the subsequent clinical path (iBID, 2019). IBID now has the ability to collect burn information on all clinically important areas. This includes data on each patient's demographics, causation and prevention, the burn injury, referral and admission information, airway injury, resuscitation, co-existing disorders, scar potential, complications, discharge and follow up information, and Nursing and therapy care. This information comes from patients admitted to the 22 specialist burn services in England and Wales. At the time of writing, iBID contained over 200,000 individual patient records and over 321,000 levels of care records.

Since its initiation iBID has been used to routinely provide summarised information to the burn services about their burn activity, mortality risk stratification and benchmarks. Additionally, it is used to provide anonymised information to commissioners and burn networks for service planning, charities for promoting burn prevention, MPs for prevention initiatives and researchers undertaking burn-related studies. The iBID data is also used to populate the burn care quality dashboards published by NHS England (iBID, 2019). The iBID data has been used to map burn epidemiology and identify vulnerable burn injury population sets (Stylianou et al., 2015). At the time of writing, iBID has provided data for 425 conference presentations and posters and has had 169 acknowledgements of contributing to peer-reviewed papers (iBID, 2021).

2.3.3.1 iBID Level of care data set

The 'levels of care' data set in iBID contains data on aspects of nursing care required to give a nursing dependency score as well as nursing skill required, therapy and medical input. They were initially identified and described by a working group of senior experienced burns clinicians (predominately nurses and therapists) based on their experience and clinical knowledge in 2006 and tested in the Manchester Adult Burn unit (Dunn, 2018). This 'levels of care' data set which contained the iBID ND score was formally added to the iBID software in 2012 for national use.

The 'levels of care' are intended to measure the dependency of burn patients and their requirements for nursing care and therapy. For this research, it is the iBID ND total score and the five sub-variable scores that make up the ND total score that are of particular interest. The five sub-variables ('Monitoring Requirements', 'Procedure Complexity', Psychosocial Support Needs', 'Activities of Daily Living (ADL) Achievement', 'Mobility Limitations') and the scores for each category are described in Table 2.2.

The categories of each variable are given a score. The different levels in each category have not been quantified and the levels do not necessarily equate across the different categories. Four of the sub-variables have five categories and are scored 1 to 5 as each category is an action in its own right. However, the procedure complexity variable has six categories with the first category being no dressing. Subsequently, this variable is scored 0-5 with the zero-score denoting no dressing was performed. This was important to identify as dressing procedures in patients with a burn can take up many hours of nursing time.

To calculate the iBID ND total score the patient is given a score for each of the five categories. These are added up to give an iBID ND total score between 4 and 25. For example, if a patient is a B1, P4, S3, D3 and L3 this is equivalent to 1+4+3+3+3 giving an iBID ND total score of 14.

Interestingly, the other care level variables 'Skilled Nursing Needs', 'Basic Care Needs', 'Medical Intervention' and 'Therapy Complexity Total Score' were not included in the iBID ND total score. Yet it could be argued that they might affect the overall nursing dependency of the patient.

The iBID ND variables are categorical in nature. However, as they are ordered in an ascending manner in accordance with the workload description, with a number assigned to each, they are classed as discrete ordinal categorical variables. The assigned numbers describe the order but not the differences in value, as it cannot be said that if they score a 2 (e.g. L2 some limitation supervision/assistance needed) this is twice as much as a 1 (e.g. L1 fully mobile). From a statistical point of view, they are treated as discrete ordinal levels of measurement.

Table 2.2 The iBID Nurse Dependency total score sub-variables with their category levels and individual scores

iBID ND Total Score sub-variables	Category Level	Score
Monitoring requirement (The type of ward level monitoring required)	B1 Surgical Ward Level	1
	B2 High dependency	2
	B3 Intensive care	3
	B4 Additional Intensive care	4
	B5 complex intensive care	5
Procedure Complexity (The size of dressing procedure or operation undertaken)	P0 no dressing or procedure	0
	P1 simple small dressing <5% or removal of sutures	1
	P2 single body segment dressing 5-11%	2
	P3 moderate dressing 11-21% / small operation	3
	P4 multi segment dressing >21% / significant operation	4
	P5 near full body dressing / major operation	5
Psychosocial Support (The type of ward level monitoring required)	S1 ward round contact - social	1
	S2 explanatory chat	2
	S3 significant support needed	3
	S4 in depth discussion or next of kin support	4
	S5 intense observation or next of kin in crisis	5
Activities of Daily Living (ADL) Achievement (The type of ward level monitoring required)	D1 self-caring / minimal input	1
	D2 minimally dep assistance few tasks	2
	D3 limited function assistance with some tasks	3
	D4 severely limited assistance with most tasks	4
	D5 fully dependant assistance with all tasks	5
Mobility Limitations (The type of ward level monitoring required)	L1 fully mobile	1
	L2 some limitation supervision/assistance needed	2
	L3 significant limitation needing 1-2 assistants and walking aid	3
	L4 severe limitation hoist/tilting table/standing frame	4
	L5 totally immobile high pressure sore risk hoist only	5

2.4 Nursing Workload

This section will discuss what is meant by nursing workload and outline various workload measurement/planning approaches. It is not the planned remit of this section to debate the different methods of workforce planning but to give an overview of some of the issues as background to this study and to situate where the iBID ND tool might sit within them.

Nursing workload in its broadest sense is relatively easy to explain – “the amount of work that has to be done” (Cambridge Dictionary, 2020) by nurses. However, explaining what that work is, is harder and ensuring a fair distribution of the work within the available resources is even harder. Which may be why there is an array of tools claiming to measure nursing workload.

The difficulty of defining and measuring workload is further compounded by the different language used to define these terms (such as acuity, dependency, case-mix, intensity) and the fact that the terms are often used interchangeably (Duffield et al., 2011; Edwardson and Giovannetti, 1994; Morris et al., 2007; Swiger et al., 2016). This is something that has not changed over the years despite being highlighted early in the literature.

There is also no one definition of ‘nursing’ in the literature (Morris et al., 2007; Scott et al., 2014) but it is recognised that nursing has several dimensions: ‘direct patient care’ (such as bathing, feeding, dressings and taking vital signs), ’indirect patient care’ (activities that are performed on behalf of the patient but not direct contact such as organising referrals, care planning, phoning relatives) and ‘non-patient care’ (such as education, administration and meetings) (Morris et al., 2007; Swiger et al., 2016). In addition, Scott (2014) discussed another dimension which was ‘direct psychological care’ but that is probably enveloped into direct nursing care for many authors. Nursing is more than a list of individual tasks. An experienced nurse will undertake several activities simultaneously and make treatment judgements while doing so. Competing demands, interruptions and patient turnover will also influence the workload (Swiger et al., 2016). The iBID ND tool does not attempt to categorise the whole extent of nursing workload but highlights some of the key aspects that senior burn clinicians judged would influence the overall nursing work/ care needs for patients with burn injuries.

The term workload adds a time dimension to nursing care (Morris et al., 2007; Myny et al., 2012). There are a variety of approaches to measuring nursing workload (Edwardson and Giovannetti, 1994) which Hurst (2010) using the terminology of ‘workforce planning methods’ categorises into six categories - professional judgement, staff to bed ratios, workload quality, time tasked, regression and benchmarking databases. They all have strengths and weaknesses, so Hurst suggested several of the methods should be used and triangulated for good workforce planning. This is reiterated throughout the literature, that no one nursing workload measurement system can measure and address all aspects of workload measurement (Duffield et al., 2006; Edwardson and Giovannetti, 1994; Flynn et al., 2010; Griffiths et al., 2020b; Reid et al., 2008). Table 2.3 lists the workforce planning methods with examples and a summary of their strengths and weakness based upon Hurst (2010) and Griffith et al (2020 b) models. Griffiths et al. (2020 b) argue that these categories are not distinct and there is overlap between them; with no evidence that one is better than the other in ascertaining the ‘correct’ staffing levels, especially as judgements are complex and many factors and daily variation will have an impact.

Table 2.3 Workload measurement methods and their strengths and weakness. Adapted from Hurst (2010), (NHS Institute for Innovation and Improvement, 2012) and Griffith et al (2020c).

Workload measurement method	Strength	Weakness
Professional Judgement [e.g. Telford method (Telford 1979)] Professionals use their expert knowledge and experience to quantify the workload and numbers of staff required per shift.	• Clinician opinions are taken into account • Able to manage complex issues • Quick, simple and cheap • Some research suggests it can be accurate • A springboard to using other methods can be used.	• No built-in service quality measure • Could be subjective • Can be workload insensitive • Difficult to calculate staffing manually
Staff to bed ratios/volume based approach [e.g. State of California nurse-patient ratios (1999)] There are centrally set baselines of the number of patients per nurse.	• Evidence-based • Provides good benchmarks • Can be used with all services	• Costly to update evidence • Does not take into account different patient acuity and ward design • Ignores patient turnover • Open to manipulation
workload/acuity-quality method or Patient prototype approaches [e.g. NAS, (Miranda et al., 2003), SNCT (The Shelford Group, 2014)] Patients are classified according to their acuity or dependency needs. A staffing allocation weight may then be applied to each group.	• A sophisticated algorithm that accounts for most variables • Nursing workload and patient acuity based • Flexible • Measures throughput • Quality weighting • Has e-rostering potential	• Costly • Extra work for ward staff to record data • Lack of evidence re ability to forecast staffing needs • Not useful for small wards

Workload measurement method	Strength	Weakness
Time task approaches [e.g. GRASP (Anderson, 1997)] Each task is assigned an amount of time and a detailed care plan or list of tasks for each patient is made. The time for all the activities are added up to determine the number of staff required.	• Evidence-based • Easily computerised • Easily updated • Links to care pathways	• Costly to update • Task orientated • Commercial so costly
Regression method or multi-factorial indicator approaches [e.g. Workload measurement system (Hoi et al., 2010), RAFAELA (Fagerström et al., 2014)] Uses data about patients, environment, and other factors in a regression formula to predict staffing numbers.	• Best forecaster for areas with a predictable workload • Simple if computer-based • Takes multiple factors into account	• Costly • Lacks ownership at ward level • Statistics off-putting and requires specialist input • Data input required
Benchmark databases [Health service data warehouses] Comparable data is compared between units and expert judgements made on these comparisons.	• Wide amount of data • Able to compare against others	• Depend on what is collected • May not be like for like

From the methods identified in Table 2.3 the iBID ND tool sits in the acuity/ prototype group as it has levels of classification based on the ND of patients. It is much simpler than many of the other patient prototype approaches but currently, there is no time measurement or staffing numbers linked to the iBID ND scores. Therefore, it can only be used as an indicator of increasing or decreasing workload. Which, maybe as Hughes (1999) suggested is what is required; a simple method of ‘monitoring’ changes to workload and quality until a universally agreed reliable workload assessment method is developed. In the future, the iBID database may have the potential to be used as a benchmark database for ND of patients with a burn injury.

It is recognised that reduced nurse staffing numbers and increased workload can mean some nursing interventions do not get done leading to increased mortality, reduced quality of care reduced job satisfaction and poor staff retention, (Duffield et al., 2011; National Institute for Health Research Dissemination Centre, 2019). However, what the actual 'correct' staffing levels are is another conundrum. Despite there being a wealth of evidence to suggest that the right staffing levels improve patient care, there is still minimal evidence to guide these staffing level decisions (Saville et al., 2019). Neither is there an agreement of what these levels should be in different situations, nor the correct skill mix of nursing levels (NICE, 2014; Saville et al., 2019). This lack of consensus on what the correct staffing levels should be, and no perfect workforce measurement system, is also likely to be why different countries and even different jurisdictions within countries have taken different approaches to nurse staffing legislation.

In 1999, California became the first state in the USA to agree on a minimum nurse: patient staffing ratio (Dumpel, 2004). Victoria in Australia then followed suit with mandated nurse: patient ratios (Twigg and Duffield, 2009). However, nurse: patient ratios are not the ultimate answer and have been criticized for their lack of flexibility with changing patient needs and the risk of minimum ratios becoming the norm. Which is why Western Australia opted for a 'nurse hours per patient day (NHPPD)' approach for different ward types using benchmarked data (Twigg and Duffield, 2009). In the UK, all four health services have taken a different approach. Ten years ago, Scotland set out a triangular approach using a specific speciality related workforce planning tool, along with professional judgement and supported with evidence from clinical quality indicators (Flynn et al., 2010). Wales advocated a similar format when it passed the Nurse Staffing Levels (Wales) Act 2016; the first law of its kind in Europe (Dean, 2018). Then, in 2019, Scotland followed suit and passed The Health and Care (Staffing) (Scotland) Act 2019. Both these Acts aim to make the calculation of and subsequent nurse staffing levels more transparent, holding the health boards responsible. England and Northern Ireland, as yet, have not passed any such laws (National Institute for Health Research Dissemination Centre, 2019). Although the National Quality Board (2018) has published an 'improvement resource' for acute adult ward staffing, which advocates for the right staff, with the right skills, in the right place, at the right time and refers back to the previous NICE guidance (2014), it does not stipulate how this can be quantified. The National Quality Board (2018) guidance proposes similar actions as the Welsh and Scottish Staffing Acts do. All four UK health services appear to be aiming towards the acuity-based tools for adult acute care as the workload assessment method supported by professional judgement and quality benchmarking.

2.5 Acuity and Dependency Definition

As with the workload assessment methods, the terms used in the literature, such as 'nurse dependency', 'patient dependency', 'nurse acuity', and 'patient acuity', are rarely defined and are often used interchangeably, to the extent that they all appear to mean the same thing. This is highlighted by articles on the SNCT which all use different terminology although they are referring to the same concepts and have some of the same authors. Initially, in terms of what the tool is aiming to capture, Harrison (2004) relates 'acuity' to physical needs and 'dependency' to the impact on nursing requirements. Smith et al. (2009) and The Shelford Group (2014) use the terms 'patient acuity' and 'dependency together', or refer to 'care levels' rather than specific acuity and dependency terms. Hurst et al. (2008), on the other hand, only talk of 'levels of dependency' and uses 'dependency' throughout with no mention of 'acuity'. Whereas in the later article Fenton and Casey (2015) tend to focus on patients' individual ‘care need’s rather than using the terms of ‘acuity’ and ‘dependency’.

Some of the literature has attempted to define patient acuity and patient dependency, usually when there has been a glossary included as shown by the examples in Table 2.4. However, although it can be seen that the definitions are similar and the patient dependency could be interchanged with nursing dependency there is no explicit definition of nursing, perhaps because even in today’s times as Barr et al. (1973: 195) suggests, “nursing dependency implies different things to different people”.

This lack of consistency in definitions is also highlighted by Brennan and Daly (2009) who point out that although the term patient acuity is commonly used, suggesting it is well defined, there is no uniformity in how it is defined and measured leading to a lack of standardisation and difficulty in comparing tools. From their analysis of the literature, they argue that acuity has several aspects to it, with severity and intensity being the most relevant to nursing. They argue that the relationship between the two may be both linear and non-linear depending on the goal of the treatment. This would explain why one of the criticisms of the use of acuity as a workload measurement is that it does not always equate to the actual work required. Brennan and Daly (2009: 1119) put forward the following definition of the attributes;

> “the severity attribute of acuity indicates the physical and psychological status of the patient, while the intensity attribute of acuity indicates the nursing care needs and the corresponding workload and complexity of care required”

Which they then sum up as “Patient acuity is a measure of the severity of illness of the patient and the intensity of nursing care that the patient requires” (2009: 1119). The intensity attribute definition is similar to some of the patient dependency definitions which might explain why they have been used interchangeably in the literature. This is further highlighted by Junttila et al.’s (2019) definition where they discuss the amount of nursing intensity per patient in relation to patient dependency rather than patient acuity.

Table 2.4 Patient acuity and Patient dependency definitions

	Patient acuity	**Patient Dependency**
NICE (2014: 40)	“How ill the patient is, their increased risk of clinical deterioration and how complex their care needs are. This term is sometimes used interchangeably with the terms 'patient complexity' and 'nursing intensity'”	“The level to which the patient is dependent on nursing care to support their physical and psychological needs and activities of daily living, such as eating and drinking, personal care and hygiene, mobilisation”
National Quality Board (NQB) (2018: 38)	Same as NICE	Same as NICE but adds mental health
National Institute for Health Research (NIHR) (2019: 25)	“the degree to which a patient has severe and recent onset symptoms which need prompt medical attention”	Does not mention dependency
Healthcare Financial Management Association (2014)	The seriousness of the patients’ medical condition	Level of nursing input required

These different definitions and use of words interchangeably are confusing. This is emphasized by Chiulli et al. (2014) who, when designing their patient acuity tool, found that their initial literature review was useful in stimulating discussion about how to define acuity, but still did not publish a definition. This lack of a clear definition and the need for many factors in describing nursing work may be why there are so many ND tools in the literature and the answer on how to calculate nurse staffing has still not been conclusively solved.

In line with the majority of the nursing workload literature, which uses the terms acuity and dependency rather than Brennan and Daly's acuity attributes, the terms 'patient acuity' and 'nurse dependency', as defined below, will be used in this thesis in an attempt to distinguish between the severity and intensity aspects of acuity.

> **Patient acuity** – The severity and complexity of the patient's illness or condition, recognising that they may not be very ill in critical terms but may have a lot of complexity in their condition.
>
> **Nurse dependency** – The amount of nursing input required, both direct and indirect care.

These definitions also enable the differentiation between the degree of illness and nursing care required, as one does not necessarily reflect the other (Edwardson and Giovannetti, 1994).

2.6 Summary

This chapter has given a brief overview of burn care, iBID, nursing workload and clarified the definitions of patient acuity and nurse dependency that will be used in this thesis. The information given in this chapter has been aimed at increasing the understanding of later discussions in this thesis. Next, Chapter Three will expand on the nursing workload and methods of measuring this as it critically analyses the literature on nurse dependency tools.

Chapter 3 Literature Review

3.1 Introduction

In chapter two the development of the iBID ND tool through clinical expert experience rather than reference to a specific theoretical model was discussed. To gain an understanding of where the iBID ND tool might sit within the ND literature, and aid in the analysis of the ND data in iBID, a literature review was undertaken. This chapter builds upon the nursing workload discussion in chapter two and presents a review of the literature pertaining to ND tools, in particular those related to measuring ND in burn care. The discussion here is in the form of a narrative analysis as the array of articles and different methodologies leads to this approach, rather than any other form such as a meta-analysis.

First, the search strategy is outlined and then a brief historical overview of ND tools is given. This chapter then goes on to examine in more depth the literature on burn care specific ND tools and how these relate to the iBID ND tool. Next, other available ND tools are explored for similarity to the iBID ND. Finally, the only UK ND tool currently endorsed by NICE SG1 (NICE, 2014), the Safer Nursing Care Tool (SNCT), will be critically discussed in detail.

3.2 Search Strategy

A review of the literature was undertaken to understand what information had been published on ND tools and whether there were any ND tools specifically for burn care. This was performed using the key nursing and medical library databases - CINAHL, Medline, PubMed, Scopus, Web of Science, Cochrane and NHS evidence. Additional focused searches were performed as required when key authors and texts for ND were identified from the literature. The search was undertaken in two parts. Initially, the search was undertaken using the search terms shown in the first column of Table 3.1 and using burns as a final filter. Then secondly, a broader search without burns as a filter was undertaken to gain insight into the wider ND literature.

Table 3.1 List of search terms, inclusion and exclusion criteria used in the literature search

Search terms	**Inclusion criteria**	**Exclusion criteria**
'Patient classification' OR 'Dependency' OR 'Workload' OR 'Acuity' OR 'Staffing levels'	➢ English language articles ➢ Nursing workload/ dependency/ acuity tools ➢ Related to adult inpatients ➢ Acute care environment	➢ Outpatients ➢ Home care residents ➢ Paediatrics ➢ Mental health patients ➢ Emergency departments ➢ Maternity department ➢ community
AND 'Tool' OR 'Measurement' OR 'instrument' OR 'score' OR 'scale' OR 'system'		
AND 'Nursing'		
AND 'Burns'		

In the initial search, all the burn ND articles were reviewed as it was important to discover what areas of burn care ND tools had been developed for. Figure 3.1 shows how the first search was conducted using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) search model. The exclusion criteria listed in Table 3.1 was only used in the second search to narrow down the sample size to those areas that were most relevant to this research.

From the second literature search without the burns filtering, but after filtering using the exclusion terms listed in Table 3.1 over 5,000 articles were found. With the overwhelming amount of literature, rather than doing a systematic review to just identify specific tools, a broader scoping review was undertaken to

a) Map out the history and development of Nurse Dependency tools
b) Identify nurse dependency tools for acute inpatient care
c) Highlight some of the central themes the tools were used for in the literature
d) Critically analyse the key review papers on nurse dependency tools

A scoping review is more appropriate than a systematic review to map the range and extent of a topic, albeit in a less deep but broader manner (Arksey and O'Malley, 2005). It is acknowledged that there is a possibility that there may be some key literature that has been overlooked. However, throughout the literature review process attention was paid to the references used in the articles. When relevant new texts were found and as ND tools or prominent authors in the ND field emerged, further searches were performed to ensure a comprehensive overview was gained.

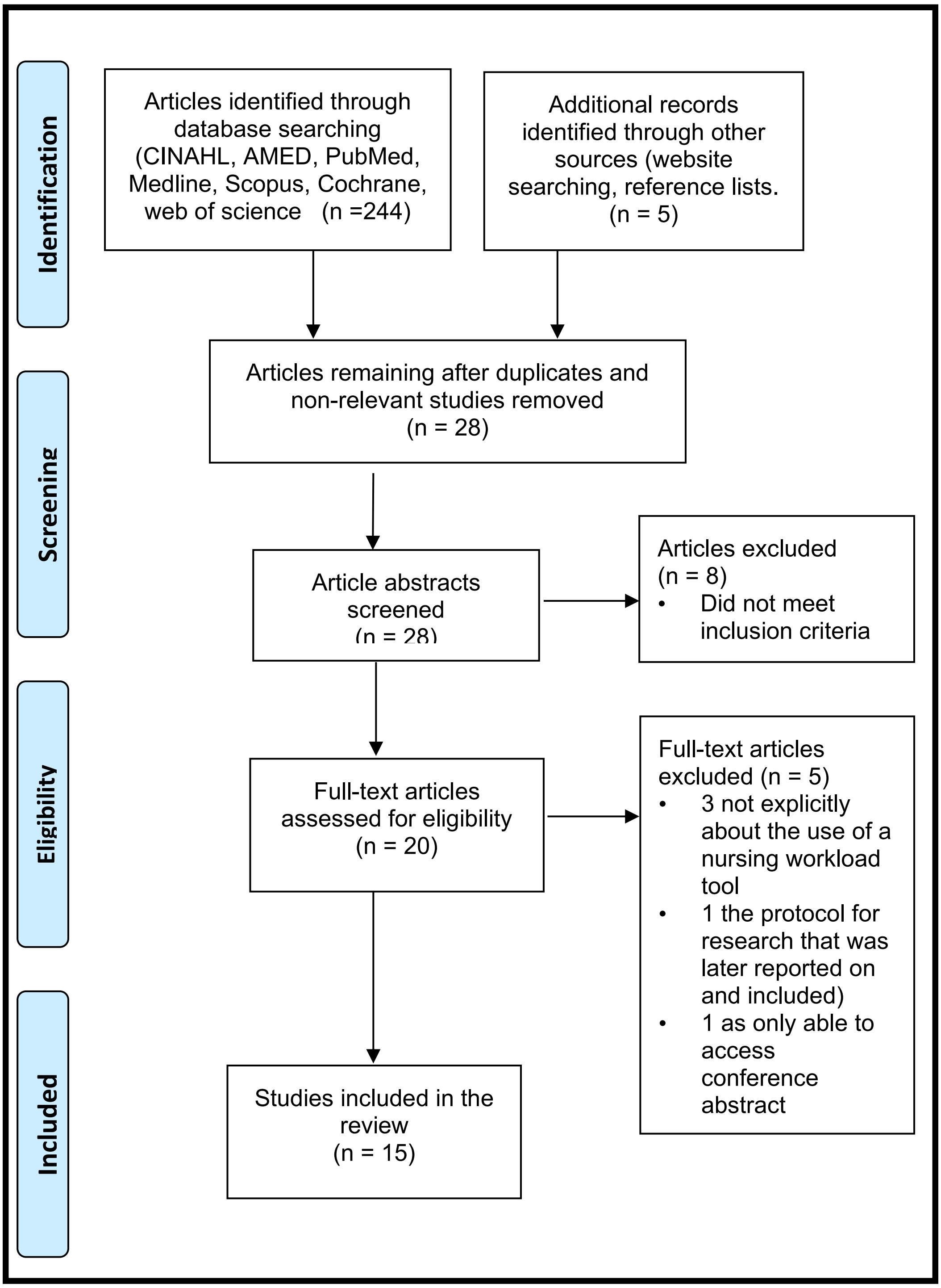


Figure 3.1 PRISMA Flow Diagram for literature search for nurse dependency tools in use in burn care.

3.3 General Overview of the Literature on Nurse Dependency Tools

Following the wider literature search, the number of articles the search revealed in 2020, was found to be considerably more than when an initial review was done at the start of this research journey in 2015. It is postulated that in the UK this might in part be due to the response to the Mid Staffordshire scandal (Francis, 2013) where low nurse staffing levels were thought to be a contributing factor to the poor-quality nursing care. Figure 3.2 gives a diagrammatic representation of how the number of articles related to ND each year has grown over time demonstrating that in this millennium the number of articles has tripled and is continuing to rise on the topic.

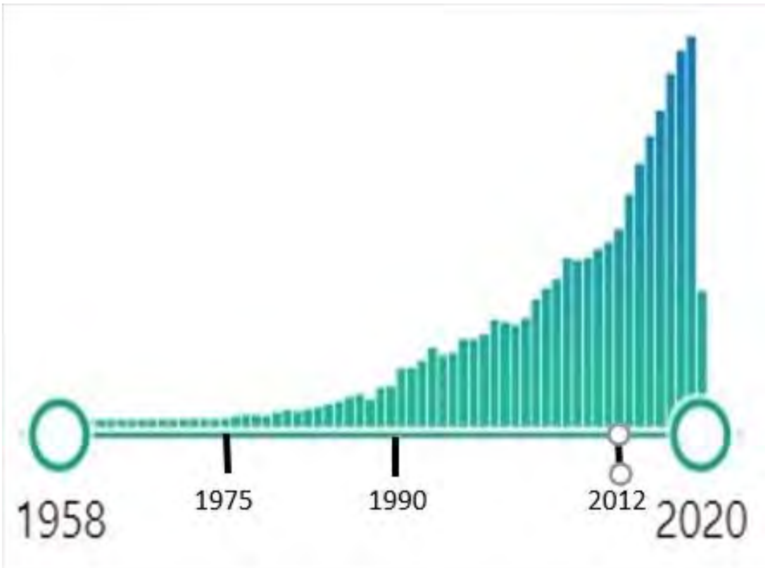


Figure 3.2 PubMed bar chart showing the trend of the number of articles yielded per year.

Prior to the 1980s, there was little published literature about ND tools. The earliest cited evidence found in this literature review was work by Bernstein in 1953 studying the amount of direct nursing care for different levels of illness (Barr et al., 1973). Barr et al. (1973) argue that Bernstein's three-point classification (acutely ill, moderately ill and mildly ill) is too broad and not much different from the intuitive professional judgement approach.

Nonetheless, Bernstein's classification, although broad, does help to add some clarity and objectiveness to any professional judgment. Subsequent ND tools have aimed at building on this definition and further defining categories and being more explicit about the criteria for each. Over the years, although the included activities may have become more technical as nursing has evolved and timings and terminology may have changed, the actual structure of the ND tool has not. For example, sixty years on, the SNCT (The Shelford Group, 2014) consists of five broad categories, each with a list of activities that equate to that category.

In the 1970s and 1980s as health services grew and resources become a topical issue there was a small increase in articles on the topic. Most of this earlier literature was concerned with defining what nursing was and how it could be measured and developed into a ND tool. Initially, patient classification systems were predominant, but over time as the complexity of nursing was highlighted the ND tools became more refined. The quality of nursing and the environment began to be taken into account in the development of ND tools, along with the acknowledgement of the indirect patient care activities that nurses performed and the realisation that nursing care was not just linked to the medical diagnoses (Miranda et al., 2003). Despite there being many nursing models that aim to describe what nursing is very few of the ND tools appear to be explicitly based on these. Only a couple specifically state an underlying nursing theory to their development (Hoi et al., 2010). Instead, many are derived from a medical disease or medical condition of the patient perspective (Miranda et al., 1996).

One of the driving factors for the increase in ND literature in the 1990s, particularly in the U.S. literature, is likely to be due to the Accreditation with the Joint Commission for Accreditation of Healthcare Organisation being recognised by USA Congress as being compliant with Medicare programs (The Joint Commission, 2020). One of the Joint Commission's nursing standards was for nursing departments to implement a system to determine the nursing care required, therefore the search for the optimal system was increased (Moores and Barr, 1982). Additionally, this was linked to the cost of healthcare and the charges for nursing time for different diagnostic groups. In the UK the ND literature to date has been less focused on the actual cost of nursing care as opposed to the number of nurses required for safe and effective care. This is likely to be due to the different systems of financing of health care.

Around 2013 there was a further sharp rise in the volume of literature on this topic giving support to the earlier idea of the impact of the Mid Staffordshire scandal where poor nurse staffing levels was identified as one of the causes of an increase in deaths (Francis, 2013). Prior to this, there had been a steady increase in published work as the concern in nursing numbers was rising (Rafferty et al., 2007; RCN, 2010; Scott, 2003). Authors were identifying that nursing and health care had changed and therefore tools needed to be updated or were not accurate. Furthermore, the acuity of inpatients was increasing but the nursing establishments were not changing (Harrison, 2004; National Institute for Health Research Dissemination Centre, 2019).

Although the need to validate ND tools has been recognised throughout the literature (Edwardson and Giovannetti, 1994; Fasoli and Haddock, 2010; Griffiths et al., 2020b), published robust validation of many of the tools has been limited. However, the more recent new ND tools have been reporting their appraisal evidence (Fagerström et al., 2014; Smith et al., 2009). Nevertheless, Griffiths et al. (2020b) argue that despite this, there is still little evidence of the impact various ND tools have on improving patient care or evidence of choosing one tool over another. Instead, the evaluations have mostly been focused on demonstrating that the ND tool worked, could measure an aspect of nursing cost, could help in the equity of workload allocation or in comparing one tool with another.

Although not the remit of this literature review, the literature on ND tools not only reports new ND tools and their evaluation but also how ND dependency tools can be used in research where the focus is on an outcome (such as cost of nursing care, mortality, missed care, nurse retention, patient satisfaction), comparison of different ND tools, their use in different countries, number of nursing staff needed and workload allocation of patients. A new emerging theme is the use of big data in workforce research. With the continued evolution of computer technology and electronic records, the increasingly large amounts of data are now enabling researchers to use data mining methods to investigate nursing workload, staffing and quality of care (Leary et al., 2016). However, as Leary et al. (2017) show, using large databases has its limitations, not least the differences in structure and data recorded limiting the comparisons that can be made. Another emerging area in the literature, due to enhanced technology, is the ability to start modelling nurse staffing levels using ND tools (Saville et al., 2020).

Throughout the literature, the need for professional judgement is advocated to validate the ND tools' predictions. Contending that the tools in themselves can help give objectivity and provide evidence for staffing levels but they cannot account for every nuance. Therefore, there is a need for professional judgement alongside, as a 'reality check'. The fact that ND tools cannot account for every aspect of workload and need may also be the reason why in the literature to date there is no conclusive evidence regarding the optimal number of nurses.

This overview of the ND literature was aimed at setting the scene for the following sections of this literature review. The next section highlights the burn ND tools identified in the literature search.

3.4 Nurse Dependency Tools for Burn Care

In this part of the literature review, the emphasis is on the ND tools that have been reported in the literature specifically relating to their use in burn care. The aim was threefold; to ascertain what burn ND tools there were, whether there were any similarities to the iBID ND tool and whether any comparisons could be made with the results.

The first mention found in the literature of the development of a ND tool for burn care was in 1986 when Helmer discussed the development of a patient classification system for burn units to identify nursing needs of patients and to identify and support staffing levels (Helmer, 1986). He argues that there is "no perfect universal system" (Helmer, 1986:512) and burn units are unique so should develop their own system rather than adopt one used in ICU or general wards. This view is repeated through the literature and was one of the reasons de Jong et al. (2009) developed their own burn nurse tool. Apart from Helmer (1987) and de Jong (2009) who designed their own specific burns ND tool, all the other authors who have written about the use of a ND tool for burn care have either used an existing tool for their study in burns (Camuci et al., 2014; Padilha et al., 2007) or adapted a pre-existing tool for use in their burn service (Abdelrahman et al., 2018; Cottey et al., 1992; Molter, 1990; Sjöberg et al., 2000). This developing of new ND tools or adapting existing tools for use in burn care would suggest that burn services have little confidence in the existing ND tools to predict the nurse staffing required for burn care and that Helmer (1986) was correct about there being no perfect universal system. This supposition is further affirmed by the wider

ND tool literature which demonstrates a continuing development and adaption of ND tools for specific specialities and services.

3.4.1 The first reported burn specific nurse dependency tool in the literature

As previously mentioned, Helmer (1986) starts the dialogue in the literature on ND tools in burn care by discussing the use of patient classification systems to answer the question of how many staff are required on a shift in the burn unit. He suggests that there are two types of patient classification systems. A prototype system that categorises the patients depending on the characteristics they exhibit and a factor system where a list of nursing needs are checked for each patient. This is arguably still the case today as evidenced by Griffiths et al.'s (2020_b) review of staffing methodologies, where they label one of the approaches to determining nurse requirements as 'patient prototype approaches'. The SNCT (The Shelford Group, 2014) would be an example of a prototype system (Griffiths et al., 2020_b) and the Therapeutic Intervention Scoring System (TISS) (Cullen et al., 1974) and Nursing Activities Score (NAS) (Miranda et al., 2003) are examples of the factor system. Factor systems can become long lists and take more time to complete, with an additional problem that nurses often do more than one task at a time making it difficult to assign an accurate time to each activity. This is one of the reasons why over time the general ICU TISS tool and NAS tool have been refined and shortened. Additionally, the time for each activity may not be transferable to another unit due to unit layout or different processes. Thus, often ND tools may start as a factor system and evolve into a prototype (Helmer, 1986). However, it can work the other way with a simple prototype classification having more descriptions added to each category for clarity and to reduce ambiguity. The iBID ND tool would be classified as a factor system as there are several categories of nursing needs that are scored individually to give a final score rather than the patients being allocated to a single group.

Thus, giving more flexibility in the ND scoring than ‘shoehorning’ them into a specific category.

Helmer highlights that any system needs to be updated as changes occur. This is evident in the successive updating and reporting of ND tools in the literature (Cunningham, 2018; Fagerström et al., 2014; Miranda et al., 1996). Additionally, Helmer (1986) points out that the use of a patient classification system not only helps determine patients' requirements of nursing care but, can help cost allocation of nursing care to individual patients. The cost per patient is a specific requirement for countries like the US where healthcare is charged in relation to each individual patient. In the UK, where the NHS is free at the point of contact, the cost is not an explicit consideration when allocating nursing staff each shift. However, with budgets being reduced and resources scrutinised the literature is looking more at ND as a way of justifying staffing costs (Abdelrahman et al., 2018; Fore et al., 2019; Stafseth et al., 2018).

In their follow up article, Helmer et al. (1987) described the updating of the Shriners factor system to be more sensitive to the specific needs of burn patients. They came up with a 32-factor list which was piloted in three of the Shriner burn units in the US. The pilot showed that the form was ‘valid and reliable’ but time-consuming to complete. No actual figures of their results were reported so it is difficult to assess how true this statement is. Following the pilot study, they collected time standard data to record the amount of time that was spent on direct and indirect patient care over a one-week period. Stepwise regression was used to analyse the data but again no further details are reported. From these results Helmer et al. (1987) then devised a five-category factor system related to the patient’s condition (critical-unstable, Critical-stable, serious, fair, good) as this, according to their findings, was the key independent variable that related to nursing care. Burn type and percentage of burn were not found to be helpful in predicting nursing time in this study. This is perhaps surprising as the size of a burn would be expected to affect the amount of dressing time. However, this study was undertaken in the 80s and burn wound care has changed since then (Pruitt and Wolf, 2009; Sjöberg et al., 2000), but as Helmer et al. (1987) do not describe their treatment of burn wounds it is not possible to say if this is the reason.

Helmer et al.'s (1987) simplified patient classification system for burn units, was performed once a day and enabled the prediction of nurse staffing for the next 24hours. Reliability of the system was checked by getting nurses to rate the same patients and compare differences and comparing the staffing level outcomes with professional judgement. Over thirty years on Griffiths et al (2020$_a$) still advocates this idea of sense checking of the ND tools' nurse staffing predictions through clinical judgement rather than just relying blindly on ND tools to set nurse staffing levels.

3.4.2 Military ND tool for burn care

Another early implementer of a ND tool specifically adapted to burn care was the Workload Management System for Nurses (WMSN) that captured direct and indirect nursing care. The WMSN is a ND tool designed specifically for use in military nursing, which Molter (1990) reviewed and adapted for use in a US Army burn centre. The WMSN has six categories of care (self-care, moderate care, acute care, intensive care, continuous care and critical care), which each have a nurse: patient staffing ratio allocated. Each patient is given individual scores in relation to nine different areas of care, which when totalled identifies the category of care they are allocated to and the nurse: patient ratio required (Rieder et al., 1985). This allocation is done prospectively for the next 24 hours. There are guidelines for the skill mix and allocation of care, but again it still remains the responsibility of the registered nurse to apply their professional judgement (Molter, 1990).

Molter (1990) discusses how a panel of seven burn nurses evaluated the WMSN indicators for applicability to burn care. Unlike in Helmer's (1987) study, where the burn size did not appear to be a workload factor, Molter determined that the original WMSN complex wound care was the only indicator that did not adequately represent the needs and workload of burn patients. The WMSN complex wound care indicator was defined as; a dressing that took more than 30 minutes to complete including the setting up and clearing of the equipment. In reality, most burn dressings take more than 30 minutes with some taking several hours. Thus, the dressing time was estimated and the relevant workload score calculated for a more accurate picture. Inter-rater reliability was checked and improved over time as the nurses got used to the system and developed a common understanding. By undertaking this wound care indicator adaptation, Molter (1990) argued that the WMSN nurse dependency model was still appropriate for the burn unit and saved administrative training for new staff as well as enabling it to be used to benchmark across the military. This adaptation, which enabled a hospital-wide ND tool to be used across a hospital and in a burns service, was also one of the reasons Cottey et al. (1992) amended their hospital's commercial ND tool in a similar way to account for the greater time required for burn dressings.

The WMSN has been updated over the years as nursing has evolved and is still successfully used in US military hospitals to aid the nursing staff scheduling and benchmarking with other military hospitals (Cunningham, 2018). It was designed specifically for US military hospitals. Military nursing is set up differently from civilian nursing in that the patient population is different (a younger and initially fitter group in the military), the hierarchy and military rank lead to different communication and decision-making practices, and the care delivery set up is more as a manager of care with additional technician roles in the US military than in UK nursing (Berwick et al., 2016; Elliott et al., 2017). Plus, there are additional military and ceremonial duties which need to be factored in. Therefore, the WMSN is not wholly transferable to civilian and UK burn services where the setup is different and thus not comparable with the iBID ND tool.

3.4.3 Wound care and burn nurse dependency tools

The need to consider burn wound management specifically in ND tools, as discussed earlier with the WSMN, is a theme that has come through the specific burn ND tool literature. Anecdotally, the increased wound care needs for patients with a burn injury is one of the reasons burn care nurses argue makes their workload higher and is not accurately reflected in generic ND tools.

Driscoll (1991) describes how the wound care category for burn patients was explored in more detail to enable a more accurate WMSN weighting to be calculated. It is not clear if this was done after Motler's (1990) previous work or as part of it. Driscoll in his observational study, rather than the overall dressing time for burn size, measured the dressing time for different body parts. His hypothesis being that dressing time would vary on the number of body parts dressed and this would then be estimated depending on the size of burn and body parts dressed. To collect the data they used an observer who was not participating in the dressing to record work sample times. Dressing of burn wounds on the back and buttocks took the longest average time followed by the head/face. This was a different way of calculating dressing times as opposed to the traditional 'total burned surface area' (TBSA). Yet it could arguably be more accurate; as different body parts, although they may be a similar percentage, are likely to take different times to clean and dress. For example, a hand, although a small area, is fiddlier and more time consuming to dress than the equivalent sized area on a thigh would be.

Conversely, Cottey et al. (1992) in their calculation of burn dressing weightings used previous work (Watson et al., 1991) that had measured overall dressing time. They found that the average burn dressing time was 74.41 minutes. This is a much longer time than is normally given in more generic ND tools such as the SNCT, which is either less than 30 minutes or more than 30 (Smith et al., 2009). It is not possible to directly compare this to Driscoll's findings due to unknown variables such as whether the dressing set up was included or excluded, or the effect of timing when doing the whole dressing versus splitting a dressing into parts. Nonetheless, the clear message that comes through these studies is that burns dressings should be included as a specific part of a ND tool for burn services, which it is in the iBID ND tool. This need to consider burn wound management, is also further emphasised in the more recent literature on burn ND tools (Abdelrahman et al., 2018; de Jong et al., 2009; Ravat et al., 2014; Sjöberg et al., 2000).

3.4.4 Burn ND studies using ICU ND tools

Part of the body of literature on the use of ND tools in burn care is made up of two studies using ND tools designed for ICU; the Therapeutic Intervention Scoring System (TISS) (Padilha et al., 2007) and the Nursing Activities Score (NAS) (Amadeu et al., 2020; Camuci et al., 2014). All of these studies were undertaken in Brazilian ICU's

In their study, Padilha et al. (2007) used the TISS to compare the workload of 11 specialist ICUs in a large Brazilian hospital which included a four bedded burn's ICU. Originally TISS was developed as a tool to identify levels of severity of illness of patients in ICU and as an indicator of nursing time required (Cullen et al., 1974). In the earliest TISS version, there were 76 interventions. The idea was that the sicker the patient, the greater number of interventions would be required. Weightings were also given to the interventions. In 1996 the TISS-76 was simplified and reduced to 28 items (Miranda et al., 1996). One TISS point equated to approximately 10.6

minutes of a nurse's time so can be used to calculate the required number of nurses needed on a shift and/or patient allocation. Although the TISS-28 was validated in twenty-two Dutch ICU's it is now used globally (de Souza Urbanetto et al., 2014; Muehler et al., 2010; Wang et al., 2018).

During their study period, Padilha et al. (2007) found that the burn ICU had the lowest percentage of ICU patients admitted but they had the longest mean length of stay (17 days) which was double the overall ICU mean length of stay. There is no discussion by the authors as to why this may have been, but it is likely to have been related to burn severity and their admission and ward step down criteria being different to other ICU's. The mean TISS-28 score for the burn ICU was lower than the other ICU's but remained consistent. This could be reflective of the longer length of stay. Nonetheless, Padilha et al. (2007) do note that the workload score only accounts for the TISS-28 interventions and may not capture all activities for burn patients. The specialist activities were one of the reasons Miranda et al. (1996) excluded burn and other specialist ICUs in their multicentre study to develop the TISS-28. Meaning that TISS may not deliver a true reflection of burn ICU care.

During the validation of the TISS-28 Miranda et al. (1996) identified that the TISS did not capture all of the nursing activities undertaken. Two reasons for not capturing all nursing activities were put forward. Firstly, that TISS was developed from the premise that nursing workload is related to the severity of illness and the more severe the illness the greater number of interventions. Secondly, that over time, intensive care and nursing tasks had increased and therefore TISS did not capture tasks not related to therapeutic interventions (Miranda et al., 2003). Therefore, they developed the Nursing Activities Score (NAS), an extension of TISS. Using an international panel of ICU professionals (nurses and physicians from 15 countries), Miranda et al. (2003) identified fifteen new items that they incorporated with the TISS-28 to give a list of thirty items with some broken down into sub hierarchal categories, for example, wound care was broken down into three subcategories depending on the length of time required. This new ND tool was then tested in 99 ICUs across 15 countries and the weighting of the different activities worked out to come up with the final NAS tool. The NAS can measure nursing workload for individual patients or the whole ICU regardless of illness severity (Miranda et al., 2003).

The NAS tool contains a list of nursing activities that are used to work out the NAS dependency score. The NAS activities included one relating to burn wounds and one to supporting the patient and family which are both important to the care of patients with a burn injury but, excluding the iBID ND tool, are often not clearly articulated in many other ND tools. Additionally, Miranda et al. (2003) acknowledged the difference in nursing workload between burn wound dressings and other dressings such as closed surgical wounds. Potentially reducing the criticism, from burn nurses, of many of the ND tools that do not account for the difference between a dressing that may take less than 30 minutes compared to a burn dressing that may take several hours of nursing time. However, it must be remembered that NAS was designed for patients in ICU and not burn wards.

Camuci et al. (2014) used the NAS to evaluate the nursing workload on a Brazilian 6 bedded burns ICU. They collected demographic and NAS data from 50 consecutive patients over an eight-month period. They excluded readmissions but did not explain why. Although readmissions may have a different profile to acute burn admissions they would still have added to the workload of nurses during this period.

Camuci et al. (2014) described the demographics of their sample and highlighted the predominance of males which is in line with other burn epidemiology literature (Stylianou et al., 2015). They state that 70% of the patients had full-thickness burns but do not comment on the size of burn or airway involvement, which might be expected to influence the workload. A mean nursing workload of 70.4% or 16.9 hours of nursing care per patient in a 24-hour period was reported, which they identify is higher than reported in most of the other literature for general ICU's. This is contradictory to the results reported by Padilha et al. (2007), where burn ICU's had the least workload recorded; suggesting that the NAS may capture nursing activities that TISS does not and subsequently record the nursing workload in burn ICU's more accurately. Nonetheless, this was a small study undertaken in one burn ICU so the findings may not be transferable to other ICU's and other countries where the burn care protocols, healthcare set up and staffing frameworks may be different (Stafseth et al., 2011).

More recently Amadeu et al. (2020) published a study, similar to Camuci et al. (2014) undertaken in a small burn's ICU. Their findings were similar, again showing an increased nursing workload for burn patients. Which they argue demonstrates the importance of assessing workload in different specialities as work processes, patient complexities and environment are likely to be different, influencing workload and outcomes. Amadeu et al. (2020) took their analysis of their NAS data further and examined the association of the NAS ND score with other variables such as intubation, outcome and size of the burn. They observed a statistically significant association of an increased NAS score with the size of the burn and outcome. As the size of burn and severity increased so did the ND. Also, patients who died had a higher mean NAS suggesting an increased ND and nursing workload. Interestingly, they did not find an association of ND with intubation or the use of vasoactive drugs, both of which one might have expected would have increased nursing workload. Especially if the patient was intubated, as this would have suggested they had an inhalation injury which is linked to increased severity and mortality in burn patients (Dyamenahalli et al., 2019).

3.4.5 A nurse dependency tool specifically for burn inpatients

Apart from Helmer's ND tool, the only other ND tool reported in the literature that was designed from the beginning specifically for burns is De Jong et al.'s (2009) tool; which was developed for their burns unit in the Netherlands. They had found that no ready-made tool existed that was transferable to their burns unit, as pointed out by Helmer (1986), so designed their own nursing workload measurement tool. De Jong et al. (2009) took a similar route as Helmer et al. (1987) in developing their tool. They established a list of activities and time estimates through semi-structured interviews and doing time measurements of the activities by following nurses during a day shift. Only a brief description is given of this process, so it is difficult to ascertain how accurate and unbiased this procedure was. De Jong et al. (2009) mention how they looked at the difference between groups but not what they did if there was a statistical difference. Perhaps, as they imply, there were no significant differences. Thirty-four activities were identified and linked to a time standard and an educational standard (registered nurse or critical care trained registered nurse). Some of these activities showed a variation in the collected time data so were further subdivided into basic, average and complex such as wound care, which was also the most time-consuming activity as suggested in earlier work (Cottey et al., 1992; Driscoll, 1991). Interestingly their division of burns complexity is different to iBID. There are five procedure categories (<5% TBSA, 5-10% TBSA, 10-20 TBSA, >20% TBSA and near full body) in the iBID ND tool, which are also aligned to operation complexity; whereas the Dutch ND tool only use three (<15% TBSA, 15-30% TBSA and >30% TBSA) as their division. Moreover, de Jong et al. (2009) add in patient size and non-cooperating patients which steps up the complexity. Conversely, iBID does not relate its levels of procedure complexity to body area which does feature in both De Jong et al. (2009) and Driscoll's (1991) work.

From the calculation of time standards for their identified activities, de Jong et al. were able to work out the care demand per patient per day. They then identified five categories of patient care that patients fitted into. Thus, similarly to Helmer et al. (1987) moving from a factor system based ND tool to a prototype one. However, they do not clarify what type of patient fits into each category only the amount of care time required so it would be difficult to utilise it elsewhere from the article. Nevertheless, although de Jong et al. (2009) argue that their ND tool takes into consideration the complexity of care required, education level of nurse required, patient's condition and complexity of the environment, they do acknowledge that their ND tool is specifically tailored to their burn care setting. Therefore, not necessarily appropriate to be used by other burn services.

De Jong et al. (2009) suggest the time standard measurements should be repeated every few years for verification of accuracy. Following personal communication with the author, it was discovered that 6 years on, the tool was not currently used due to the time needed to update it and change in staff. This highlights some of the ongoing issues with ND tools. Suggesting that perhaps a more generic tool without specific times allocated is required that would give trends in the change of workload rather than specifics.

3.4.6 Additional global perspectives on burn ND and workload for burn inpatients

There was no literature found on the use of inpatient burn ND tools in the UK. However, there was literature from three other countries (France, Sweden, and Iran) whose research gave further insight into nursing workload and ND tools for inpatient burn services. These are discussed below.

In Iran, Vafaee-Najar et al. (2018) undertook a cross-sectional study to identify an estimated nursing norm, a coefficient for calculating the nurse staffing resources required, for each type of ward in a number of best-practice hospitals. The WHO's Workload Indicators of Staffing Needs (WSN) resource management tool was used as a framework for this. Nursing expert focus groups were used to identify nursing activities and the time required to undertake these. The time standards were then validated via non-participant observations and an agreed average time for each activity obtained. The patient records were then used to identify the nursing activities undertaken and the nursing care time per day of hospitalisation required. How accurate a retrospective review of records would be is debatable. Although they took steps to mitigate calculating errors from the research, it would depend on how accurate the patient records are and their format. In the UK, where often exception reporting is used, many activities may not be recorded in the notes. Conversely, in North America where all care has to be prescribed, it might be a more comprehensive record.

Vafaee-Najar et al. (2018) then calculated an estimated coefficient for required nurse numbers per bed for each area; taking into account nursing hours available per person, the activities undertaken and an allowance for other non-patient activities. The burn ICU and burn ward had the highest nurse requirements compared to the other ICU's or wards. This increase in nurse numbers could be due to nurses in the burn speciality working fewer hours a week compared to other areas, following the Iranian Productivity Improvement Act of 2009, rather than an increased workload. Nonetheless when the results for the nursing activity standard (nursing care time per patient day) were studied they show a similar pattern with both the burn ICU and burn ward having the higher activity times compared to the other ICUs or wards. Only the open-heart surgery and bone marrow transplantation ICUs had a higher activity standard than the burn ICU. This supports Camuci et al.'s (2014) previous findings that burn ICUs have a higher workload than general ICUs. However, Vafaee-Najar et al.'s study is the only one, identified in this literature review, which also suggests the same may be true for burn wards, that they have a higher workload than other wards. These findings add to the argument that a burn specific ND tool is required to identify the specific additional needs of patients with a burn injury.

Moving continents, Ravat et al. (2014) conducted a small one month study of the working time and workload of nurses during the day in a French burn service. The burn service had fifteen beds of which eight were classed as ICU beds. They categorised nursing work into 3 categories: care, administrative and other. Each day shift a nurse was followed and the distribution of time spent on each category measured along with the time spent walking between areas was recorded. The amount of time that was spent delivering care in each category was compared. Twenty per cent of the time was spent in direct patient care (e.g. wound care, hygiene) more of which was carried out in the morning, 42% in indirect patient care (e.g. monitoring, pain management, laboratory tests), 31% administration activities and 8% cleaning (required by French legislation). This does not really equate to a workload tool but it did help the service identify areas where adjustments could be made to administrative activities and ward layout to optimise the efficiency of nursing care to meet the ND needs of the patients.

To quantify the amount of work allocation Ravat et al. (2014) used a patient classification system that they had developed 20 years ago but does not appear to be previously reported in the literature. Patients are assigned a classification with a score. The nurses are allocated a set of patients whose classification scores add up to 8, for example, either one unstable critically ill patient (score of 8) or one stable critically ill patient (score of 5) and three self-caring patients (score of 1 each). These categories, although at first glance appear similar to the WMSN categories (Rieder et al., 1985) in that they describe the type of patient (for example self-caring, continuous care, critical care), they are calculated using different activities and scoring system so a direct comparison cannot be performed. Ravat et al.'s (2014) classification system is also similar to the National Burn Care Review burn levels (National Burn Care Review Committee, 2001) which are discussed later, and Helmer et al.'s (1987) patient acuity classifications in that they describe the type of patient and the ratio of nurses for each category. However, Ravat et al. (2014) do not discuss how they came up with this ratio leaving the reader to assume that, like many other ND tools, it could be based on professional judgement. Thus again, as de Jong et al. (2009) observe, reducing the transferability to other burn services with any confidence.

The most recent article found in the literature regarding a ND tool for inpatients with a burn injury is from Sweden. Abdelrahman et al.'s (2018) study analyses the ND data recorded in their burn service's burn registry over 15 years. The ND tool they used in their unit was the Linköping 'Burn Score'. The 'Burn Score' had originally been adapted from the Swedish ICU nursing care recording system to include dressings and skin grafting in the early 1990s and validated against the TISS (Sjöberg et al., 2000). Their 'Burn Score' appears to have been mostly used for providing burn care costings according to what they have published rather than nursing workload explicitly.

The Linköping burn scoring system consists of seven categories (surveillance, ventilation, circulation, wound care, mobilisation, lab tests, infusions), each with five scoring levels, and an eighth category of operation that is scored depending on the length of the operation. The score for each category is then totalled up for an overall score for that patient that day. This is very similar to the way the iBID ND tool works. Three of the iBID ND total score sub-categories can be directly linked to the categories of the Swedish tool, but the iBID 'psychosocial support' category is the standout different category that does not equate to any of the Linköping 'Burn Score' categories.

Similar to iBID, the Linköping burn registry contains data on ND activities and burn severity such as size and cause of the burn. Abdelrahman et al. (2018) aimed to analyse the association between ND activities and burn severity to validate their burn score and identify the factors that resulted in higher scores/workload. At first glance, this seemed very similar to the research aims of this research study, which is to identify relationships between ND and burn severity and any that might predict burn ND. However, Abdelrahman et al. (2018) concentrated upon the cumulative scores to relate to the cost of a particular burn injury, which thus did not have the granularity to predict ND on a daily basis. It is not clear how this validates their burn score as they claim, unless they were assuming that there should be a correlation with increased burn size and workload.

Abdelrahman et al. (2018) used the mean cumulative burn scores over time to compare against the different factors. They found that the wound management and mobilisation categories made up the largest part of the score and that the proportions of each category that made up the score were different between those patients in ICU and those who were not. This is not surprising and is alluded to in much of the literature discussed here. They reported an association between the mean cumulative burn score and burn size, both in those that died and those that survived. With the cumulative burn score increasing for larger burns in those that survived, as would be expected, but the opposite for those that died. They also reported a difference in age and workload with those >45 years having a higher cumulative score. How this can help with daily nurse workload and staffing decisions is not clear.

Although, some comparisons may be able to be made with some of Abdelrahman et al.'s (2018) findings at a later stage; it must be remembered that the two scoring tools, although similar, are not exactly the same. Additionally, the healthcare systems in Sweden, although analogous in that they are publicly funded, are structured, and managed differently to the UK's NHS (Hauter, 2012) so the two sets of results will not be directly comparable.

3.4.7 Burn outpatient nurse dependency tools

The previous literature discussed has all related to the ND of acute burn inpatients. However, two of the articles considered workload in burn outpatient clinics; one from the UK (Perin et al., 2016) and the other from the USA (Swan-Mahony et al., 2018). Both articles highlighted the issue that the burn outpatient clinic workload had increased but staffing levels had not. Therefore, there was a need to measure patient acuity and improve nurse staffing in this area also. One of the reasons put forward for this was the change in inpatient demographics and earlier discharge from the wards (Swan-Mahony et al., 2018). This is similar to Harrison's (2004) observation that there was an increased acuity for inpatients which was then the driving factor for the initiation of the SNCT development.

Swan-Mahony et al. (2018) developed their 'Pediatric Ambulatory Acuity Tool' (PedAAT) using a combination of two ambulatory care acuity tools and tailored it to their Paediatric burn outpatient clinic patients and specific paediatric nursing interventions undertaken there. Although an age-appropriate tool for paediatrics, it was similar to the iBID ND tool as it consisted of several categories that made up a total acuity score that ranged from 7-24. The PedAAT takes the scoring one step further than the iBID ND tool by dividing the scores into 4 acuity levels. However, they do not explain how the different acuity levels relate to staffing numbers; only that staffing adjustments were made as a result of the tool.

Perin et al.'s (2016) study differed as their outpatient clinic was not in a separate area and the inpatients' and outpatients' responsibilities were shared by the staff on duty. This was true for both their paediatric and adult services. Consequently, an increase in workload for either inpatients or outpatients would have an impact on patient care. They collected data on inpatient and outpatient dressing activity and the number of nurses the National Burn Care Review (National Burn Care Review Committee, 2001) suggested they should have for the number and level of patients they had daily (as described in the B levels in Table 3.2). They identified that when a nurse was utilised in the outpatient department it frequently left the inpatient service understaffed and therefore concluded that the two should be staffed separately. Perin et al. (2016) argue that outpatient activity should be taken into account when setting nursing levels and identify that currently it is not mentioned in any guidelines for safe staffing, which is still true. This is probably because usually outpatient care and staffing are in a separate area to inpatient care. Also, possibly apart from dressings, the needs of outpatients and the nursing care required are different from inpatients where daily living activities and 24-hour needs must also be taken into account (Prescott and Soeken, 1996).

The different focus of nursing care for inpatients and outpatients means that different patients will have a different level of ND and different staffing levels will be required. Therefore, just as Swan-Mahoney (2018) submit that an inpatient ND tool may not be transferable to the outpatient setting, conversely an outpatient ND tool is not transferable to the inpatient setting.

3.4.8 The National Burn Care Review burn levels

As mentioned earlier Perin et al. (2016) mention staffing ratios outlined in the National Burn Care Review. The National Burn Care Review (2001), although it does not attempt to advocate a specific ND tool, does consider ward staffing; acknowledging a lack of validated ND scoring systems and arguing that staffing should be based on patient dependency rather than the number of beds. The Burn care review does recommend a crude, five level classification for the monitoring of patients with a burn injury (Table 3.2) which includes a nursing ratio indication. These burn levels (B levels) are loosely based on critical care guidance at the time and therefore have 3 levels related to critical care (Department of Health and Social Care, 2000; National Coordinating Group for Paediatric Intensive Care, 1997). They tend to be used to classify the level of burn bed needed or available. However, one burn service has developed these levels further to act as a guide to ND staffing levels required (Myers, 2009) and in essence created a non-validated prototype patient classification system based on patient monitoring requirements. Considering the earlier discussion about the importance of including wound management in a burn ND tool, it is noticeable that dressing time requirements were not explicitly included in their adaptation of the National Burn Care Review's levels of burn care. Albeit, they do highlight that procedures such as dressings may require a higher level of nurse allocation for some of the day. These B levels are also the descriptors used in the iBID ND tool monitoring category levels.

Table 3.2 The National Burn Care Review (National Burn Care Review Committee, 2001) burn care monitoring levels (B Levels) with suggested nurse: patient ratios

B Level	Descriptor
B1	Standard surgical ward monitoring Nurse: Patient Ratio 1:4
B2	High dependency care Nurse: Patient Ratio 1:2
B3	Intensive care Nurse: Patient Ratio 1:1
B4	Additional intensive care Nurse: Patient Ratio 1.5:1
B5	Complex intensive care Nurse: Patient Ratio 2:1

3.4.9 Burn nurse dependency tools summary

In summary, there are some burn care ND tools reported in the global literature but these have been designed for a specific unit and not necessarily transferable. The other tools that have been reportedly used with burn-injured inpatients have been designed predominantly for general ICUs. Therefore, they would not be suitable for burn wards as well as the burn ICUs.

None of the inpatient burn ND tools reported in the literature fully resemble the iBID ND tool, nor are they UK based. However, the elements that make up the iBID ND tool can be found to various degrees in the reported tools. Hence, suggesting that the iBID subcategories are relevant to burn ND and the iBID ND tool is likely to measure at least some aspects of ND. Even so, the literature did not reveal any burn ND tools or dependency measures that could be used to compare the iBID ND tool directly against. The nearest was the Linköping Burn Scoring system (Abdelrahman et al., 2018; Sjöberg et al., 2000) and although direct comparisons cannot be made, it may help to give some further insight into the results of this research. The similarity of the iBID ND tool to non-burn specific ND tools is explored in section 3.6.

Wound management seems to be a key theme in relation to burn ND. Apart from the earliest study (Helmer et al., 1987) all the other burn specific articles either have wound care as part of their burn ND tool or adapt them to take burn wound management into account. However, there is a debate as to whether the dressing size should be described according to TBSA or body part. Motler's (1990) is the only one that uses body parts. The iBID ND tool along with the other burn specific ND tools uses TBSA.

Having reviewed the literature on burn specific ND tools in this section, the next section examines the more generic inpatient ND tools and explores their similarity to the iBID ND tool.

3.5 Nurse Dependency Tools

A search of the literature yielded a plethora of ND tools with many different focuses and designs. The tools come from all around the world and related to many specialist areas. Nevertheless, despite there being many tools, no single ND tool appeared to dominate the literature and meet all the needs of the nursing workforce. Nor did anyone ND tool appear to be heralded as the gold standard. This suggests that the search for the ideal, reliable ND tool that meets the needs of all areas, if indeed one exists, continues. Although difficult to evidence, experienced nurses' professional clinical judgement on the wards still appears to be the measure to check the ND tools against in the absence of anything better (Griffiths et al., 2020a).

To establish how the iBID ND tool might compare, other ND tools were reviewed as potential comparators. Table 3.3 lists many of the tools identified in the literature relating to adult acute and critical care. It does not purport to be fully comprehensive but does contain the most widely reported ND tools and those that have the description of the tool included in the literature. The table does not include the commercially available computerised database tools such as GRASP (Mittmann et al., 2008) as these consisted of a list of activities or diagnosis groups so were not comparable to the iBID ND tool and were not available for review. Nor are individual hospital-specific computerized systems discussed in the literature included, as detailed descriptions were not available and would not easily be generalizable to other areas. In addition to listing the various ND tools Table 3.3 gives a brief description of the tool and highlights any similarities to the iBID ND tool.

The use of professional clinical judgement seemed to be key in the initial development of many of the ND tools, including the iBID ND tool. Following their development, ND tools were then validated in various ways to confirm their ease of use and time weightings. Most of the ND tools used a time sampling methodology to determine any time weightings that could be used to calculate the number of nurses required. The RAFAELA system (Fagerström et al., 2014) was the only one that used a scoring system that was calculated using the bedside nurses' perception of whether they had enough time to meet the care needs of their patients that shift, as opposed to measuring the time required for each activity. Supporting the argument, throughout the literature, that the clinical professional judgement of nurses is fundamental in the design and validation of ND tools and why to date no ND tool has been shown to be significantly better than the professional judgement of practising nurses in assessing the nursing workload (Edwardson and Giovannetti, 1994; Fasoli and Haddock, 2010; Griffiths et al., 2020b). Perhaps not surprising when one takes into consideration all the multi-dimensional aspects of nursing, multi-tasking, the different ward environments and layouts, the variability of patient needs even those with the same illness, the different skill levels of nurses and the lack of consensus on what staffing levels should be (Saville et al., 2019).

The fact that no ND tool appears to stand out as the perfect one, nor objectively any better than professional judgement, was one of the reasons Griffiths et al. (2020a) used the professional judgement of nurses as the 'gold standard' to determine whether there was adequate nurse staffing on shift when assessing the levels of nursing staff predicted by the SNCT. This methodology to validate a ND tool's predictive ability is also similar to the Professional Assessment of Optimal Nursing care Intensity Level (PAONCIL) element of the RAFAELA system that uses nurses' views on whether they had enough time to provide the care required.

Table 3.3 ND tools descriptions and their similarity to the iBID ND tool

Tool	**Country of origin**	**Date**	**Speciality**	**Description**	**Similar to iBID ND tool**	**Comments**
Telford Method (Telford, 1979)	UK	1970	All areas	Nurses' professional judgement is used to identify the number of nurses required per shift. This is can be converted into full-time equivalences to work out the ward staffing establishment	No.	It could be said that nurses' professional judgement is used to decide which iBID subcategory level is scored. It can be argued that this professional judgement method is not objective but professional judgement is often used to compare objective methods against.
Therapeutic Intervention Scoring System (TISS-28) (Miranda et al., 1996)	USA	1974 original TISS -76 was developed and then reduced to TISS-28 1996.	ICU	The original TISS was reduced to 28 items of therapeutic interventions. These are totalled up for each patient to give a total number of TISS points. Each point equates to 10.6 minutes of nursing time required	No	Does not take into consideration non-direct nursing activities. Has been tested, validated and benchmarked in various countries over the years

Tool	Country of origin	Date	Speciality	Description	Similar to iBID ND tool	Comments
Burn Unit Patient Classification System (Helmer, 1986) (Helmer et al., 1987)	USA	1985	Burn service	Patients are classified into five categories with criteria (critical and unstable, critical but stable, serious and stable, Fair and good). There are time standards that go with this classification, but these are not clearly reported in the literature.	No	However, the time study worksheet used to collect times was divided into six elements four of which resembled iBID categories: ADL, emotional support, mobility and procedures. The other two categories were discharge planning and escort.
Workload Management System for Nurses (WMSN) (Cunningham, 2018; Molter, 1990)	USA	1985 revised several times the latest documents in the literature 2018	Military hospital patients	A patient classification system that originally consisted of 6 categories ranging from self/minimal care to critical care that patients were assigned and indicated the number of nursing hours required for each category. The patients were assigned depending on the sum of the points weighting for the nursing care requirements related to nine indicators groups (vital signs, monitoring, ADL, feeding, procedures, intravenous therapy, teaching, emotional support and continuous care) Adapted to take into account burn dressing needs.	No	Categories are more detailed and specific than iBID although apart from 'mobility limitations' contain a reference to the other iBID ND tool sub-categories. The endpoint is a classification category rather than just a total score. The latest version of WMSN is a computerized tool.

Tool	Country of origin	Date	Speciality	Description	Similar to iBID ND tool	Comments
Oncology Acuity Tool (OAT) (Brennan et al., 2012)	USA	1985	Oncology inpatient	Consists of 10 dimensions (categories) which each have 4 levels of needs (0-3). Each dimension is scored and added together for a total score	No	Concept of categories with differing levels of scores totalled for a final total score. Similar to iBID ND tool there also does not appear to be a published weighting for the scores. However, the categories are very different although the OAT does have a psychosocial category.
Nottingham Patient Dependency System (Viney et al., 1997)	UK	1988 approx.	ICU	Consist of 9 dependency categories of need (respiratory needs, cardiovascular needs, neurological needs, pain control needs, elimination needs, non-physical needs, personal care needs, nutrition needs, mobility needs) with 4 levels in each. Patients are scored for each and totalled. This enabled the patients to be assigned to one of 9 dependency groups.	No	The patients and families psychosocial needs are recognized in the non-physical needs group. Mobility is the only other explicit group that links to iBID. Only mentioned in one article found. Talking to colleagues in Nottingham they are not aware of this ND tool being used now.

Tool	Country of origin	Date	Speciality	Description	Similar to iBID ND tool	Comments
National Aeronautics and Space Administration Task Load Index (NASA-TLX) Tubbs-Cooley et al. (2018)	USA	1986 Originally developed	Adult and paediatric ICU	Although not originally designed for nursing the NASA-TLX has been used as a ND tool aimed at assessing the subjective workload of individuals and tasks in nursing. The original NASA version had 6 categories (mental demand, physical demand, temporal demand, performance, effort, frustration) which were each given a score between 1 and 20. The summed total then gave an unweighted score. Tubbs-Cooley et al. (2018) suggest that just using mental demand, physical demand, temporal demand, performance and effort is simpler and reliable for assessing workload. There is no time weighting given to this score However there was a weighting given to the original scale (Hart, 2006)	No	

Tool	Country of origin	Date	Speciality	Description	Similar to iBID ND tool	Comments
Linköping Burn Score (Abdelrahman et al., 2018)	Sweden	1992	Burn ICU	Has 8 care categories (surveillance, respiration, circulation, wound care, mobilization, laboratory testing, infusions, and operation). For each category, the patient is given a score between 0-4 daily, apart from the operation category where 2 points are given for each hour of operating time. These are then totalled up to give a total score.	No	There are different categories with scores assigned similar to iBID. Three categories are similar to iBID (wound care, mobilization and surveillance) but the descriptors in each are different. Initially designed to calculate the cost of care. Based on TISS and validated against TISS.
Workload Calculation Score (Ravat et al., 2014)	France	1994	Burns service	Patients are assigned to one of 4 categories (critically ill unstable or ICU, critically ill stable, patient cannot meet their needs, self-caring). Each category is allocated a set number of points that enables the number of required nurses to be calculated	No	The categories are based on patient acuity/self-care needs only. According to the authors, this workload calculation score has been upgraded regularly

Tool	Country of origin	Date	Speciality	Description	Similar to iBID ND tool	Comments
Critical Care Patient Dependency System (CCPD) (Donoghue et al., 2001)	Australia	1993	ICU	Each patient is given a score for each of the seven activity groupings (1- hygiene, mobility, wound care; 2- fluid therapy, intake, elimination; 3- drugs, nutrition; 4- respiratory care; 5- observations, monitoring, emergency treatment; 6- mental health care, emotional support, education; 7- admission, discharge, death, escort). The number of available points in each activity grouping ranges from 3 to 5. The total score will then determine which of the 4 patient classification category the patient fits into and the amount of nursing time required.	No	However, the CCPD activity groupings do explicitly include 4 of the 5 iBID ND tool categories with the 'ADL' category being implicitly included.

Tool	Country of origin	Date	Speciality	Description	Similar to iBID ND tool	Comments
Oulu Patient Classification System (OPC) (Fagerström, 2000)	Finland	1995	All areas	This ND tool is based on 6 areas of patient needs (planning and coordination of care; breathing, blood circulation and symptoms of disease; nutrition and medication; personal hygiene and secretion; activity/movement, sleep and rest; teaching, guidance in care/follow-up care and emotional support). Each area is allocated an intensity score ranging from 1-4. The total score then indicates which category the patient is in (Category I - minimal need for care, category II- average need for care, category III - more than average need for care, and category IV- maximal need for care). Weight coefficients assigned to each category	No	The classification of caring needs is supported by a manual describing the needs in more detail

Tool	Country of origin	Date	Speciality	Description	Similar to iBID ND tool	Comments
RAFAELA system (Rauhala and Fagerström, 2004)	Finland	Late 1990s and has been regularly refined since		Consists of three parts – daily measurement of the nursing care intensity using OPC and daily nursing resources which gives a measure of nursing intensity per nurse. This is compared to the optimal nursing care intensity for the ward calculated using the Professional Assessment of Optimal Nursing Care Intensity Level (PAONCIL) rather than the traditional time assessment measure. With the PAONCIL method nurses score the extent they were able to meet the caring needs of their allocated patients that shift, on a scale of -3 to 3 with 0, being the optimal. Multiple regression is then used to find the optimal level for that ward over a baseline period of time. This can be repeated if needs change or on an agreed regular basis.	No	A triangulation method that is more detailed than many of the other ND tools. Uses Professional judgement to set the optimal level of nurse staffing.

Tool	Country of origin	Date	Speciality	Description	Similar to iBID ND tool	Comments
Nine Equivalents of Nursing Manpower (NEMS) (Miranda et al., 1997)	The Netherlands	1996	ICU	The TISS-28 items were amalgamated into 9 items with allocated points weighting	No	Simpler than TISS-28 but may not be as discriminatory in identifying staffing numbers
Perroca's Patient Classification System (Perroca, 2011)	Brazil	late 1990's and revised 2010	Acute inpatient and ICU	Originally had 13 care areas which were reduced to 9 (care process planning, monitoring and investigations, hygiene and elimination, skin integrity, nutrition and hydration, activity, therapeutics, emotional support, health education) when the system was revised. Each care area has a score range from 1 to 4. When these scores were totalled up patients were then classified into one of 4 categories (minimum, intermediate, semi-intensive and intensive care) depending on the total points scored.	No	Some similarity in the methodology to get a total score. However, there are more care areas than the iBID ND tool. Also, the iBID ND tool does not classify patients into groups with the total score.

Tool	Country of origin	Date	Speciality	Description	Similar to iBID ND tool	Comments
Fugulin Patient Classification System (Fugulin et al., 2012; Nobre et al., 2017)	Brazil	2002	All areas	Consists of nine areas of care (mental state, oxygenation, vital signs, feeding, motility, ambulation, body care, elimination, therapeutics). Each area receives a score of 1 to 4. The sum of these areas of care then corresponds to one of 5 categories of increasing complexity of the patient's care (minimal, intermediate, high-dependency, semi-intensive and intensive care).	No	Some similarity in the methodology to get a total score. However, there are more care areas than the iBID ND tool. Also, the iBID ND tool does not classify patients into groups with the total score
Nursing Activity Score (NAS) (Miranda et al., 2003)	The Netherland but was validated in 15 countries	2003 Has been tested and validated in various countries over the years	ICU. However, it has also been used in non-ICU settings (Panunto and Guirardello, 2009)	Developed from the TISS-28 and added additional nursing interventions/activities that were not included in TISS. A time weight for the final 22 items was calculated. A score is calculated for each patient and indicates the proportion of time required in the 24-hour period. A score of 100 indicates 1 nurse per shift around the clock is required	No .	NAS is essentially a list of activities rather than categories with different levels. It does have a couple of categories with different intensity levels. 'Hygiene procedures' is one of them and includes wound care. It takes into account the time the procedure took

Tool	Country of origin	Date	Speciality	Description	Similar to iBID ND tool	Comments
Comprehensive Nursing Intervention Score (CNIS) (Yamase, 2003)	Japan	2003	ICU	This ND tool scores not only the time needed for nursing activities but also the number of nurses required for the activity, job intensity, muscular exertion, mental stress and specialist skills giving a total CNIS score for each of their 73 activities which are assigned to 8 categories.	No.	There are two specific burn-related items 'management using burn bed' and 'burn dressing changes'. The burn dressing changes has one of the highest scores with only open chest CPR and emergency procedures scoring higher. Some of the additional categories are similar to the NASA-TDX categories.
Safer Nursing Care Tool (SNCT) (The Shelford Group, 2014)	UK	2004 revised 2012, 2014	Inpatient acute care	Has 4 levels of care and the patient is allocated to one. There are descriptors for each level and a staff weighting	No	There are more descriptors than with iBID but the variant of workload in them such as wound dressing is less. NICE endorsed and used widely in the UK

Tool	Country of origin	Date	Speciality	Description	Similar to iBID ND tool	Comments
Chinese Nursing Interventions in Intensive Care Unit Instrument. (Chou et al., 2007)	China	2006	ICU	This tool is based on medical and nursing activities organized into 12 categories with a total of 86 items. Is not clear how the scores were utilised.	No	Has a clinical reference handbook with operational definitions
Nursing Workload Measurement Instrument in burn care. (de Jong et al., 2009)	Netherlands	2009	Burns service	Comprised of a list of intensive care and non-intensive care activities with time standards. These are summed up for each patient and used to assign a care category to the patient. There were 5 care categories with the top 3 being related to intensive care	No	Designed specifically for one burn unit. No longer used due to the work required to update the time weighting

Tool	Country of origin	Date	Speciality	Description	Similar to iBID ND tool	Comments
Workload Intensity Measurement System (WIMS) (Hoi et al., 2010)	Singapore	2010	Acute care wards	Uses Neuman's conceptual nursing practice model (Snowden et al., 2010) as the theoretical framework for this ND tool. 10 'nursing diagnoses' were identified that added to the calculated nursing time required for each speciality. It is acknowledged that the WIMS would be limited to the observed environment and would need revisiting if any changes	No	The specialities did not include burns and were time specific to the study areas. Unclear why some of the 'nursing diagnoses' did not potentially apply to all areas such as mobility impaired.
Medical-Surgical Patient Acuity Tool (Chiulli et al., 2014)	USA	2011	Medical and surgical inpatient wards	Consists of 10 categories related to patient severity and nursing workload. Each category has three levels (stable patient typical workload, Complex patient increased workload, High risk highest workload). Each patient is given an acuity rating of 2, 3 or 4 depending on the highest level ticked. These acuity levels were used to balance assignments and identify staffing numbers	No	Some similar categories such as ADL, psychosocial and wound. Interestingly their wound classification would immediately put a burn patient into the level 4 highest workload acuity as most dressings would take over 30 minutes

Tool	Country of origin	Date	Speciality	Description	Similar to iBID ND tool	Comments
Synergy Model (Khor 2012)	USA	2012	Acute and critical care	Takes into consideration patient and family characteristics that will affect patients' needs and nursing care required. It defines 8 patient dimensions (stability, complexity, predictability, resiliency, vulnerability, participation in care, participation in decision making and resource availability).	No	
Clinical Activity Monitoring System (Guo et al., 2016)	New Zealand	2015	ICU	Aims to non-invasively track nursing interventions at the bedside using motion-sensing equipment and software to identify patterns related to different interventions	No	Only tracks direct interventions at the bedside. Not translated into a ND tool

Tool	Country of origin	Date	Speciality	Description	Similar to iBID ND tool	Comments
The Critical Patient Severity Classification System (Oh and Seo, 2008)	South Korea	1994	ICU	Consists of 8 areas of nursing (vital sign measurement, monitoring, ADL, feeding, IV therapy and medication, treatments and procedures, respiratory therapy, teaching and emotional) which contain a list of items each having a score. The total score for all the items enables the patient to be assigned to one of 6 classification categories with category 6 being the highest severity category. Not clear how this scoring was then related to nursing workload	No	Although some of the categories appeared similar the items and scoring within them were not
Korean patient classification system (Ko et al., 2021)	South Korea	2018	General wards	Consists of 8 domains (symptom management, infection control, nutrition and medication, personal hygiene and secretion, activity/sleep, guidance in nursing/emotional support, nursing activity planning and coordination, indirect activities) which contained various nursing activities and criteria. The nursing intensity for each is scored taking into account the patient characteristics.	No	Designed to include indirect as well as direct nursing activities. Appears to have been designed to incorporate costing related to nursing intensity.

Tool	Country of origin	Date	Speciality	Description	Similar to iBID ND tool	Comments
Nursing hours per patient day (NHPPD). Twigg (2009)	Western Australia	2002	All areas	Seven ward type categories were identified along with how many nursing hours would be required for each patient in that ward to set the establishment.	No	

Although there have been many different ND tools developed over the last fifty years, the majority can be apportioned into three fundamental model types:

- A long list of individual activities/interventions that the patient is compared against to give an idea of the nursing time required (such as TISS and NAS). For some of the ND tools that fall into this model type, the final activities score is then allocated to a final grouping for staffing levels (such as Nursing Workload Measurement Instrument in burn care and CNIS)
- A shortlist of grouped categories that the patient is given a score for each category that is totalled for a final score (such as NASA-TLX, OAT and iBID). For some of the ND tools in this model, the combined category score is then used to indicate the level of nursing care required group they subsequently go into (such as Medical Surgical Patient Acuity Tool and OPC).
- A small number of descriptive groups and the patient is assigned to one (such as SNCT and the workload calculation Score).

None of the ND tools were fully comparable with the iBID ND tool. However, several of the tools used a category scoring model similar in methodology to the iBID ND tool but with different individual categories and levels. Although no ND tool was made up with exactly the same categories as the iBID ND tool, the iBID ND tool categories were all found in some form throughout the various ND tools suggesting that the categories used in iBID are relevant to ND. It was also noted that the psychosocial category was not present in all of the ND tools and for several where it was listed it was combined with patient education.

3.6 Safer Nursing Care Tool

There appears to be a dearth of validated UK ND tools for acute inpatient ward care in the literature. The most predominately used ND tool in the UK is the SNCT (Ball et al., 2019) despite there being limited published evidence for its validity and reliability and until recently little evaluation of the tool other than that published by the authors (Griffiths et al., 2020a) which could be argued lacks impartiality. The reason for the wide use of the SNCT is likely to be threefold. Firstly, it is one of the few tools that have been developed in the UK using research linked to UK nursing activity times. Secondly, Directors of Nursing from large university hospitals were involved in the development of the SNCT. Thirdly, an even more compelling reason, is that it is the only staffing decision support tool kit for acute care endorsed by NICE (2014) and as such it was chosen to compare the iBID ND tool against for validity.

The SNCT was designed to help calculate safe nurse staffing levels (Fenton and Casey, 2015) and has been developed over many years. The first version started from work done at Southampton University Hospitals NHS Trust (SUHT) following the recognition that ward care acuity was increasing (Harrison, 2004; Hurst et al., 2008). The SUHT team took the Intensive Care Society's level of care classifications (Intesive Care Society, 2002) and further divided the level one category, which was for patients whose care could be delivered in a ward setting but required more care, into two. 1a patients with an increased acuity and 1b patients with an increased dependency, as summarised in Table 3.3, in order for it to become relevant to medical and surgical wards as well as high dependency and critical care (Harrison, 2004).

Table 3.3 Southampton University Hospitals NHS Trust acuity and dependency measurement tool summary. (Adapted from Harrison, 2004: 22)

Level	**Care descriptor**
0	Patient requires hospitalisation but needs are met through normal ward care
1a	Patient is in stable condition but with increase acuity or potential to deteriorate. Should be managed on wards with appropriate staffing levels, skill mix and equipment.
1b	Patients who require intensive therapy or nursing input that demands more than baseline resources allow.
2	These patients are unstable and at risk of deteriorating. Should not be cared for in areas currently resourced as general wards
3	Patients needing advanced respiratory support or monitoring and therapeutic intervention to multiple organs.

Harrison (2004) acknowledges that the tool was not fully evidence-based and is open to interpretation, as is any dependency scoring tool. However, it was designed to be simple and used instinctively by experienced staff to capture acuity and dependency. This is similar to the development of the iBID ND tool in its aim.

SUHT recognised that the next step to develop the tool further was to work out the whole time equivalent (WTE) staffing requirements for all levels of care. This work was taken forward by the University Teaching Hospitals Executive Nurse forum (Harrison, 2004) and the Association of UK University Hospitals (AUKUH). Workload multipliers were developed and the tool became known as the AUKUH workload assessment instrument. As these multipliers were initially calculated using professional judgement, a project group was then set up to test and validate them independently (Hurst et al., 2008; Smith et al., 2009). First, a literature search was undertaken and the AUKUH multipliers adjusted in light of this before comparing the AUKUH workload assessment instrument against the Leeds University Acuity-Quality staffing System (Hurst et al., 2008) of which there is very little publicly available information on. This was achieved in 3 ways

- 30 postgraduate students assessed a case study using both instruments. The authors suggested that the resultant Cronbach's alpha score of 0.99 demonstrated good agreement between the instruments and scorers. However, Cronbach alpha is a measurement of the internal consistency (reliability) of a scale (Field, 2018), so it is not clear how this demonstrates inter-rater reliability (Griffiths et al., 2020_a). Notwithstanding, Griffiths et al. (2020_a) found that the SNCT could be completed with a high degree of inter-rater reliability.
- In three hospitals, ward nurses scored patients using both instruments for a month and the results analysed using the Spearman correlation test. The authors concluded that as the results fell and rose in line with each other the AUKUH instrument was valid and reliable. This is a reasonable process to check for validity and is the method used in this research to compare the SNCT with the iBID ND tool.

- The multipliers were compared and adjusted against a previously collected ND data set, the Leeds University Acuity-Quality database of quality-assured wards (Hurst, 2003) using calculations for both direct and indirect care and an extra amount for annual leave and other leave. However, there is little published data on the Leeds University Acuity-Quality database to judge the suitability and reliability of its use.

The subsequent validated instrument was piloted in six hospitals for a two year period and information about patient flow and staffing numbers collected. They also collected retrospective information on nurse-sensitive indicators (NSI) for each site. In an attempt to link workload planning to service quality the AUKUH developers suggest the linking of the calculated staffing levels to NSI's, such as the number of complaints, patient falls and medication errors as a way to assess the quality (Smith et al., 2009).

In 2012, the Shelford group commissioned a review and update of what is now called the Safer Nursing Care Tool (The Shelford Group, 2014). This updated version took into consideration the profile changes in hospital inpatients such as an ageing population, shorter patient stays and new roles although they do not say how they did this and the effect. The authors discuss using a UK database but do not expand on what this database is. The multipliers in this third model have all gone down from the original except for level 0 which has increased. This may be due to the increased bed turnover and ageing population although this is not discussed in the literature. The sceptical might suggest that the multipliers have been reduced to make the figures more palatable to managers and finance staff. Nonetheless, if the tool is to be used in conjunction with other measures that might influence nursing workload locally such as staff capacity and capability, ward layout and NSIs, it could be argued that the SNCT is the best UK evidence-based dependency tool that we have and it is a good starting point. A viewpoint reflected partly in the motivation for Griffiths et al.'s (2020_a) recent observational study on the use of the SNCT as a guide to nursing requirements on hospital wards.

The SNCT was not originally designed to be used on a daily basis to predict staffing numbers but to be used for a minimum of 20 days, twice a year to help calculate the proposed ward establishment (The Shelford Group, 2014). However, Griffiths et al. (2020a) found that a much larger sample was required to estimate the average staffing requirements. In reality, many areas are looking for a daily predictor for ND, so consequently, some trusts have started to use the SNCT daily which it was not validated for. This has caused the developers concern over the accuracy of the tool when used in this way or when the tool has been adapted to meet the perceived needs of individual areas. Therefore, a training programme for the use of the SNCT has now been developed (Merrifield, 2018) and additionally further development is ongoing to adapt the multipliers to provide care hours per patient day (CHPPD) (The Shelford Group, 2019).

In their study, exploring the use and effectiveness of the SNCT, Griffiths et al. (2020a) compared the number of staff the daily SNCT scores suggested were needed with the number of staff on duty. Additionally, they sought the professional judgement of the nurses in charge on their perceptions of the staffing levels and whether any care was missed. They found that there was less chance of the nurses reporting enough staff for quality care and a higher chance of them reporting missed care when the staffing numbers were lower than suggested by the SNCT. Interestingly Griffiths et al. (2020a) did not find evidence to suggest that the calculated SNCT staffing was the ideal nurse staffing threshold. Nevertheless, they did suggest that although the SNCT may not include all factors that influence staffing levels, their research gave some indication of validity for the SNCT in regards to being associated with professional judgement of staffing adequacy. Following on from these findings Griffiths et al. (2020a) did some simulation modelling on the cost-effectiveness of different approaches to using the SNCT to set nurse staffing numbers. They found that setting staffing numbers to meet the staffing demand observed for 90% of the time may be more expensive but could be more cost-effective because the setting of lower nurse staffing establishments and using temporary staff led to a higher mortality risk.

Overall Griffiths et al. (2020a) did not find that the SNCT had superiority over professional judgement which they suggest may be the gold standard. Nonetheless, the use of a tool like SNCT can be a starting point to setting nursing establishments and used alongside professional judgment may help give some support to the nurse in charge's staffing requests. The use of ND tools alongside professional clinical judgement to identify staffing needs is a common theme that has occurred throughout the ND literature. This is perhaps predictable as nursing workload and patient needs are multi-faceted. It is therefore difficult to capture all aspects and allow for different environmental and speciality variations in a unidimensional tool, leading to a need for experienced professional judgement to sense check the outcome of any ND tool.

Although the SNCT was designed to be used across specialities, one of the criticisms is that it does not necessarily take into consideration some factors specific to a speciality. For example, the impact of large, complicated dressings in burn care that can take a couple of nurses several hours or the increased psychological support required for these patients. The SNCT also does not appear to take into account an accumulation of the workload if a patient meets many of the care descriptors in a level as may be the case with some patients with a burn injury. However, it has been recognised that there are some areas that a different validated model is required and to that end, a version of the multipliers have been worked out for acute assessment units, children and young people inpatient wards and mental health (The Shelford Group, 2019) with a plan for one for accident and emergency departments (Fenton and Casey, 2015). Significantly, Griffiths et al. (2020a) excluded specialist wards from their original study into the SNCT on the basis of having atypical staffing, acknowledging that the SNCT may not be able to predict staffing levels for these areas. However, they did find that surgical wards compared to medical wards were less likely to perceive adequate staffing, as were areas with a higher proportion of single rooms, which would be the case for most burn services. In a subsequent analysis of the data they collected, Saville and Griffiths (2021b) examined possible reasons for a 'poor fit' when the staffing requirements did not match those estimated by the SNCT. Some of the potential reasons hypothesized for the 'poor fit' were high levels of 1-1 specialing, small ward size, speciality wards and older patients. All of which could be associated with burn services.

In summary, reviewing the literature on the SNCT has shown that the majority of the articles are from the developers of the tool discussing its development or the reporting of its development and potential to help with staffing issues in the nursing press. A couple of articles report the use of the SNCT as a tool to measure nursing workload for other research (Blignaut et al., 2017; Rivera, 2017) or to investigate the suitability of the use of the SNCT in other areas such as district nursing (Kirby and Hurst, 2014), care homes (Mitchell et al., 2017) and most recently for use in a Canadian hospital (Caron et al., 2021). There are no articles prior to the Griffiths et al. (2020_a) study on its effectiveness. That appears to be the case for many ND tools, in that the tools development and use as part of research studies are recounted but little evaluation of their effectiveness in practice.

Although the SNCT was not burn specific and did not contain the same dependency grouping, it is the most widely used ND tool in the UK and the only one endorsed by NICE (NICE, 2014). Even though the content of the tools could not be compared directly the ND trends could. For example, did the iBID ND total score go up when the SNCT score did? Therefore, in the absence of an alternative, accessible and suitable international burn ND tool the SNCT was considered the best tool for comparison against the iBID ND tool.

3.7 Summary

This literature review has shown a plethora of ND tools developed over time and only those that are repeatedly refined and updated standing the test of time. Despite the many ND tools reported in the literature only a few relate specifically to burn care and the majority of these have themselves been adapted from another ND tool to make them more applicable to burn care. Even the ones that have been specifically designed for use in a burn service from scratch, such as De Jong et al.'s (2009) Nursing Workload Measurement Instrument in burn care, are designed specifically to the area they were developed in and not easily generalized. None of the ND tools mirror the iBID ND tool although the elements of the iBID ND tool are included in the other ND tools to various degrees. Thus, suggesting that the iBID ND tool does measure aspects that are relevant to ND.

One aspect of burn care that has been shown to be important in burn ND tools is wound care. This was seen to be a crucial factor in adapting other ND tools for use in burn care and was an explicit component in the majority of burn ND tools. Even the more generic tools that purported to be for multiple specialities, including burns had an increased wound care option (for example the NAS and CNIS) that increased the ND requirements.

One central theme that has emerged from this literature review is the importance of nurses' professional clinical judgement both in developing the ND tools and validating them. No ND tool has emerged as the 'gold standard' tool for predicting ND, probably due to the many factors that affect ND and because no optimum staffing level has been agreed upon. Moreover, there is no evidence in the literature that suggests any ND tool is superior to professional judgement. Indeed, more than once the literature has pointed to the use of a combination of an objective ND tool and professional judgment which may well give the best outcome.

Following on from this literature review chapter four will outline the research methodology used in this research to answer the research questions.

Chapter 4 Research Methodology

4.1 Introduction

This chapter will recap the research aims and objectives before giving an outline of the study design. The research methodology decision making and choices are presented in detail. The first part of the research, comparing the iBID nurse dependency tool with the SNCT and assessing the inter-rater reliability of the nurses undertaking the ND scoring, is set out in Section 4.3. The results of which are given in chapter five. The second part of the research, Section 4.4, gives a synopsis of how the iBID sample was explored before going on to explain in Section 4.5 some of the statistical terminology and an overview of the statistical methods used. This will be built upon in chapter six, where the results of the sample analysis are given and the reader is guided through the analysis in more detail. The research methodology for part three of the research, where data from the whole database is analysed is given in section 4.6. The chapter then concludes with a discussion of the ethical considerations in relation to this study (section 4.7) along with the ethical approval process undertaken.

4.2 Research Design Framework

4.2.1 Aim

As discussed in the first two chapters, the iBID database has been collecting information about ND in burn care for several years now. However, it has never been analysed to discover if any of the information can be used in practice to inform managers about the nursing workload of patients with a burn injury or whether it could be used to predict or pre-determine ND of patients with a burn injury. As little information was known about the ND of the burn-injured patient population, in particular the ND data held in iBID, an inductive research approach was initially envisaged. Subsequently the aim of this research was;

> To explore the nurse dependency data contained within iBID; to gain an increased understanding of nurse dependency in relation to burn injuries and to assess if iBID contained information that could be used to predict nurse dependency of acute burn inpatients and help with nursing staff planning.

Following a preliminary examination of the data and discussion with the Clinical Director of iBID, two issues became apparent. Firstly, there was an overwhelming number of possible variables that could be explored. Secondly, that the ND scoring system within iBID had never been checked for validity as a dependency scoring tool. This made it difficult to use a purely inductive approach. Therefore, a more reductive approach, to identify salient variables and to assess whether the iBID ND tool did measure ND, was required. The specific research objectives and research questions consequently formulated are outlined below.

4.2.2 Objectives

1. Evaluate the quality of the nurse dependency data in iBID.
2. Establish whether the iBID nurse dependency tool did indeed measure nurse dependency.
3. Analyse the nurse dependency data from iBID to ascertain if
    - any relationships between nurse dependency and burn severity existed.
    - a predictive model for burn nurse dependency could be derived from the data.

4.2.3 Research questions

1. Does the iBID nurse dependency tool actually measure nurse dependency?
2. Do burn nurses score nurse dependency consistently?
3. Which burn severity/demographic variables show signals of a relationship with the iBID nurse dependency scores?
4. Can the iBID nurse dependency scores be predicted for adult inpatients with acute burns?

4.2.4 Study design

As discussed in chapter one, in line with the researcher's pragmatic values a quantitative design was deemed the most appropriate for this piece of research. There is very little literature on ND and ND tools in burn care as discussed in chapter three. This lack of previous research on ND in burns meant that an 'experimental' design was not feasible as there were no established parameters to test against. Thus, as no interventions would be carried out, an 'observational' design was the most appropriate method to explore the iBID data. Grounded theory was briefly considered as a research methodology as little is known about what relationships exist and the intention was to develop a deeper understanding through exploration of the data (Holloway and Galvin, 2015; Lingard et al., 2008). However, this was rejected as the aim was not to generate a theory for a better understanding of the phenomenon but to use the information gained from the data analysis to develop a predictive model. Furthermore, the tandem approach of data collection and analysis in grounded theory (Holloway and Galvin, 2015) does not fit with the analysis of existing data; as pre-conceived ideas and theories already exist and only variables that may have a plausible association with ND of patients with a burn injury were considered (Hill, 1965). Additionally, as the iBID ND data was reviewed it became apparent that a more reductive approach would be required to answer specific research questions.

To achieve the research objectives and answer the research questions, this observational exploratory research study was undertaken in three parts as shown in Figure 4.1. Part one links to objective two and aimed to confirm whether the iBID nurse dependency tool did measure nurse dependency and whether there was good inter-rater reliability between nurses in scoring nurse dependency, therefore addressing the first two research questions. Part two was an exploratory analysis of a sample extracted from an existing database, iBID. The aim was to evaluate the data available and to identify if any predictive relationships between nurse dependency and burn severity existed. This part was linked to objectives one and three and was intended to start answering research questions three and four. Following the findings from parts one and two, part three tested any hypothesis generated on the whole iBID database and cross-validated the regression models developed thus confirming the outcomes and answers to the research questions.

Alongside part one and part two of this study a quality evaluation of the iBID data was undertaken using the PARENT quality dimensions framework (Zaletel and Kralj, 2015). This narrative evaluation addressed objective one of this research (to evaluate the quality of the nurse dependency data in iBID) and is discussed in detail in chapter 7.

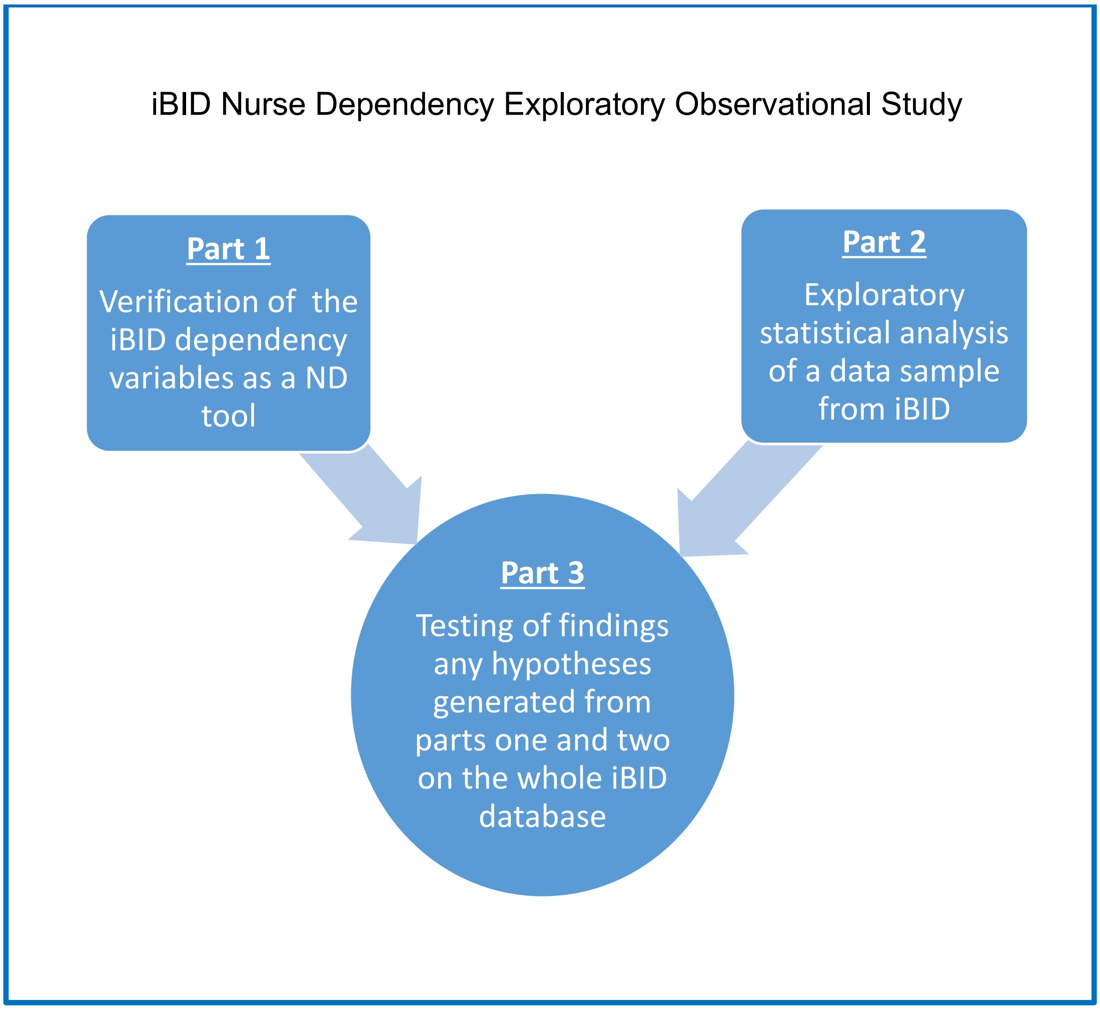


Figure 4.1 Exploratory Observational research study of iBID Nurse Dependency data research design

Having explained the research questions, aims and objectives and how they will be met through the research design, the following sections will expand on the methodology for each part in more detail.

4.3 Part One Methodology – Verification of the iBID Dependency Variables as a Nurse Dependency Tool

The iBID nurse dependency score was originally devised from the professional clinical judgement of senior burn nurses on what they thought would identify burn patient acuity. However, it has never been tested for validity, in other words did it actually measure nurse dependency? Therefore, before any conclusions from the iBID sample could be drawn it was necessary to verify that it did measure nurse dependency. Part one of the research was designed to answer this, thus addressing objective two.

To test the validity of the iBID nurse dependency tool it was compared against a recognised and validated nurse dependency tool. The SNCT was chosen because it is a recognised and widely used UK nurse dependency tool (Ball et al., 2019). It was one of the few nurse dependency tools that has been validated in the UK and furthermore it was the only nurse dependency tool that had been endorsed by NICE for acute care (NICE, 2014).

In addition to assessing whether the iBID ND total was able to measure dependency, it was important to establish what degree of consistency and reliability there was among the nurses in scoring their patients' dependency (inter-rater reliability) in order to help understand the potential reliability of the iBID dependency data. That is whether the nurses would consistently score similar patients the same with the two ND tools. Thus, answering the second research question; do burn nurses score nurse dependency consistently? A detailed explanation of the methodology for this part of the study, along with the results, can be found in chapter five.

The sections below expand on the research methodology for this aspect of the study, comparing the SCNT and iBID nurse dependency tool as well as assessing the inter-rater reliability of the participants. It will discuss where this part of the research took place, how the participants were selected and consented, the design and implementation of the data collection and how the data was analysed.

4.3.1 Study setting

The study took place in three adult burn services in England. They were chosen for the following reasons:

- They were all classed as ‘burn centres’, as described in section 2.23, and therefore admitted burns of all sizes leading to the likelihood of a range of ND scores.
- They all submitted data to iBID as part of their normal practice. Therefore the collection of the iBID ND data would not increase the nurse's workload.
- They came from different Burns Operational Delivery Networks in England and thus represented three of the four England and Wales burn networks.
- Two of the services periodically collected ND data using the SNCT for their trust so the nurses would be familiar with the process. The third had not been using the SNCT but following this study continued to collect nurse dependency data locally using the SNCT at their trust’s request.

Although all three burn services were burn centres, their set up and bed numbers differed. Service A cared for ICU, HDU and ward level patients on the same unit. They had 12 beds in total, two of which were designated burn ICU beds. Service B had 15 beds that would cater for ward and HDU level patients but their burn ICU patients were nursed in the hospital’s general ICU. Service C was divided up into a six bedded burns ward and eight bedded burns ICU. While it was anticipated that for service B the nurses would not be scoring any ICU patients it was originally expected to get a mixture of ward, HDU and ICU patients from the other two services to give a range of patient acuity and ND scores.

4.3.2 Participants and consent

The participants were all the senior nurses (bands 6 and 7) that had agreed to participate in the research; scoring their burn patients' dependency over a two-week period and scoring the fictitious burn case study patients. While all registered nurses on duty at the time of the research could have been eligible to participate if they wished, it was agreed in conjunction with the ward managers to only ask the nurses who would routinely fill in the nurse dependency scores as part of their normal practice and would already have an understanding of nurse dependency scoring. This meant that in practice only band 6 and band 7 nurses were asked to participate.

Prior to the start of the study, the researcher visited the three burn services in person to explain the purpose of the study and the process of data collection. Information about the study and consent forms (which can be found in Appendix C) were left with the service. The ward manager or research nurse, who had been nominated by the service to be the research coordinator for the study, explained the study to those who were not present and gave them a participant information sheet and consent form. Potential participants were informed that they could choose to participate or not throughout the study but that once data had been recorded it would not be possible to remove their input as all data was recorded anonymously and it would not be possible to identify individuals. It was also explained to the potential participants that, although unlikely, if any unsafe practice was identified during the study the researcher would have a duty to report it to the ward manager. However, this could only be reported in general terms as participants could not be identified individually.

The potential participants were given the opportunity to ask questions at the time and also after they had time to reflect on the study via email or phone. A few questions were asked via the local research coordinators clarifying a few aspects of completing the forms. For example confirming that the scoring was not required if the patient was on home leave. One participant asked why the consent forms were numbered which enabled reassurance to be given that this was for research administration and not linked to the data collection sheets nor case studies, so anonymity was maintained.

The completed written consent forms of the nursing staff agreeing to participate were collected by the local research coordinator and then sent to the researcher or in the case of the local hospital collected by the researcher. Once the researcher had received the completed consent forms these were stored in a sealed envelope in a locked cabinet in line with Birmingham City University (BCU)'s storage of data policy (Foster, 2018).

4.3.3 Data collection

This section explains how the data was collected for the comparison of the two tools, inter-rater reliability assessment and post data collection survey.

Each service operated differently in how they normally collected the required data for iBID. In one service the nurses completed a form daily whereas for another the data clerk collected information during a ward round. Therefore, for each service, it was discussed and agreed with the local research coordinators the best way for that service to collect the information required for this study. It transpired that for all the services the nurses used a scoring sheet that was then collected by the data clerk and inputted into iBID.

The timing of the data collection period was negotiated with the services once approval had been given by Health Research Authority (HRA) and their local research departments. The timing was governed by how quickly the consents were obtained and the local coordinators' availability. Service A started the month after permission from HRA was gained and Service B a month later. Service C did not start their actual data collection till 8 months later due to a combination of delay in getting consent, sick leave and the busyness of the service. Further details of how the data was collected for this part of the research study is given in the sections below.

4.3.3.1 Daily iBID and SNCT scores

This part of the study consisted of a two-week period where the SNCT score was collected alongside the routinely collected iBID ND scores, on a daily basis by the participating burn services, for each burn in-patient. The highest dependency score for the day was recorded for each patient late afternoon or early evening. If new admissions arrived before the dependency scores were recorded, they were included for that day otherwise they were scored the following day.

A two-week period was agreed upon as this was not seen as too onerous by the nurses. More importantly, it was expected that this would give approximately 140 sets of scores per service which, having consulted the educational establishments statistician, was deemed a reasonable sample size. A too small a sample size would risk type 2 errors of missing an existing signal (accepting a false null hypothesis). However, undertaking a formal power calculation to calculate the sample size would have been of little value as the data required to do this did not exist (Jones and Harrison, 2003). It is recognised that pre-prepared tables have their limitations as they make assumptions about the normality and size of population which may not be accurate for all study populations (Machin et al, 2009). Nevertheless, in this case in the absence of data specific to this field for a power calculation, Cohen’s statistical power calculations for correlation tests was deemed better than nothing as a guide to the lower sample size boundary that would be required. Cohen suggests that for a large effect size at a significance criterion of 0.05 a sample of 28 is required or 85 for a medium effect size. (Cohen, 1992). Indicating that the sample size expected (140) would be a large enough sample to statistically analyse for a medium effect at the 0.05 significance level. The significant level and effect size are discussed in more detail later in this chapter in section 4.5.

All three services collected the two sets of scores on a form. Services B and C used a version of the form in Appendix D, whereas service A added an additional box for the SNCT score onto the form they normally collected the iBID scores on. The scores were recorded once daily in line with the normal iBID collection practices for each service, usually towards the end of the day shift. It is recognised that the dependency needs of a patient can vary throughout the 24-hour period. Therefore, as only one score was being recorded daily, the highest dependency need during that period was scored. The local coordinator was responsible for checking that the scores had been recorded daily.

The information on the forms was then entered into iBID in the normal way by the iBID data clerk. As there was no specific SNCT tab in iBID this score was entered under the iBID daily dependency 'other events' tab as a number in square brackets e.g. [1a]. This meant that the researcher did not have access to any patient identifiable data to maintain confidentiality and anonymity. At the end of the data collection period, the relevant iBID data for that period was extracted centrally, anonymised and sent as a password protected Excel spreadsheet to the researcher for analysis.

Prior to the start of the formal data collection period in each participating burn service, a two-day pilot study was undertaken. The reason for this was to familiarise the participants with the process of collecting both scores in parallel and to enable any problems that might occur to be addressed prior to the main data collection period. Originally it was expected that following the pilot study there would be a break before the main data collection period in order to sort out any issues that may have arisen with the dependency scoring. However, as no issues were identified by those participating, the data collection continued uninterrupted for the next two weeks. This was a decision that was taken at the local level without consultation with the researcher. However, on discussion, it was confirmed that there was no reason that this would be a problem, therefore the pilot data was included in the main data set.

In addition to the daily dependency scores, the nurse-in-charge of the ward was asked to document the actual number of nursing staff on duty per shift and record if, in their opinion, the number of staff was sufficient or insufficient with an explanation. The question was not asked about what they did about any unsafe levels of staffing as this was outside the remit of this research. The nurse-in-charge was also asked to record any circumstances that may have affected the staffing level/workload. The purpose of collecting this information alongside the nurse dependency scores was to see if any links could be made between staffing levels and the nurse dependency scores. This information about the daily staffing was retained on the ward until the end of the data collection period and then given to the researcher. See Appendix E for the staffing levels daily record sheet.

4.3.3.2 Case Study nurse dependency scores

In addition to the daily ND scoring discussed above, the participants were asked to score three case studies. The purpose of this was to assess the degree of consistency and agreement among the participants and across services in scoring their patients' dependency using both the SNCT and iBID ND tool.

Three artificial case studies were written by the researcher in the format of a patient handover summary. They contained the type of information that the nurses would normally have in practice when making decisions about a patient’s needs. These case studies were designed to encompass three of the SNCT levels and a range of the elements that made up the iBID nurse dependency total score to allow for a variation of scores and complexity.

Three were chosen as this gave a variation in the scores without being too onerous in number and increase the risk of non-completion. The case studies (Appendix F) were based on the following profiles:

Case study 1 – A patient with a new burn, requiring fluid resuscitation but otherwise no complications with an expected SNCT score of 1b
Case study 2 – An older adult patient with a small burn, pre-existing comorbidities and psychosocial issues with an expected SNCT score of 0
Case study 3- A ventilated ICU patient with a large burn and smoke inhalation injury with an expected SNCT score of 3

Once written, the case studies were piloted by five senior nurses with burns or critical care experience and who were not going to be participants in the actual study. These nurses were also asked to scrutinise the case studies for accuracy and clinical realism. They gave feedback directly to the researcher either verbally or by email. No structured feedback form was utilised because spontaneous responses were wanted without any provoked influences that might affect those feeding back. The comments that came back were positive in that those scrutinising the case studies found the case studies easy to understand and did not report any difficulties in being able to score the dependencies. There were a couple of suggestions about changing a patient’s name, so it fitted with the ethnic profile portrayed in the case study and one amendment in the ventilation information and a couple of typographical errors. Following these comments, some minor amendments were made, but no changes to the actual burn and dependency aspects.

The case studies and a score sheet were then given out to the participating nurses in the three burn services by the research coordinators in each service. For two of the services, the participants were also emailed the case studies and score sheets a couple of weeks later as a reminder to complete them. The participants were asked to rate each of the case studies using both the SNCT and iBID ND tools, in the same way that they were doing with the daily scoring on their patients and record their answers on the supplied score sheet. The participants were asked to score the case studies during the data collection period. The aim of this was to allow the participants to complete them in their own time during the period and avoid putting any unnecessary pressure on them to complete in a short time frame. As all three services collected the iBID dependency data, and at least one of the services collected SNCT data for their trust, the participants were all likely to have been involved in dependency scoring previously. Consequently, it did not matter when during the data collection period they completed the case study scoring as the point was to assess inter-rater reliability and not check the nurses' ability to use the dependency tools. Additionally, the analysis was not going to be undertaken until after all the data was collected so the results of the case study analysis would not have affected the two-week data collection scoring. While it could be argued that if the case study results were analysed prior to the data collection period training could be put in place, this would have detracted from the nurses' normal practice and not given a true picture of what is routinely assessed and recorded in iBID.

To preserve anonymity, the participants were asked not to put their name on the score sheet and to return them in a sealed envelope via the local coordinator at each site. In practice though, many of the participants returned the completed sheets to the coordinator not in a sealed envelope and a couple emailed their sheets directly to the researcher. It is recognised that this could be seen as a cause of potential bias. However, with these cases, the researcher removed any identifying details prior to use in the research and thus they were indistinguishable from the other scores when the statistics were performed.

4.3.3.3 Post data collection survey

At the end of the two-week data collection period, an online survey was sent out to all the nurses that had agreed to participate. This was to gain an understanding of the participant's views and experiences using the two dependency tools, so it could be taken into account when analysing the suitability of the iBID nurse dependency scoring tool.

The survey was devised using the JISC Online Surveys platform. The survey (see Appendix G) consisted of 15 questions. The questions aimed to find out how important the participants thought daily ND scoring was, how easy they found using the two tools and if they preferred one ND tool over the other. The first three questions were generic demographic questions about the participants' experience and workplace. The last two questions were open-ended questions to allow the participant to add any comments they wanted to about the use of the two dependency scoring tools and the research process they felt was important. The remaining questions consisted of five Likert scale questions about the ease and importance of using a ND tool and five multiple-choice questions related to their experiences in scoring ND and their preferred ND tool. The participants were also given free text opportunities to explain the rationale for their answer.

The survey was piloted by 4 people to ensure that it was accessible and understandable. None of those piloting the survey had a problem accessing the survey and they were all able to navigate through. Feedback on how some of the wording/ grammar could be improved was given by email and acted upon.

At the end of the two-week patient ND data collection period and following the return of the case study scores a link to a survey was emailed to all the participants, with details of how to complete the survey and a reminder of why they were being asked to do so.

4.3.4 Analysis

The results obtained from the quantitative data collected from the burn services were analysed using the IBM SPSS statistics 25 software package

(IBM Corp., 2017). The qualitative data, resulting from open text answers, was analysed using thematic analysis. This section describes how the collected data was analysed and the rationale for the choice of statistical test or method. A more detailed explanation of the individual statistical tests is given in section 4.5.

The SNCT and iBID ND scores collected over the two-week period were analysed using Spearman correlation to identify if there was a correlation between the two tools. It was postulated that if there was a positive correlation that would suggest that they both captured nurse dependency and that the iBID ND tool did measure ND. The Spearman correlation, as opposed to the Pearson correlation, was used as the data was ordinal in nature and therefore non-parametric (Field, 2018). The data was analysed as a whole and also analysed separately in burn service groups to see if there was a difference between services.

The case study scores were analysed for inter-rater reliability using the Krippendorff alpha statistics test which quantifies the extent of agreement and reliability between the scorers (Hayes and Krippendorff, 2007). The Krippendorff alpha was an appropriate statistic test because it can be used with ordinal data, which the nurse dependency scores are, and is suitable for use when there are multiple raters and multiple categories as was the case here (Hayes and Krippendorff, 2007). In addition to the inter-rater analysis, the case study scores were analysed using Spearman's correlation statistic test to investigate whether the results corroborated the results from the above daily nurse dependency scores analysis.

The staffing qualitative questions and survey were analysed descriptively to give an idea of which tool the participants preferred. The initial plan was also to compare the staffing numbers with the daily dependency scores to establish if any patterns existed. Unfortunately, this was not possible to do as explained in chapter five, section 5.5.

4.4 Part Two Methodology - Exploratory Analysis of a Data Sample from iBID

In line with the research objectives, the purpose of this part of the study was to start to develop an understanding of the quality of the ND data in iBID and to statistically analyse a sample of data from iBID to identify if any predictive relationships for ND of burn patients existed. The iBID was chosen to explore burn ND as it is the largest UK burn database that collects ND data and the only one that collects burn specific data across England and Wales.

The help and advice of a statistician was sought to plan the analysis process and identify the relevant statistical tests to perform. As no specific data analysis process was found in the literature that could be followed, the process shown in Figure 4.2 was formulated and used.

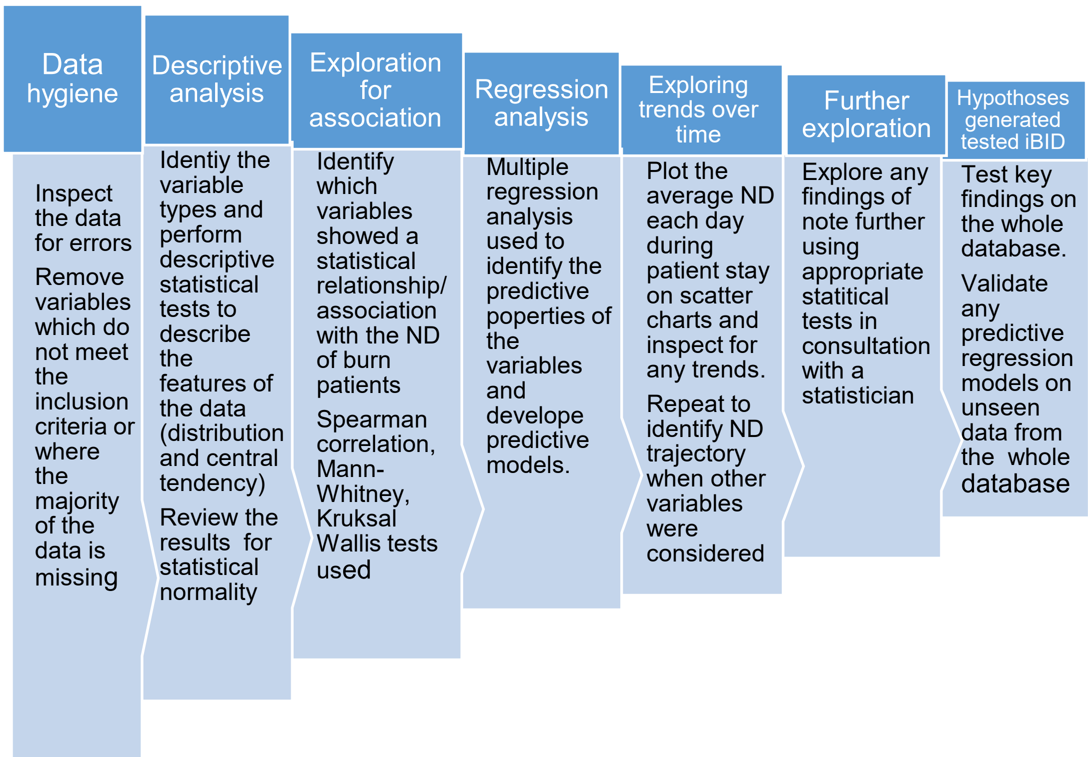


Figure 4.2 The iBID data sample analysis process flow path

4.4.1 Data sample

iBID contains several hundred data fields, not all of which were relevant to this study. Therefore the iBID database was reviewed and the fields in the database that might have an association with the ND of patients with a burn injury were identified. First, fields that were not routinely populated by the burn services, contained identifiable demographic data and those used only for data input quality checking in the database were excluded. The remaining fields were then reviewed by the researcher and a Consultant Burn Surgeon (who had extensive knowledge of the database as well as burn care) to identify the variables considered likely to affect the ND level of burn patients and could potentially be used to predict ND on admission. A total of 103 variables, were initially identified.

A data sample of 5000 patients with 39458 dependency records was received as a Microsoft Excel® spreadsheet; which was screened for errors and omissions, before 'cleaning' and coding in line with expected SPSS conventions (Pallant, 2010; Tabachnick and Fidell, 2014). The data hygiene process is explained in more detail in chapter six section 6.2.1.1. Following the data hygiene process, a total of 24473 ND records for 3679 patients remained available for analysis. Additionally, the number of variables had reduced to 94. The variables are described in detail in section 4.5.1 of this chapter. The prepared spreadsheet was then imported into the IBM SPSS statistics 25 software package (IBM Corp., 2017) for analysis.

4.4.2 Data analysis of iBID data sample

Once the data was prepared for analysis a set of descriptive statistics were performed to understand and describe the characteristics of the data sample. For example, the type of variable (continuous, nominal or ordinal), the distribution (frequency or range of values), central tendency (estimate of the centre of the values) dispersion (spread of the values around the central tendency). This information was used to ascertain the correct statistical tests for the inferential analysis. Section 4.5 describes the statistical tests in more detail and explains the statistical terminology and parameters used in this research.

Following the descriptive statistical analysis, the relationships between the ND score and other variables were explored to identify suitable variables for use in the predictive modelling. As the data was not normally distributed, the following three non-parametric statistical tests were used depending on the type of variable being analysed – Spearman correlation (for continuous variables), Mann-Whitney U test (for dichotomous 'grouped' variables), Kruskal-Wallis test (for categorical variables with more than two groups).

The iBID variables are a mix of variables, those that potentially change on a daily basis (for example, 'ward type', 'therapy complexity') and those that are known on admission and would remain constant throughout the patients stay (for example, 'gender', 'TBSA'). Therefore, in order to analyse the iBID ND total score against the variables that were constant over the patients stay, an iBID ND total score value fixed at a point was required. Four sets of iBID ND total scores were identified to be used as the dependent variables for the inferential statistics tests (the average, maximum, minimum and first ND total scores recorded for each patient). For a full description of why these fixed ND scores were chosen see section 6.2.1.3.

Once the variables that had some association with the iBID ND total score were identified, they were then subjected to multiple regression analysis in order to develop 'predictive models' that would identify the important factors/variables that influence the ND score. Any patterns discovered or questions raised were investigated further. Chapter six explains the results and the rational for any further analysis. The process described here is summarised a flow chart in figure 4.3.

In addition to the statistical analysis process just described, the daily average of the iBID ND total scores per TBSA group were plotted on a scatter graph to identify if ND trends were present that could form a predictive ND trajectory from admission.

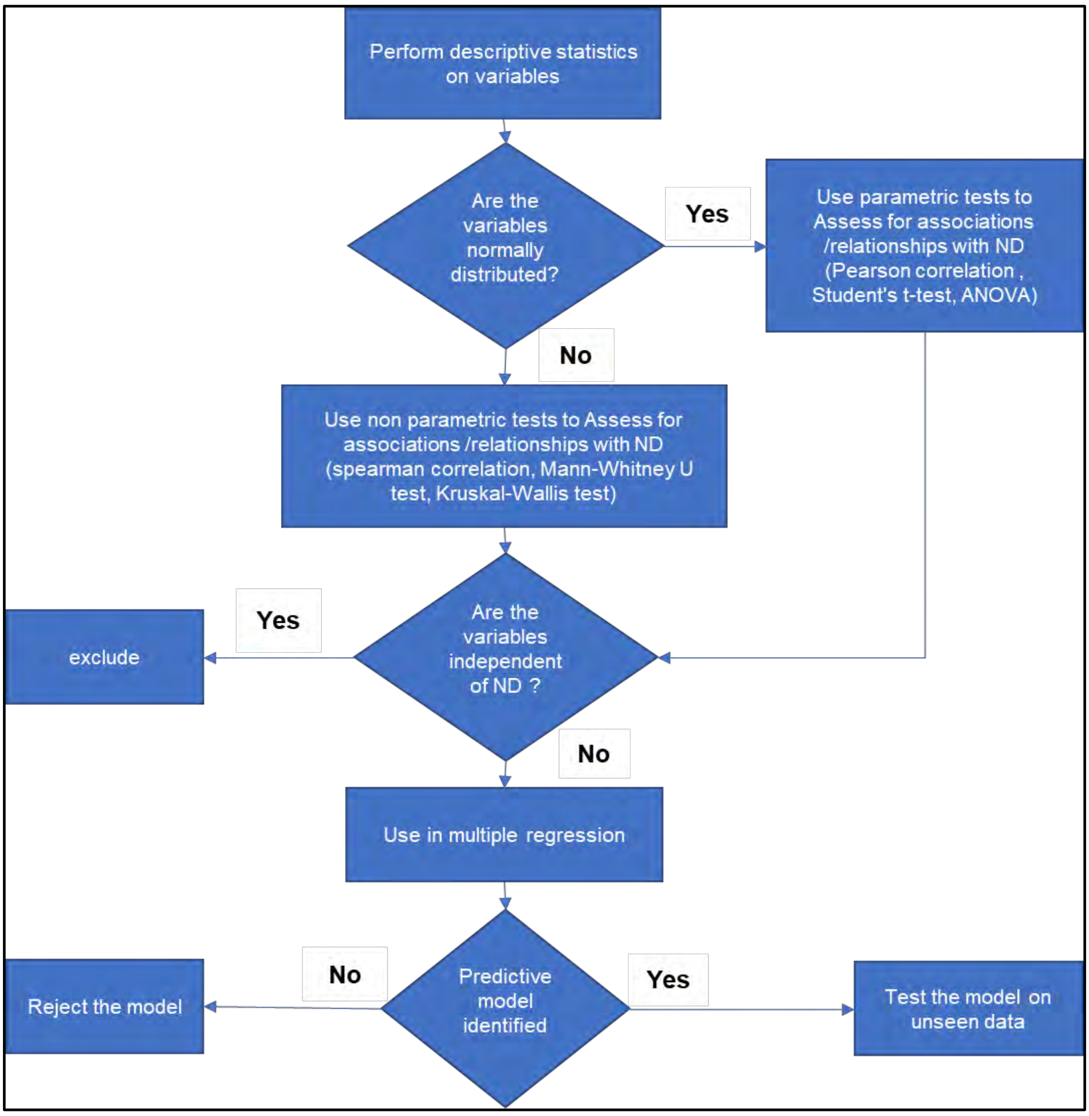


Figure 4.3 Flow chart of the statistical analysis process

4.5 Statistical Terminology and Methods Used

This section will explain some of the statistical terminology and gives a brief overview of the statistical techniques that were used to analyse the data collected in this research. The specific rationale for use in relation to the actual data collected in the different parts of this research will then be discussed in more detail in the relevant chapters (five, six and seven).

4.5.1 Variable categorisation

Categorisation of the variables was an important first step as the choice of statistical technique would be influenced by the categories assigned (Pallant, 2010). Hence all the data collected or extracted from iBID was classified into categorical variables which are made up of distinct categories (for example 'type of injury') and continuous variables which are measured along a continuum (for example 'age'). These can be further subdivided into levels of measurement - nominal, ordinal, interval and ratio. The categorical variables were divided into nominal (no order to the groups existed, such as the 'gender' and 'type of injury') and ordinal (an order or hierarchy existed but this was not quantifiable, such as 'monitoring requirements' and 'TBSA' groups) variables. The continuous variables were divided into interval (a numerical value that is measured along a scale and can be negative or positive, such as temperature) and ratio (a numerical value that is measured along a scale but where the zero measurement indicates there is none. Therefore, a negative value cannot exist, such as 'age' and 'ND total') variables. A list of all the variables originally extracted and their categories can be found in Appendix H.

The other way that the variables were categorised was into dependant variables (also known as outcome or response variables) and independent variables (also known as predictor and explanatory variables). The dependant variable is the variable being tested to ascertain if it is affected by the independent variables, which in the case of this research was usually the ND score. The independent variables are the ones that may have an effect on the dependant variable, such as TBSA.

4.5.2 Significance and confidence intervals

Statistical significance is a term used in statistics to mean that there is a difference between two groups that is unlikely to be due to chance (Salkind, 2017). This does not necessarily mean that any importance or meaning can be attached to the findings (Field, 2018). The significance level is often expressed as a 'p-value' denoting the probability of observing the difference completely by chance alone. In other words, the chance of obtaining the result if the null hypothesis (there is no difference) is assumed to be true. Nevertheless, although it may be suspected that a difference between groups is not by chance there is always a possibility this could be the case, no matter how slight. Therefore, a significance level needs to be set to indicate the acceptable level of risk of rejecting the null hypothesis if it was true (a Type 1 error). A p-value of 0.05 is widely accepted as significant, that is there is only a 5% (1 in 20) chance that there may be no difference. According to Field (2018), this value is not a “magic number” and the acceptable level of risk that there is no difference should be decided depending on the research area and before data is collected for transparency. For example, if the risk of a type I error (falsely rejecting the null hypothesis) could lead to a death then a 5% chance of being wrong may be considered too high and the level may be set at 0.01 or 0.005. In this research study, the significance level of 0.05 will be used as it is an exploratory study and not a clinical trial where 0.01 might have been more appropriate if the risk of wrongly rejecting the null hypothesis was greater. Additionally, while we do not want to falsely reject a null hypothesis, we also do not want to risk falsely accepting the null hypothesis (a type II error) and miss some potential signals of a relationship. If a p-value is close to the 0.05 value the potential significance of this will be evaluated and taken into account in the ensuing discussion, because as previously mentioned a significance level is a guide not an absolute.

Hypotheses can be directional indicating a positive or negative relationship. In this exploratory study, we do not know whether any relationship will be positive or negative and therefore two-tailed significance tests will be used throughout. This also reduces the risk of rejecting a null hypothesis when it is true, as any probability levels will be split between the negative and positive tail leading to a lower significance level at each end (0.025) but still with an overall significance level of 0.05. If a one-tailed test was performed and the hypothesis could be in both directions, then only one end of the distribution would be looked at risking bias and type I errors (Field, 2018).

Confidence intervals (CI) are a range of values that the true value is likely to lie between (Field, 2018). Therefore, a 95% CI is the range that the population parameter will lie between in 95% of the cases. Comparing CIs can show whether the population values come from the same groups or different groups and are thus significantly different or not (Field, 2018). If the 95% CI does not contain the value (often zero) reflecting 'no effect' it indicates a statistically significant result at the 5% level. This is similar to that inferred by the p-value, but the CI also gives the largest and smallest likely value given the data sample. Thus, if the CI is narrow, there can be more confidence that the estimate of the true value is more precise than if the CI is wide (Davies and Crombie, 2009). The larger the sample size the narrower the CI is likely to be as it will reflect the population more than a smaller sample. The literature now suggests that CIs should be reported as well as p-values as they give information about the size and direction of the differences between groups as well as level of significance (Griffiths and Needleman, 2019; Pandis, 2013; Ranstam, 2012; Sedgwick, 2013). Consequently, both will be reported in this study.

The size of the sample is also linked to significance and CIs. The larger the sample size the more likely a difference, if one exists, will be detected. This is because a larger sample size has more power to identify a statistically significant effect than a small sample size (Field, 2018). Accordingly, the larger the sample the less risk of either a type I or type II error occurring.

As previously mentioned, the p-value indicates the probability of the difference between two groups being due to chance, but it does not tell us how big that difference may be and whether it is meaningful (Sullivan and Feinn, 2012). The Effect Size (ES) on the other hand quantifies the size of this difference, enabling judgements to be made on how important, or clinically significant, it may or may not be (Field, 2018). Also, unlike the p-value, it is not dependent on the sample size. ES can be expressed as the absolute ES, which is the raw difference between groups in their original units, or as a standardised measurement that can be compared between studies (Field, 2018; Sullivan and Feinn, 2012)). Standardised ES can be measured in several ways (Cohen, 1992). Three ways that are relevant to this study are; correlation coefficient, standardised means difference such as Cohens d and in multiple regression Cohen's f. To give meaning to these values Cohen's (1992) scale of small, medium and large effect was used, as shown in Table 4.1. Cohen set the medium effect as one that would "likely be visible to the naked eye of a careful observer" (Cohen, 1992: 156). Although now widely used, Cohen himself admits that these cut off points were made subjectively so discretion needs to be used when discussing the magnitude of the ES.

Table 4.1 Effect Size Indexes and their Values for Small, Medium and Large Effects. Adapted from Cohen (1992, pg. 157)

Test	**Effect size**		
	Small	Medium	Large
Correlation (*r*)	0.10	0.30	0.5
Independent means (*d*)	0.20	0.50	0.80
Regression (*f*)	0.10	0.25	0.40

The British Medical Journal, in their web advice to readers, agree that any cut of points used to classify effect sizes or strength of association are arbitrary (Campbell, 2020). For clinical papers, they suggest a classification for correlation strengths of association similar to Schober's (2018), which will be the one used in this thesis, and is discussed in more detail in section 4.5.4.1.

4.5.3 Descriptive statistics

A descriptive analysis of the variables was undertaken in order to describe the characteristics of the variables in the sample and to check the quality of the data from iBID. Additionally, the descriptive analysis enabled the checking that any assumptions would not be violated when choosing which statistical tests to run. In particular, the descriptive statistics enabled identification as to whether the variable data met the parametric test assumptions shown in Figure 4.4.

- **Linearity** – that the variables have a linear relationship with each other
- **Normal distribution of the variables** – the mean, median and mode are equal to each other and the frequency distribution has a symmetrical bell shape curve.
- **Homoscedasticity** – data from the different groups have a similar variance (square of the standard deviation)
- **Independence** – that the data measurements are independent of each other and not influenced by another measurement.

Figure 4.4 Parametric test assumptions (adapted from Field, 2018)

The descriptive analysis included the count of each variable and their categories, along with a set of descriptive statistics. Table 4.2 summarises the statistics calculated, the results of which are presented in chapter six section 6.2.1.2. Not all of these descriptive measures were appropriate for all variables (Pallant, 2010), for example, the 'ward type' as a categorical variable is not a continuous scale, so the mean and standard deviation are not suitable measures whereas the frequency and mode are.

Table 4.2 Descriptive statistic tests definitions (Field, 2018)

Statistic	**Definition**
Frequency	The number of times the value/category appears
Histogram	A graph that displays the frequency distribution of a continuous variable
Interquartile range	It is the difference between the upper quartile and lower quartile values, where 50% of the data will fall. A measure of dispersion.
Mean	The total of all the values divided by the number of values. A measure of central tendency.
Median	The middle value in a list of ordered observations. A measure of central tendency.
Mode	The most frequently occurring value in a set of data. A measure of central tendency.

Statistic	Definition
Range	The largest value minus the smallest value. A measure of dispersion of a set of scores.
Skewness	The measure of the asymmetry of a distribution. It is positive if the scores are clustered to the left and tail points to the right. Negative if tail points to the left and zero if symmetrical.
Standard deviation (SD)	An estimate of the average spread of the data. The square root of the variance. A measure of dispersion of a set of scores.
Standard error (SE)	An estimation of the difference between the sample measure and population measure. The SE is the SD of the sampling distribution (repeated sampling). It indicates how accurately the sample parameters may reflect the population parameter.
Sum	All the values added together. This value is sensitive to the sign of the individual values.
Sum of squares	An estimate of the total spread of the data. The sum of the squared differences of each score from the statistical parameter (e.g. mean). This value is not sensitive to the sign of the individual values.
Variance	An estimate of the average spread of the data. The squared SD or the averaged sum of squares. A measure of dispersion of a set of scores or how far the data is scattered from the mean

4.5.4 Inferential statistics

Inferential statistics were then used on the sample to make inferences about the population from the sample and to develop a predictive model for ND score in patients with a burn injury. Three statistical techniques (Spearman correlation coefficient, Mann-Whitney U test and Kruskal-Wallis test) were used to explore the data for relationships between continuous variables or differences between groups on a continuous measure in order to identify which of the variables were not independent from the ND scores. These statistical techniques are individually described in more detail below. They are all non-parametric tests as the ND data did not meet the parametric assumptions for a normal distribution.

Nonparametric tests make fewer assumptions about the population that the data is drawn from and are less sensitive to outliers (which for this study are data points that lay outside of 2.5 SD of the mean). Hence, nonparametric tests can be seen as robust statistical tests that enable accurate results when the traditional parametric assumptions are violated (Field, 2018; Kitchen, 2009). However, the statistical power of nonparametric tests can be weaker than parametric tests leading to the potential risk of missing a signal of a relationship. But this reduction in statistical power is only true if the data had a normal distribution (Field, 2018), meeting the assumptions discussed in section 4.5.3.

In addition to the statistical tests to explore associations and differences between groups mentioned above, two other statistical tests (Multiple regression and Krippendorff alpha test) have been used in this study. Multiple regression analysis was undertaken to explore the effect of variables, not showing signals of independence from ND, as predictors for ND. Whereas the Krippendorff alpha test was used to measure the level of agreement among the nurses scoring and between the two ND tools (Krippendorff, 2011).

4.5.4.1 Correlation

Correlation statistics are used to explore whether a relationship exists between two continuous variables and subsequently its strength and direction, assuming there is a linear relationship. Although exploring the correlation can indicate whether a relationship exists between variables it does not indicate causality. It does not mean that if one changes the other necessarily will, as a third factor could be causing both to change (Pallant, 2010).

The two most common correlation tests used are the Pearson product-moment correlation for parametric data or the Spearman correlation for non-parametric data. They both produce a numerical correlation coefficient between -1 and 1 that reflects the strength of the relationship between the two groups. Zero suggests that there is no relationship but the closer to 1 or -1 the correlation coefficient is the stronger the relationship. If the correlation is positive there is a direct relationship with both variables changing in the same direction, whereas a negative correlation indicates an indirect relationship where the variables move in opposite directions (Salkind, 2017). The literature varies as to what values equate to a strong, moderate or weak relationship and different disciplines set different values to these descriptions (Akoglu, 2018). However, Schober (2018) suggests that the cut of points are perhaps arbitrary. Therefore, to help with the description of the results, for this research the 'rule of thumb' as given in Table 4.3 will be used as a guide to the strength of the Spearman Rho (ρ) correlation as a version of this is quoted in the medical literature several times (Mukaka, 2012; Overholser and Sowinski, 2008; Schober et al., 2018). However, this 'rule of thumb' is a guide only and the actual coefficient should also be considered in the wider context of the research and alongside the confidence intervals when interpreting the results (Schober et al., 2018).

Table 4.3 Interpretation of correlation coefficient strength. Adapted from Schober et al. (2018, pg. 1765). The correlation coefficient ranges from 0 to 1 regardless of whether it is in a positive or negative direction as only the magnitude is considered.

Observed Correlation Coefficient	**Interpretation of strength of relationship**
0.90 -1.00	Very strong
0.70 – 0.89	Strong
0.40 – 0.69	Moderate
0.10 – 0.39	Weak
0.00 – 0.10	Negligible

The Pearson product-moment correlation test is designed for use with two continuous variables, or one continuous and one dichotomous variable, which meet the parametric assumptions (Pallant, 2010). Spearman’s rank-order correlation test on the other hand is a nonparametric test and does not require a normal distribution. It can be used with ordinal or continuous variables as long as there is a monotonic relationship (where, as one value increases/decreases so does the other) (Laerd, 2019). Spearman’s test works by ranking the variables and then applying the Pearson correlation equation to the ranks to get a correlation coefficient (Spearman, 1910, cited in Field, 2018). The ranking of the data reduces its sensitivity to outliers thus making it a robust statistical test. However, as it is not a parametric test, which has more statistical power as more assumptions can be made about the normality of the population, the Spearman test may miss some small significant differences that exist (Field, 2018). As this was an initial exploratory study it was reasoned that this would not be an issue.

4.5.4.2 Mann-Whitney U test

The Mann-Whitney U test is used with dichotomous ‘grouped’ variables to test for a difference between the two groups on a continuous or ordinal variable (for example do males and females differ in terms of their ND score). It is the non-parametric version of the independent –samples t-test which compares the medians, rather than the means, of the two groups. It does this by converting the continuous variable’s measures to ranks across the two groups and calculating whether the ranks for the two groups differ significantly. Assumptions are not made about the population distribution (distribution-free test), so consequently, it does not matter if the variable does not have a normal distribution (Pallant, 2010). The Mann-Whitney U Test does make the assumption that the variable groups are mutually exclusive, that is the data can only belong to one of the groups.

One issue with ranking is that some values may tie for the same rank. SPSS includes a correction for this (Pallant, 2010). However, SPSS does not provide an ES statistic for the Mann-Whitney U Test. Therefore, the following formula (Figure 4.) was used to calculate the ES.

r (effect size) = z value /square root of the total number of cases

Figure 4.5 Calculation for the effect size following a Mann-Whitney U test (Field, 2018: 295).

4.5.4.3 Kruskal-Wallis test

The Kruskal-Wallis test is also a rank-based nonparametric test. It is similar to the Mann-Whitney U Test but differs in the fact that a categorical variable with more than two groups can be compared to determine whether there is a difference between the groups (Pallant, 2010). For example, whether the six types of burn injury categorised in the 'burn injury group' variable significantly differ in terms of their ND score. The parametric alternative of this test would have been the one-way between-groups ANOVA test.

Although the Kruskal-Wallis Test will confirm differences between groups it does not identify which groups are different. Follow up Post-Hoc tests are required for this to compare all the pairs of the groups (Field, 2018). In this study Post-Hoc tests were not performed as the relevant variables were subsequently subjected to multiple regression, negating the need once a difference between groups had been identified.

4.5.4.4 Multiple regression

Variables showing signals that they might not be independent from the ND score were examined for their predictive ability using multiple regression. Multiple regression enables the relationship between a continuous dependant variable (in this case the iBID ND score) and several independent (predictor) variables to be assessed and a predictive model developed to explain the data (Tabachnick and Fidell, 2014). The independent variables were a mixture of continuous variables (for example 'TBSA', 'age') and categorical variables (for example 'ward type', 'TBSA group'). Whereas the continuous independent variables could be entered directly into the regression calculation, categorical variables were recoded first into 'dummy' variables. This was because category variables need to be converted into a numeric format but to simply apply a number to each group would imply a directional and size order where none existed. Dummy coding avoids this problem by converting each category group into an exclusive dummy variable using the numbers ‘1’ (yes in this group) and ‘0’ (not in this group) (Field, 2018). Table 4.4 shows how the dummy variable coding for the ‘burn network’ category would work out. Although 4 dummy variables are created only three would be used in the multiple regression as the fourth group could be predicted by the other three and would lead to multicollinearity. The group that is left out of the regression is known as the reference group.

Table 4.4 Example of Burn network’s dummy variables

Patient	**Burn network**	**Dummy variable**			
		Northern	Midlands	London and South East	South West
1	Northern	1	0	0	0
3	Midlands	0	1	0	0
4	London and South East	0	0	1	0
8	South West	0	0	0	1

Multiple regression assumes a linear relationship between each independent variable and the dependent variable and calculates a line of best fit to the data (or regression line) so that the values of the dependant variable can be predicted as shown in Figure 4.. The line of best fit also includes an intercept (the constant). The error in the prediction (the difference between the predicted value and the real value as shown in Figure 4.) is also called the ‘residual’. From the residuals, regression analysis can calculate how well the model fits the data, giving a value of R^2. R^2 indicates how much of the variance in the ND score is explained by the model. The adjusted R^2 statistic corrects the value to give a better estimation of the variance in the ND score explained by the model for the population (Pallant, 2010).

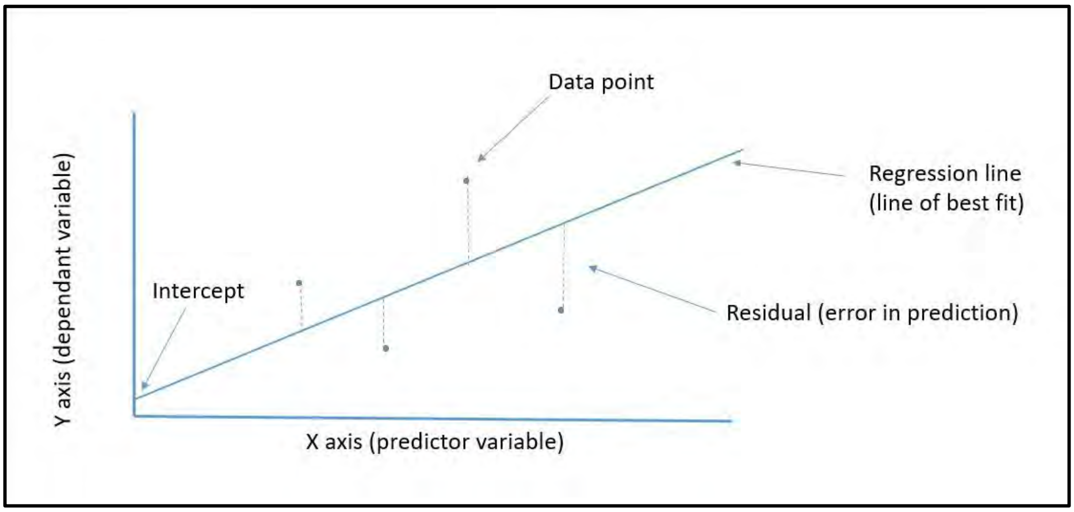


Figure 4.6 Example of a line of best fit and residuals

The model parameters reported for multiple regression are the coefficients or beta values. The unstandardized coefficients (*b*-value) represent how much the dependent variable (ND score) would change, from the calculated constant value, with a unit change to the independent variable; that is how much the ND total score would go up (positive value) or down (negative value) if the independent variable changed by 1. If the independent variable makes no difference to the predicted outcome its *b*-value will trend towards zero as the sample size increases. If the independent variable is making a statistically significant contribution to the predictive model this will be indicated by the calculated p-value and confidence intervals. SPSS also reports the standardized coefficients (β). These have been converted to a comparable scale (standard deviation units) so can be directly compared to establish which variable makes the largest unique contribution to the model. The use of the standardized coefficients is not applicable for comparing categorical data and dummy variables because these variables do not have a scale that can be compared, they either are or are not that value (Field, 2018).

Multiple regression does make several assumptions about the data when calculating the model parameters. These are described below along with how the results were checked for violations of these assumptions.

- **Large enough sample size** – The sample size needs to be big enough for the number of independent variables and size of effect to be detected. If the sample was too small the results could not be generalised as it is unlikely a similar result will be gained if repeated with other samples (Pallant, 2010). Furthermore, if there are too many independent variables to the number of cases in a model this will lead to 'overfitting'. Overfitting can cause misleading values as the model describes the 'noise' of the data (the random disturbance or variability in the sample (Encyclopedia.com)) rather than the relationships, generating the impression of a near-perfect fit and preventing the generalisation of the model.

There are several 'rules of thumb' to calculate the sample size for regression analysis. At its simplest, Field (2018) suggests the larger the sample size the better. Conversely, Tabachnick and Fidell (2014) suggest it is possible to have too large a sample size so that signals, albeit small, are seen from most variables. In the sample analysed here, there are potentially 2,000 plus samples, so for most of the regressions there would be adequate numbers. Nonetheless, the rule of thumb suggested by Tabachnick and Fidell (2014, 159), shown in Figure 4., was used as a guide to ensure a suitable minimum number of cases existed as the number of independent variables increased.

$$N >= 50 + 8m$$

Figure 4.7 Sample size rule of thumb for multiple regression where a medium size relationship is assumed. N is the number of cases and m is the number of independent variables. (Tabachnick and Fidell, 2014, 159)

It is not just the number of variables that need to be taken into account but the number of degrees of freedom, that is the number of independent entities (for example variables) that can vary in a statistical test (Field, 2018). This is usually one less than the number of entities. Using a five-a-side football team as an example; if you have five positions when you allocated the first player, you have five positions to choose from but only four for the second player. By the time you get to the last player, there is no choice left as there is only one position left. So here you would have four degrees of freedom. This is similar in multiple regression and other statistical tests. The more degrees of freedom the greater risk of overfitting of the model.

- **No multicollinearity** – This occurs when there is a strong correlation between two or more independent variables. In multiple regression it is assumed that there is no multicollinearity or it is only at very low levels. As multicollinearity increases the beta coefficients become untrustworthy as their standard errors increase, the size of R is limited because the two variables will account for the same variance and it is difficult to assess the importance of the independent variable in the model (Field, 2018). The regression output was checked for Multicollinearity by looking at the correlation matrix (a table showing the correlation coefficients between the variables) correlations and the variance inflation factor (VIF). The VIF indicates whether an independent variable has a strong correlation with another independent variable. It is the inverse of the 'Tolerance' which indicates how much of the variability of the variable in question is not explained by the other variable. There appears to be no definitive value to confirm multicollinearity but one commonly used guideline to identify warning signs is a VIF value above 10 (tolerance below 0.1) (Field, 2018; Pallant, 2010). Therefore, the correlation matrix was checked for strong correlations of > 0.8 and VIF's around 10 to identify possible signs of multicollinearity.
- **No Singularity** - Multiple regression also assumes that there is no singularity. That is no variable is a combination of other variables. Where this was the case either the total or the parts were used and not both. For example, the variables of full-thickness burn size and partial thickness burn size make up the total burn size, so either

the total burn size was used on its own or the full thickness and partial thickness burn size variables but not all three.

- **Normally distributed errors** – It is assumed that the residuals (as opposed to the data itself) are normally distributed. That is, the differences between the predicted and real value are small. This was assessed by viewing the Normal Probability- Probability (P-P) Plot of the standardized residuals which shows the observed cumulative probability against the expected (normal) cumulative probability. For normality to be assumed the points should closely follow the straight diagonal line of normality as shown in Figure 4. (Field, 2018).

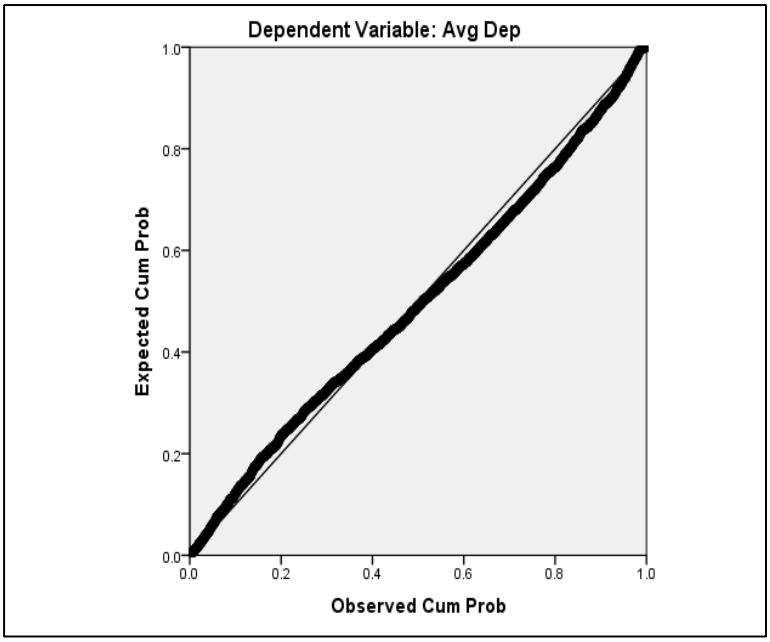


Figure 4.8 Example of a normal P-P plot showing a normal distribution of the residuals

- **Linearity** – A linear relationship between the dependent and independent variables is assumed.
- **Homoscedasticity** – There is an equivalent variance in residuals across all the values of the variables. In other words, the size of residuals for each data point is the same as for other values (they have the same scatter). If this assumption is violated (heteroscedasticity) it can lead to a biased significance and confidence intervals (Field, 2018). Linearity and homoscedasticity

can be investigated by analysing the scatter plot of the standardized residuals. If the assumptions of homoscedasticity and linearity are correct there will be no obvious pattern and the scatter plot will be roughly rectangular shaped with most of the score concentrated around zero as shown in Figure 4.9 (Pallant, 2010).

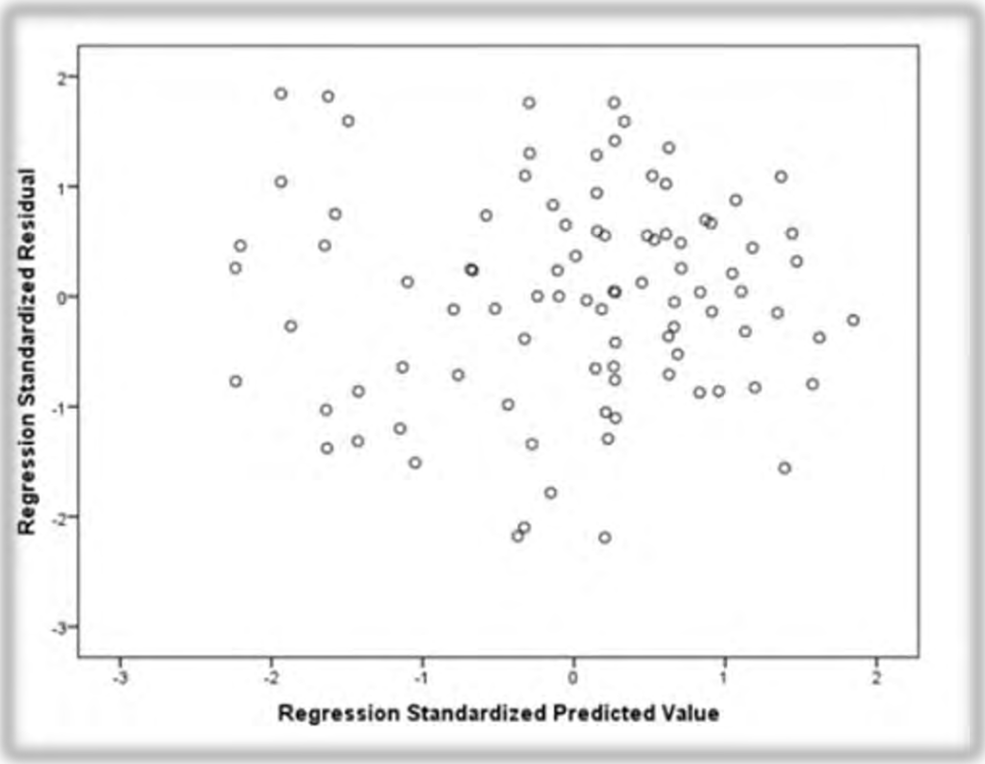


Figure 4.9 Residual scatter plot showing no homoscedasticity (Statistics Solutions, 2021)

- **Independence of residuals** – An assumption is made that there is no autocorrelation between the values of the variable across different observations (that the difference in the residuals is not related to each other). The Durban-Watson statistic tests for this autocorrelation in the residuals. Field (2018) suggests that a Durban-Watson statistic greater than 3 or less than 1 would be a cause of concern that autocorrelation may exist reducing the model's accuracy.
- **Outliers** – The presence of extreme outlying scores can affect the regression model. To evaluate these, the cases whose standardised residual fell outside the limits of ± 2.5 SD (expecting

this to be approximately 1%), were reviewed. These were checked for any obvious data entry errors. The influence of these outliers on the model was also assessed via the calculated Cook's distance. The 'Cook's distance' assesses the influence each data point has on the model's predictive ability (Field, 2018) by measuring its effect when removed. Pallant (2010) suggests that any cases with a Cook's distance value over 1 should be examined further.

The independent variables can be entered into the regression in three ways; all together at once, one at a time in a determined hierarchical order or stepwise where the computer enters or removes the variables one at a time in an order determined by the mathematical effect they have on the model. Each method would result in a slightly different regression equation. If there was no correlation between the predictors the order of entry would not matter as it would not affect the results. However, as there is some degree of correlation between them, they either need to all be entered at once or a decision made on the specific order of importance based on evidence-based judgement (Field, 2018). There is controversy in the literature over the use of stepwise entries because of the risk of overfitting and variations in the sample can affect the importance of a variable for addition leading to difficulties in generalisation of findings and replicability (Field, 2018; Tabachnick and Fidell, 2014).

4.5.4.5 Logistic regression

As discussed earlier, multiple regression can be used to explore the relationship between a dependent continuous variable and other independent variables. However, if the dependant variable is not a continuous variable multiple regression is not appropriate. In this situation, logistic regression is used to test the predictive ability of independent variables on a categorical dependant variable. There are two types of logistic regression, binomial and multinomial, depending on the number of categories the dependant variable consists of.

Logistic regression uses the probability of an observation falling into one category or another to generate a model to predict the likelihood of the independent variable being in a particular category of the dependant variable (Field, 2018). Instead of directly measuring the y variable for a given x as you do in linear regression, in logistic regression it is the probability of obtaining the value for a given x that is used and it is the natural log of the odds ratio that is used to find the best fitting predictive equation (McDonald, 2014). The odds ratio (the ratio of the odds of an event happening to it not happening) are calculated from the probability.

So, using the probability of a burn patient in ICU having a low or high ‘mobility limitation’ score as an example. The probability would have a value between 0 and 1. If the probability of a burn patient in ICU having a high ‘mobility limitation’ score was 0.75 (75%) the probability of them having a low ‘mobility limitation’ score would be 1 - 0.75 = 0.25 (25%). The odds (the ratio of the probability of something happening over the probability it will not) of a burn ICU patient having a high ‘mobility limitation’ score would be 0.75/0.25 = 3. Therefore, the odds of a burn ICU patient having a high ‘mobility limitation’ score is 3 to 1, or 3 to 1 against a burn ICU patient having a low ‘mobility limitation’ score. Another way of stating this is that a burn ICU patient is 3 times more likely to have a high ‘mobility limitation’ score to a low ‘mobility limitation’ score.

In binary logistic regression, the probability of being in the larger of the two groups of the dependent variable is calculated first. Then the model with the predictor variables is compared against this to see if the inclusion of the predictor variables contributes significantly to model fit. It is not possible to work out the R^2 for the amount of variance in the dependant variable explained by the model in the same way as in linear regression. Nevertheless, an idea of what the explained variance maybe can be given by Cox and Snell R square and Nagelkerke R square values which are known as pseudo R square statistics (Pallant, 2010).

Similarly to multiple regression, the B values are given. Here they are the probability of a case falling into a particular category. If the B values are negative values then they will indicate that an increase in the predictor variable will cause a decrease in the probability of the outcome. Whereas if it is a positive value there will be an increase in the probability. This is mirrored in the SPSS 'Exp(B)' (odds ratio) column. If the odds ratio is between 0 and 1 then it is less likely the event will occur compared to the reference group. If greater than 1, it will be more likely. These calculations are performed controlling for all the other variables in the equation so may give differing results than if calculated separately.

Logistic regression makes four assumptions (Stoltzfus, 2011). First, that the categories are independent of each other. In other words, it is not possible for an observation to be in more than one category. Second, that there is no multicollinearity between the predictor variables as discussed in the previous section on multiple regression. Third, that there are no influential outliers that will compromise the model's accuracy and lastly, that there is a linear relationship between the variables and their log transformation.

Like with multiple regression, the sample size and number of predictors will affect the result. If the sample size is small and there are lots of independent variables the resulting model will be an overfit with the beta coefficients being larger than they should. Regardless of sample size, there needs to be data in all the possible combinations of the variables included in the model otherwise the model is likely to be inaccurate. Large standard errors may be an indication of this (Field, 2018).

4.5.4.6 Krippendorff alpha

The Krippendorff alpha test was used to analyse the data for inter-rater reliability using Hayes' (2007) KALPHA macro for SPSS. The Krippendorff alpha test quantifies the extent of agreement and reliability between the scorers (Hayes and Krippendorff, 2007). The Krippendorff alpha test, although initially designed for assessing the degree of reliability between coders undertaking content analysis, is applicable for other situations where the level of agreement between raters needs to be measured (Krippendorff, 2011). It differs from other coding reliability measures as it calculates disagreements rather than agreement (Hayes and Krippendorff, 2007).

Although the simplest way of calculating the level of agreement between the scorers is to calculate the per cent agreement this does not take into consideration any agreement by chance and could overestimate the level of agreement (Glen, 2020). The smaller the sample, the greater the probability of agreement by chance. Other methods suitable for categorical variables are Cohen's and Fleiss's kappa. Cohen's kappa is designed for when there are only two raters so was not suitable here. Both Cohens and Fleiss's kappa although they consider the agreement by chance and are suitable for categorical variables, they only treat the data as nominal, (Hayes and Krippendorff, 2007). The data being analysed in this study was treated as ordinal as although there was an order to the scoring categories the distance between them is not measurable i.e. it is not possible to say that a score of two is twice that of one. Krippendorff alpha on the other hand can be used when there are more than two raters, multiple categories being rated, for small or large sample sizes and different levels of measurement including ordinal as is the case in this study.

There is no universal agreement of what is a good or bad level of inter-rater reliability (Van Stralen et al., 2012). The closer to 1 the coefficient is the nearer it is to perfect agreement, whereas zero would be no agreement at all. However, the cut-off point of what might be seen as an acceptable level of agreement will depend on the research and risks if invalid conclusions are drawn from the results (Krippendorff, 2004). For example, decisions that might affect lives will have a higher acceptable score set. For the purposes of this research, the strength of inter-rater reliability will be interpreted here in line with Altman's (1991) agreement levels as follows: <0.20 = poor; 0.21-00.40 = Fair; 0.41-0.60 = moderate; 0.61-0.80 = good and 0.81-1.00 = very good.

4.6 Part Three Methodology - Testing of Findings and any Hypotheses Generated from Parts One and Two on the Whole iBID

The aim of the third part of this research study was to confirm any hypotheses and predictive models that emerged from the first two parts of the research on the whole database. First the descriptive and correlation statistic results that had been identified as having potential clinical significance, as well as statistical significance, were repeated on the whole database to confirm the findings. Specifically, the frequency and spread of the iBID ND total scores were confirmed, along with the Spearman correlation tests with the iBID total score and its sub-variables. The average ND daily trends for the different TBSA groups were also repeated on the whole database to check out the sample findings and see if the results could be applied clinically.

Secondly, the stepwise regression models generated for the maximum, first and average ND scores were cross-validated on the whole database, excluding the data sample that had been analysed and the predictive models trained on. The aim of the cross-validation was to see how well the sample predictive model worked on unseen ('held-out') data and to validate any predictive models that might be potentially useful clinically. This cross-validation was performed by a statistician using the statistical programme R (R Core Team, 2017).

Thirdly, a narrative data quality review of the iBID was undertaken in relation to the ND data to ascertain the likely quality of the data being analysed and the confidence that might be had from the results of this research. The PARENT framework (Zaletel and Kralj, 2015) was used to undertake this analysis.

4.7 Ethical Considerations

Consideration of ethical issues is essential in any research study, particularly in healthcare (HRA, 2017a). The principles of sound ethical research are very similar to the Nursing and Midwifery Code (NMC, 2018) which sets out professional standards of practice and behaviour for Nurses. Heale and Shorten (2017) take this one step further suggesting that the ethical principles for research are a natural extension of nursing practice ethics. The ethical issues for this study will be discussed using the Beauchamp and Childress (2013) suggested framework of four core principles; respect for autonomy, non-maleficence, beneficence and justice. There is a debate about whether one ethical principle can override another. Beauchamp and Childress (2013) explicitly argue that no order should be assigned to the principles whereas, contrastingly, Armon (2018) suggests a hierarchical order is needed as some principles require answering before moving to the next (e.g. the principle of justice first to establish a need for the research). While this may be a reasoned argument, in reality the ethical issues of a study do not always fall neatly into a category and may overlap and have conflicting aspects. Therefore, in this study, no principle was given more priority than others as each situation is different and the justification for an action needs weighing up taking all the principles into consideration (Beauchamp and Childress, 2013).

4.7.1 Respect for autonomy

One of the key ethical principles in research and healthcare is the right to ‘autonomy’ or the right to make one’s own decisions (Beauchamp and Childress, 2013). In research, this translates into the imperative need for ‘informed consent’. Thus, in line with the HRA (2017a) guidance, the participants were given verbal and written information about the study and what their participation would involve. They were encouraged to ask questions either at the time the study was explained or later, via email or phone, after they had had time to reflect on the information. Participation was purely voluntary, and participants were assured that even if they agreed to take part they could withdraw at any time without having to give a reason or prejudice.

HRA says participants should be "informed in broad terms of the nature and purpose of the research and the material risks, benefits and reasonable alternatives" (HRA, 2017b: 6). The new HRA guidance also now suggests that the amount of information given to participants should be proportionate to the type of research and potential risks, so that participants are not overwhelmed with information. However, when this study was designed, an in-depth participant sheet was required which potentially could have put some participants off. If the research was to be conducted now, part two of the participant information sheet could have been made accessible for the participant to access if they so wished which is the layered approach that HRA now suggests.

Respecting the participant's autonomy also means respecting their right to privacy and confidentiality (Gillon, 1994). To ensure confidentiality, the data collection and surveys were anonymised. The only personal, identifiable data that was collected was the participant's name on the consent forms. To ensure confidentiality was maintained the consent forms were stored in a locked designated cabinet in the Health, Education and Life Sciences (HELS) faculty research offices which only designated research staff have access to, in line with the HELS Faculty's storage of research generated physical personal data policy (Foster, 2018). Confidentiality of the patients was also protected as no identifiable patient data was collected as part of this research and the data that was extracted from the iBID database was anonymised before being sent to the researcher.

4.7.2 Beneficence

Beneficence is the duty to act in a way that benefits others (Beauchamp and Childress, 2013; Heale and Shorten, 2017). This topic of nursing staffing levels and quality of patient care is currently high on the health care agenda

(RCN, 2019; UK Government, 2018). It is therefore a timely and socially acceptable topic of potential benefit to patients and staff as it is widely recognised that if staffing levels are not sufficient to meet patients' needs there is a risk to them: Care may be missed or problems not noticed and acted on in a timely manner, leading to adverse events early and increase mortality (Ball et al., 2018; Griffiths et al., 2018). The iBID dependency scoring of patients is undertaken routinely in burn services, so is not a new concept, but it is currently not used in any meaningful manner. If a better understanding of ND in patients with a burn injury can be gained this will ultimately enable more informed staffing levels to be calculated to the benefit of burn patients and nursing staff.

4.7.3 Non-maleficence

Non-Maleficence refers to the duty to 'cause no harm'. The research study does not affect the patient's condition or treatment so no risks to patients were anticipated. There were no risks of physical harm to the participants either. Nonetheless participating in this study would mean some extra work for the participants on top of their normal workload. In burn services, in England, data on patient dependency is collected and recorded in iBID daily as a matter of routine, so no new data was being collected, nor additional work generated in this respect. However, although the SNCT is routinely used in NHS trusts in the UK on an intermittent basis it was not the case in all these trusts so collecting this data may result in a small amount of additional work (5-10 minutes) for the nursing staff each day. This was discussed with the nursing teams and agreement reached as to when the data would be collected and how, to cause as little disruption to their routine as possible.

One concern when doing research in a health setting is what to do if unsafe or poor practice is identified (Surmiak, 2019). The risk of identifying poor practice was minimal as all data was collected anonymously and not linked back to individual participants nor patients. Nevertheless, it was agreed with participants that if unsafe standards of care/staffing levels were identified it would be reported to the ward manager to deal with locally as appropriate.

4.7.4 Justice

This principle relates to fairness, equality and non-discriminatory treatment (Beauchamp and Childress, 2013). It is often related to the ethical issues of allocation and cost of treatments. Although arguably not directly relevant to this research study, indirectly it could be claimed that all patients should be entitled to the correct levels of nurse staffing for their needs and the results of this study could influence this. That without having a true understanding of patient dependency in burn care, patients may not get the level of care they require due to the current economic restraints on staffing. Therefore, under the principle of justice, more weight is added to the case that it is ethically appropriate to undertake this research.

4.7.5 Ethical approval

Ethical approval, for all parts of this study, was obtained from Birmingham City University Faculty of Health, Education and Life Sciences Ethics Committee. Permission for access to the raw data from iBID for analysis was sought and gained from the Burn Care Informatics Group. This is the group that, on behalf of NHS England, oversees the management and use of the database and have the responsibility to ensure that access to the data is appropriate. Part two of this research was undertaken in the NHS, so approval from the HRA was also gained along with permission from the three burn services and their Research and Development departments. See Appendix B for a copy of the ethical approval letters from BCU and HRA.

4.8 Summary

The purpose of this chapter was to reiterate the aims and objectives and to explain the methodology used to answer the research questions. To this end, the chapter has explained how each stage of the research was undertaken.

An overview of the different statistical tests used in this research has also been given in order to underpin the rationale for the statistical analysis process given in the next three chapters along with the results of those tests.

The next chapter will present the findings from the first part of this research, the comparison of the iBID ND tool with the SNCT.

Chapter 5 Comparison of the SNCT and iBID Nurse Dependency Tool Results

5.1 Introduction

Part one of the research aimed to address the second research objective to 'establish whether the iBID ND tool did measure ND' by comparing iBID ND scores with SNCT scores. Furthermore, the inter-rater reliability of the nurses' dependency assessment scoring was explored through the use of fictional case studies. Thus, answering the first two research questions ("Does the iBID ND tool measure ND compared to another nurse dependency tool?" and "do burn nurses score nurse dependency consistently?")

This Chapter presents the results of part one of the research, some of which have already been published (Leaver et al., 2021). A link to which can be found in Appendix I. First, a summary of the returned daily ND scores are given along with the results from the subsequent correlation analyses. Next, the correlation results and inter-rater results using the Krippendorff alpha for the case studies are presented. Finally, the post-study survey and staffing level results are discussed. The chapter will conclude with a discussion and appraisal of the results obtained in this part of the research.

5.2 Daily Dependency Scores' Results

When all three services had completed their data collection, the required data was extracted from iBID and sent electronically as a password protected spreadsheet to the researcher. A total of 283 entries were obtained for inpatients. Four of the entries had iBID ND scores of 0 which is not possible and were removed along with the 11 non-burn patients, leaving a total of 268 patient entries in total (each having both an iBID and SNCT score). Table 5.1 shows the number of patient entries per service. For services B and C the numbers were lower than expected, but after checking with all the services they thought that their numbers were typical for their capacity at that time.

Service B's low numbers were due to having had a quieter period than normally expected and service C because on investigation there had been a communication problem and only their ICU had recorded the scores and not the ward. Service C's deviation from protocol could have added location bias but is arguably counteracted as one of the other services did not have many ICU patients during this period. Nonetheless, despite there being fewer patient entries than expected the numbers were still more than Cohen's (1992) minimum of 28 for identifying a large effect size at the 0.05 significance level for a correlation test.

Table 5.1 The number of patient entries scored using both the SNCT and iBID ND total score

Service	Number of patient entries
A	165
B	55
C	48

A Spearman's correlation analysis was performed to examine how well the SNCT and iBID ND total scores were correlated with each other and the variables collected. Spearman's correlation was used because the data was a mixture of ordinal and scale data and was therefore non-parametric in nature. It was noted that service C had not filled in any data for the 'skilled nursing needs' and 'medical intervention' variables so these were left out of the initial correlation as SPSS would have removed all these cases pairwise anyway and the results would have been skewed.

The results of the first correlation on all the data are shown in in Table 5.2**.** The Spearman correlation coefficient between the iBID ND total score and the SNCT score was 0.87 ($p<0.0005$, 95% CI = 0.82-0.90), indicating a very strong positive relationship between the two, in that as the SNCT score increases so does the iBID ND total score. This would suggest that in all probability the iBID ND total score does measure at least an aspect of ND.

Table 5.2 Spearman correlation coefficient (ρ) and bootstrapped 95% confidence intervals of the IBID ND score and SNCT score (N= number of cases. The results highlighted green are a strong correlation, those highlighted orange a moderate correlation and those highlighted yellow no statistically significant correlation).

		SNCT score	dependency days post-admission	Group age 1	Ward type	Monitoring	Procedure complexity	Psychosocial support	ADL achievement	Mobility limitations	Basic care requirements	Therapy complexity total
IBID ND total score (N=268)	correlation coefficient (ρ)	0.87	0.48	-0.01	-0.87	0.87	0.45	0.59	0.88	0.88	0.88	0.82
	sig. (2-tailed)	<0.0005	<0.0005	0.99	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	95% confidence interval	0.82 - 0.90	0.39 - 0.56	-0.10 - 0.10	-0.88 - -0.85	0.84 - 0.88	0.32 - 0.55	0.49 - 0.68	0.85 - 0.90	0.85 - 0.90	0.86 - 0.90	0.78 - 0.84
SNCT score (N=268)	correlation coefficient (ρ)	1.00	0.53	0.04	-0.85	0.84	0.20	0.44	0.84	0.84	0.89	0.75
	sig. (2-tailed)		<0.0005	0.47	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	95% confidence interval		0.45 - 0.60	-0.05 - 0.14	-0.90 - -0.81	0.80 - 0.87	0.06 - 0.32	0.33 - 0.54	0.79 - 0.89	0.79 - 0.88	0.84 - 0.92	0.70 - 0.79

The only variable that did not appear to correlate with the iBID or SNCT scores was the age group; which is probably not surprising as any age could have any ND score depending on their condition and period of hospitalisation. The ‘ward type’ had a negative correlation due to the way the areas were ordered in the data. The ICU had been allocated a one and the burn ward a three. Nonetheless, the results demonstrated that the dependency score was higher in ICU than on the ward as would be expected.

Intuitively a negative correlation between ND total score and the number of days post-admission/injury would have been expected (as the number of days increased the dependency went down). However, the results appear to show a moderate positive correlation. This could be because the relationship was not a linear one, as it would not be unreasonable to expect the dependency to go up initially and then gradually reduce. Nonetheless, this data is only a snapshot during a patient’s admission, so it is not possible to make any generalisation about this.

Of particular note is the correlation coefficient of the ‘procedure complexity’ and ‘psychosocial support’ variable which were 0.45 and 0.59 respectively with the iBID ND total score. Both demonstrated a positive correlation but were much lower than the other variables that made up the iBID ND total score. These were also the two variables that showed the lowest correlation with the SNCT score (ρ = 0.20, 95% CI = 0.06-0.32, and ρ = 0.44, 95% CI = 0.33-0.54 respectively); which interestingly, in both cases, was noticeably lower than for the iBID ND data.

The weaker correlations of the ‘procedure complexity’ and ‘psychosocial support’ variables with the SNCT was not unexpected as, unlike iBID, the SNCT does not explicitly differentiate between different levels of dressing needs or psychosocial support required. The SNCT (The Shelford Group, 2014, 6) only refers to ‘psychological support’ in its level 1b category when referring to “patients/carers requiring psychological support due to poor prognosis or clinical outcome”, which fails to address the extent to which pre-existing or ongoing psychological and social needs impact on ND. It has been shown that the life-changing impact of a burn will tend to cause a greater extent of psychosocial harm than arises from general medical care (Knol et al., 2020). Thus the SNCT is potentially limited in its ability to reflect this aspect of nursing acuity. With regards to procedure complexity, the SNCT (The Shelford Group, 2014: 6) only mentions wound care in their level 1b descriptor in reference to “Complex wound management requiring more than one nurse or takes more than an hour to complete”. Within burn care, the level of wound management does not necessarily scale with case complexity, for example, a dressing may require several hours for a patient with larger burns on a general burn ward and hence would be limited to a 1b under SNCT descriptors regardless of the other descriptors met. Conversely, when a patient that is in ICU and categorised at a higher SNCT level, the SNCT does not have the ability to identify the increased workload and resource drain that the addition of a time consuming, complex dressing adds

The spread of the iBID sub-variable values for each of the SNCT levels was examined in more detail in Table 5.3. Table 5.3 shows that apart from the ‘procedure complexity’ and ‘psychosocial support’ sub-variables, only the higher iBID variable scores were used for SNCT level 3, as might be expected, as these patients would be ICU patients. The other categories were less consistent. In particular, the 1a SNCT level showed a wide variation of all variables. This may be because 1a patients are classed as acutely ill or likely to deteriorate so the care required may vary considerably in terms of the iBID ND variables. Also, when investigating the cases for the SNCT 1a level further it was noted that there were two cases where the iBID score was notably higher than the rest. This was where a patient was in ICU but scored a SNCT level 1a. It is not possible to say whether this was an error in the scoring, an anomaly in this sample or an accurate score which with a larger sample would have been more representative.

Table 5.3 Range of the different iBID ND variable values for the SNCT categories. An explanation of each variable value can be found in Table 2.2. (For the ward type BW = burn ward, BHDU = burn HDU, BICU = burn ICU)

SNCT score	iBID ND total score	Monitoring	Procedure complexity	Psychosocial support	ADL achievement	Mobility limitations	Basic care requirements	Medical interventions	Ward type
0	4-8	B1	P0 – P3	S1 – S2	D1 – D2	L1 – L2	C0	M2	BW
1a	5-23	B1, B4	P0 – P4	S1, S2, S5	D1, D2, D5	L1, L2, L5	C0,C3	M2-M3	BW/BICU
1b	4-11	B1	P0 – P4	S1, S2, S3, S5	D1 – D3	L1, L2,	C0,C1	M0 – M2	BW
2	5-18	B1, B2	P0 – P5	S1 – S5	D1 – D5	L1, L5	C0 - C3	M1 – M2	BW/BHDU
3	11-25	B2 - B5	P0 – P5	S1 – S5	D3 – D5	L3 – L5	C1 - C3	M2 – M3	BHDU/BICU

The ‘procedure complexity’ and ‘psychosocial support’ variables utilised a much wider range of all their variable levels in all the SNCT levels compared to the other variables. This wide range in the ‘procedure complexity’ and psychosocial support’ variables may account for the reduced correlation. For the ‘procedure complexity,’ this may be expected; as depending on the patient’s wound needs and dressing applied, it is feasible that a dressing procedure is not undertaken every day irrespective of burn size. Therefore, the Spearman correlation analysis was repeated without the zero ‘procedure complexity’ cases.

The results of removing the ‘no procedure’ (P0) category are shown in Table 5.4. There was little change to the variables with the exception of the ‘procedure complexity’ variable, which demonstrated an increase in the correlation coefficient from 0.45 to 0.76 when correlated with the iBID ND total score. Although lower than had been expected, as anecdotally burn nurses feel that the size of the dressing has a big impact on their workload, it was more in line with the other variables. A similar picture was seen with the change in the correlation coefficient with the SNCT scores with the ‘procedure complexity’ variable changing from 0.20 to 0.61. Despite this change, the correlation of the SNCT score was still much lower for the ‘procedure complexity’ and psychosocial support’ variables than the other variables, suggesting that the SNCT does not capture these aspects of burn care well. Additionally, the fact that the ‘psychosocial support’ variable had a lower correlation with both ND tools, albeit still a moderate effect size according to Schober et al. (2018), suggests that there may be other unknown factors that influence the scoring of the psychosocial needs of patients with a burn injury.

To explore this data further and see if there were differences between services the Spearman correlation test was run again, this time separately for each service. The result of this for the three services are shown Table 5.5.

Table 5.4 Spearman correlation coefficient and bootstrapped 95% confidence intervals of the IBID ND score and SNCT score with the zero procedure complexity cases removed (N= number of cases, The results highlighted green are a strong correlation, those highlighted orange a moderate correlation and those highlighted yellow no statistically significant correlation

		SNCT score	Dependency days post-admission	Group age 1	ward type	Monitoring	Procedure complexity	Psychosocial support	ADL achievement	Mobility limitations	Basic care requirements	Therapy complexity total
IBID ND total score (N=167)	correlation coefficient	0.88	0.53	0.04	-0.86	0.87	0.76	0.60	0.90	0.90	0.90	0.83
	sig. (2-tailed)	<0.0005	<0.0005	0.57	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	95% confidence interval	0.81 - 0.92	0.42- 0.63	-0.07 - 0.16	-0.88 - -0.83	0.83 - 0.90	0.66 - 0.83	0.48 - 0.70	0.87 - 0.92	0.86 - 0.92	0.87 - 0.92	0.80 - 0.86
SNCT score (N=167)	correlation coefficient	1.00	0.54	0.04	-0.85	0.83	0.61	0.46	0.84	0.85	0.80	0.75
	sig. (2-tailed)		<0.0005	0.60	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	95% confidence interval	1.00	0.45 - 0.63	-0.08 - 0.16	-0.89 - -0.78	0.78 - 0.87	0.50 - 0.72	0.32 - 0.58	0.77 - 0.89	0.79 - 0.90	0.83 - 0.92	0.68 - 0.80

*Table 5.5 Spearman correlation coefficient and bootstrapped 95% confidence intervals of the IBID ND score and SNCT score for each of the services showing the difference in correlations when all cases included against when the zero procedure complexity 0 are removed (N= number of cases, **= statistically significant at the 0.05 level, green = strong/very strong correlations, orange= moderate correlation, white= weak correlation, yellow = no correlation).*

			SNCT score	ward type	Monitoring	Procedure complexity	Psychosocial support	ADL achievement	Mobility limitations	Basic care requirement	Therapy complexity total	Skilled nursing needs	Medical intervention
Service A	IBID ND total score	All cases (N=165)	0.87**	-0.84**	0.84**	0.37**	0.66**	0.87**	0.87**	0.84**	0.84**	0.71**	0.64**
		Without procedure complexity 0 (N=113)	0.90**	-0.82**	0.83**	0.59**	0.69**	0.91**	0.89**	0.86**	0.83**	0.71**	0.63**
	SNCT score (N=165)	All cases (N=165)	1.00	-0.82**	0.82**	0.09	0.53**	0.84**	0.85**	0.84**	0.77**	0.73**	0.63**
		Without procedure complexity 0 (N=113)	1.00	-0.82**	0.82**	0.42**	0.57**	0.86**	0.86**	0.84**	0.75**	0.72**	0.60**
Service B	IBID ND total score (N=55)	All cases (N=55)	0.68**	-0.71**	0.70**	0.68**	0.80**	0.67**	0.62**	0.71**	0.65**	0.71**	0.66**
		Without procedure complexity 0 (N=29)	0.78**	-0.72**	0.72**	0.89**	0.81**	0.67**	0.68**	0.72**	0.81**	0.72**	0.63**
	SNCT score (N=55)	All cases (N=55)	1.00	-0.87**	0.87**	0.21	0.81**	0.64**	0.80**	0.87**	0.64**	0.87**	0.85**
		Without procedure complexity 0 (N=29)	1.00	-0.88**	0.88**	0.69**	0.82*	0.69**	0.77**	0.88**	0.68**	0.88**	0.84**
Service C	IBID ND total score (N=48)	All cases (N=48)	All scored the same (3)	-0.19	0.57**	0.81**	0.52**	All scored the same at D5	0.47**	All scored the same at C3	0.67**	Not scored	Not scored
		Without procedure complexity 0 (N=25)		-0.16	0.78**	0.58**	0.69**		0.72**		0.92**		
	SNCT score (N=48)		Unable to compute as all the same SNCT score										

For service C it was found that all the patients were in the SNCT 3 level, which was not too surprising as only ICU patients had been scored. Therefore, only a correlation with the iBID ND total score could be analysed. All the patients each day were scored the same for ‘ADL achievement’ (D5 fully dependant assistance with all tasks) and ‘basic care needs’ (C3 Requires help from > 2 people or 1:1 supervision). Considering that all these patients were likely to be ventilated this was not unexpected. Overall, for service C, the correlation coefficients although still statistically significant with a large effect size, were smaller than the other two services with the exception of ‘procedure complexity’. The ‘procedure complexity’ correlation coefficient value for all cases was 0.81, higher than the other two services (0.37 for service A / 0.68 for service B) and higher than the score for all services together (ρ = 0.76 as shown in Table 5.4**.**). Additionally, in contrast to the other services when the zero ‘procedure complexity’ was removed the correlation coefficient value dropped to 0.58 rather than improving. It is unclear why this would be the case even though the sample number was small (25). For service C there was minimal correlation with ‘ward type’, probably because the majority of their patients were recorded as being in a BICU with only two entries recorded as being in a BHDU. However, the other services had ND scores from patients on the ward, HDU and ICU.

Service A’s correlation coefficient values were on the whole similar to the values when all the data was analysed together (Table 5.2 and Table 5.4). The exception being the ‘procedure complexity’ and ‘psychosocial support’ variables. Where, for both the SNCT and iBID ND total scores, the ‘procedure complexity’ correlation was less and the ‘psychosocial support’ correlation was higher.

For service B the iBID ND total score correlation coefficient values were lower than service A but higher than service C’s. The exceptions, again being with the ‘procedure complexity’ and ‘psychosocial support’ variables, where their correlations coefficient values were higher than service A’s. Furthermore, service B’s SNCT scores had higher correlations than for service A. It was noticed that unlike service A which had a range of ward types recorded and service C which mainly had only BICU recorded, service B had mostly burn ward recorded as the ward type. Therefore, it was postulated that it could be the ward types that caused the correlation variations as opposed to the services. To examine this further the data was split into ward types rather than services and then analysed. See Table 5.6.

Table 5.6 shows the Spearman correlation coefficients of the iBID ND total score and the SNCT score when the data was compared based on ward type. Comparing the data by ward type shows a very different picture to where the data was compared by service. For the BICU and BHDU, the SNCT did not have any statistically significant correlation with the iBID variables apart from the ‘psychosocial support’ where there was a small unexpected negative correlation in the BICU patients. Suggesting perhaps that in a BICU as the patients’ overall SNCT score decreased their psychosocial needs increased. A suggestion for this could be that a BICU patient is likely to be ventilated with a greater focus on their physiological needs and it is perhaps not until their ND reduces that the priorities of care and focus shifts to consider the wider additional needs of the patient in the SNCT scoring system. However, with the iBID ND total score there is a strong positive correlation (0.60) with ‘psychosocial support’ which does not fit with this theory. It is likely to be that the iBID ND tool is more sensitive to psychosocial needs than the SNCT as it had a dedicated variable and will take into account the increased psychosocial support required for relatives in BICU even if the patient is ventilated and unconscious. For the burn ward, the SNCT had weak to moderate statistically significant correlations (0.24 – 0.57) with the variables and the iBID ND total score moderate to strong statistically significant correlations (0.44 – 0.84). Interestingly the iBID total score correlation with the ‘procedure complexity’ and ‘psychosocial support’ variables was higher than with the others which is different from the correlations in Table 5.2, Table 5.4 and Table 5.5.

.

*Table 5.6 Spearman correlation coefficient and bootstrapped 95% confidence intervals of the IBID ND score and SNCT score for each of the ward types showing the difference in correlations when all cases included against when the zero procedure complexity 0 are removed (N= number of cases, **= statistically significant at the 0.05 level, green = strong/very strong correlations, orange= moderate correlation, white= weak correlation, yellow = no correlation)*

			SNCT score	Monitoring	Procedure complexity	Psychosocial support	ADL achievement	Mobility limitations	Basic care requirement	Therapy complexity total
BICU	IBID ND total score	All cases (N=92)	-0.10	0.30**	0.77**	0.60**	0.14	0.40**	0.05	0.42**
		Without procedure complexity 0 (N=53)	-0.13	0.55**	0.59**	0.71**	0.26	0.45**	0.18	0.40**
	SNCT score	All cases (N=92)	1.00	0.06	0.02	-0.21***	-0.04	-0.07	-0.02	-0.17
		Without procedure complexity 0 (N=53)	1.00	0.03	0.01	-0.18	-0.04	-0.06	-0.02	-0.15
BHDU	IBID ND total score	All cases (N=28)	0.08	0.36	.78**	.61**	0.36	0.40**	0.15	0.62**
		Without procedure complexity 0 (N=16)	0.15	0.43	0.90**	0.45	0.83**	0.61**	0.53**	0.67**
	SNCT score	All cases (N=28)	1.00	0.35	0.21	-0.09	-0.03	-0.05	0.41**	-0.21
		Without procedure complexity 0 (N=16)	1.00	0.37	0.29	0.00	0.00	0.04	0.30	-0.13
Burn ward	IBID ND total score	All cases (N=148)	066**	All scored the same at B1	0.67**	0.66**	0.47**	0.44**	0.51**	0.45**
		Without procedure complexity 0 (N=98)	0.67**		0.72**	0.62**	0.61**	0.55**	0.59**	0.51**
	SNCT score	All cases (N=148)	1.00		0.24**	0.49**	0.33**	0.40**	0.56**	0.36**
		Without procedure complexity 0 (N=98)	1.00		0.43**	042**	0.35**	0.44**	0.57**	0.32**

To explore the differences between the three ward types in more detail the range of iBID variable values for each ward type was put into Table 5.7 to see if there was a pattern. It was noted that the burn ward had the lower iBID variable values but there was overlap between the BICU and BHDU iBID variable values. When BICU and BHDU were combined together there was a clear demarcation of the iBID variable values between the burn ward and BICU/BHDU combined. The 'procedure complexity' and 'psychosocial support' variables were the exception with both the burn ward and BICU/BHDU having the full range which could explain their lower correlations.

Table 5.7 Range of the different iBID ND variable values for the ward type categories (N= number of cases)

Ward type	iBID ND total score	Monitoring	Procedure complexity	Psychosocial support	ADL achievement	Mobility limitations	Basic care requirements	Medical interventions	SNCT score
BICU N = 93	14-25	B3-B5	P0–P5	S1–S5	D4–D5	L4–L5	C1, C3 (N.B. only 1 C1)	M2-M3	3, 1a (N.B. only 2x1a)
BHDU N = 28	11-22	B2-B4	P0–P5	S1–S5	D3-D5	L3–L5 (only 1 L3)	C1-C3	M2-M3	2-3
Burn ward N = 148	4-15	B1	P0–P5	S1 - S3, S5	D1 – D3	L1–L3	C0-C1	M0-M2	0-2
BICU/ BHDU	11-25	B2-B5	P –P5	S1–S5	D3–D5	L3-L5	C1, C3	M2-M3	1a, 2, 3 (N.B. only 2x1a)

The Spearman correlation test was repeated (see Table 5.8), this time with the ward types divided into two (burn ward and combined BICU/BHDU). With the BICU and BHDU combined the correlations were statistically significant for the variables with the iBID ND total score similar to the burn ward. However, Table 5.8 showed that for the burn ward the variables had a stronger correlation with the SNCT score than the more intensive care areas. It was also interesting to note that the therapy complexity, which later comes out as a strong predictive factor in the predictive regression analysis models (section 6.2.2.2), had a stronger correlation with the burn ward than the BICU/BHDU.

*Table 5.8 Spearman correlation coefficient of the IBID ND score and the SNCT score split into two ward type groups with BICU and BHDU combined showing the difference in correlations when all cases included against when the zero procedure complexity 0 are removed (N= number of cases, **= statistically significant at the 0.05 level, green = strong/very strong correlations, orange = moderate correlation, white= weak correlation, yellow = no correlation.*

			SNCT score	Monitoring	Procedure complexity	Psychosocial support	ADL achievement	Mobility Limitations	Basic care requirement	Therapy complexity total
BICU/ BHDU	IBID ND total score	All cases (N=120)	0.29**	0.54**	0.73**	0.51**	0.45**	0.56**	0.43**	0.28**
		Without procedure complexity 0 (N=69)	0.30*	0.70**	0.72**	0.52**	0.63**	0.68**	0.56**	0.24**
	SNCT score	All cases (N=120)	1.00	0.44**	0.14	-0.12	0.32**	0.25**	0.56**	-0.19**
		Without procedure complexity 0 (N=69)	1.00	0.40**	0.31**	-0.12	0.37**	0.29**	0.49**	-0.15
Burn ward	IBID ND total score	All cases (N=148)	0.66**	All scored the same at B1	0.67**	0.66**	0.47**	0.44**	0.51**	0.45**
		Without procedure complexity 0 (N=98)	0.67**		0.77**	0.62**	0.61**	0.55**	0.59**	0.51**
	SNCT score	All cases (N=148)	1.00		0.24**	0.49**	0.33**	0.40**	0.56**	0.36**
		Without procedure complexity 0 (N=98)	1.00		0.43**	0.42**	0.35**	0.44**	0.57**	0.32**

5.2.1 Comparison of the IBID sample correlations with the correlations of the iBID and SNCT ND scores collected over a two-week data collection period

Following the analysis of the daily dependency scores that were collected for part one of this research, the resulting iBID correlations in Table 5.2 were compared to the equivalent correlations obtained from the analysis of the iBID sample in part two of the research (see Table 5.9). This was in order to ascertain whether the findings from part one of the research were mirrored by the larger iBID sample.

Looking at the iBID correlations in Table 5.9, prior to any filtering of categories, it was seen that six of the variables (‘procedure complexity’, ‘psychosocial support’, ‘ADL achievement’, ‘mobility limitations’, ‘basic care requirements’, and ‘therapy complexity total’) had similar correlations for both the part one sample and the iBID sample. The ‘days post-admission’, ‘ward type’ and ‘monitoring’ variables for the iBID sample, compared to the part one collected data, all continued to have a statistically significant correlation but the Spearman correlation coefficient had nearly halved in each case. Thus, indicating a lower strength in the relationship with a larger sample collected from a wider population.

Analogous to the part one collected data, Table 5.9 shows that the ‘procedure complexity’ variable in the iBID sample had a lower correlation with the iBID ND total score than the other variables. When the ‘no procedure’ category was removed from the ‘procedure complexity’ variable a similar picture, to the one shown in Table 5.4, is seen in Table 5.10 where the procedure complexity correlation strength increases. Additionally, Table 5.9 shows that the ‘psychosocial support’ variable remains the one, out of the iBID ND tool sub-variables, with the lowest correlation with the iBID ND total.

Table 5.9 Spearman correlation coefficient and bootstrapped 95% confidence intervals of the daily collected and sample iBID ND scores (N= number of cases, green = strong/very strong correlations, orange = moderate correlation, white= weak correlation, yellow = no correlation)

		dependency days post-admission	Group age 1	Ward type	Monitoring	Procedure complexity	Psychosocial support	ADL achievement	Mobility limitations	Basic care requirements	Therapy complexity total
The iBID ND total score from part one daily collected comparison data (N=268)	correlation coefficient	0.48	-0.01	-0.87	0.87	0.45	0.59	0.88	0.88	0.88	0.82
	sig. (2-tailed)	<0.0005	0.99	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	Boot strapped 95% confidence interval	0.39-0.56	-0.10 - 0.10	-0.88 - -0.85	0.84 - 0.88	0.32 - 0.55	0.49 - 0.68	0.85 - 0.90	0.85 - 0.90	0.86 - 0.90	0.78 - 0.84
The iBID ND total score from the iBID data sample (N=18276)	correlation coefficient	0.18	0.07	-0.44	0.56	0.50	0.49	0.82	0.78	0.71	0.71
	sig. (2-tailed)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	Boot strapped 95% confidence interval	0.16 – 0.19	0.06 – 0.08	-0.45 - -0.43	0.55 – 0.57	0.49 – 0.52	0.48 – 0.50	0.82 – 0.83	0.78 – 0.79	0.70 – 0.72	0.70 – 0.72

Table 5.10 Spearman correlation coefficient and bootstrapped 95% confidence intervals of the daily collected and sample iBID ND scores with the no procedure category removed (N= number of cases, green = strong/very strong correlations, orange = moderate correlation, white= weak correlation, yellow = no correlation)

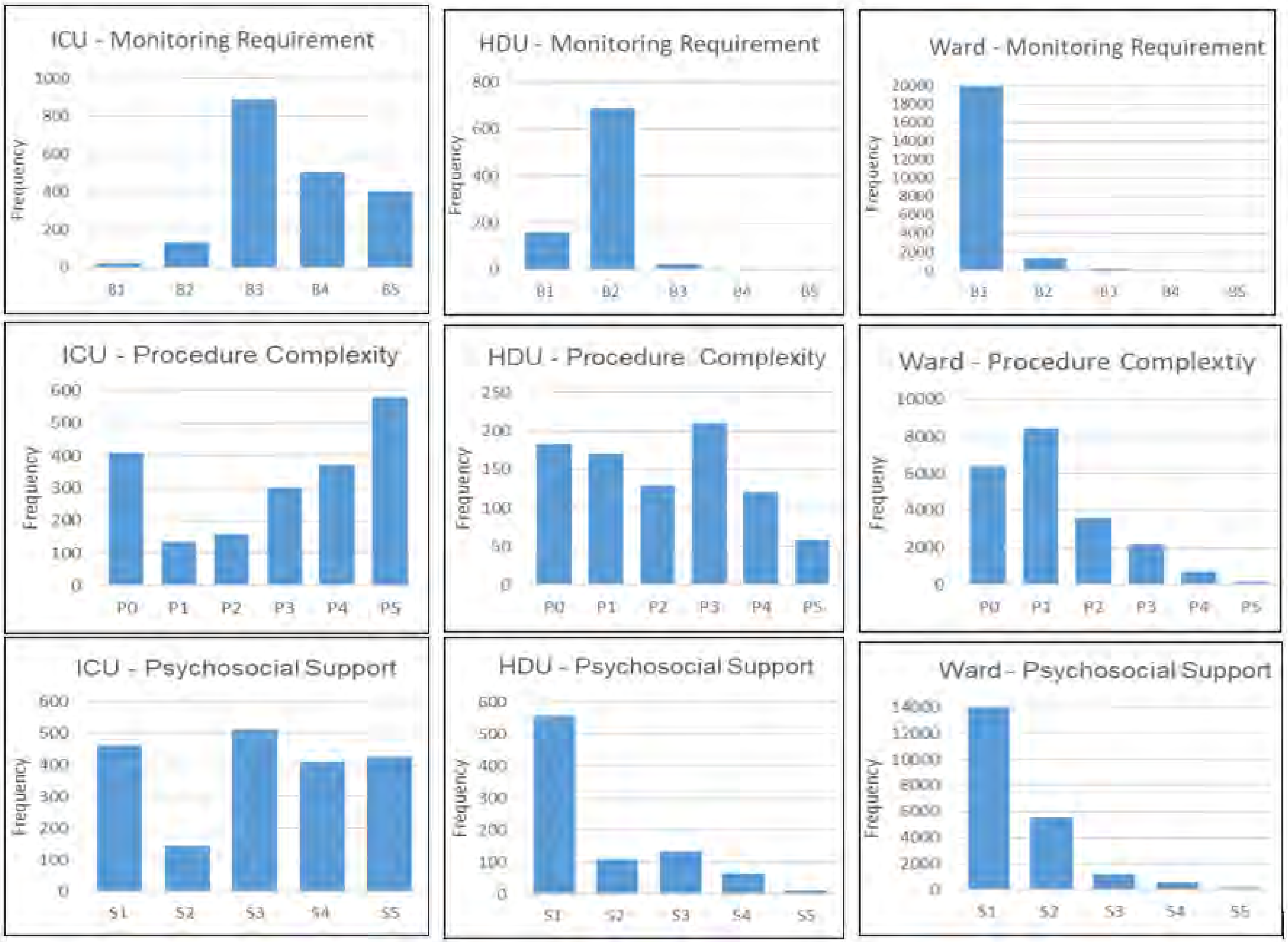
		dependency days post-admission	Group age 1	Ward type	Monitoring	Procedure complexity	Psychosocial support	ADL achievement	Mobility limitations	Basic care requirements	Therapy complexity total
Daily collected comparison data IBID ND total score (N=167)	correlation coefficient	0.53	0.04	-0.86	0.87	0.76	0.60	0.90	0.90	0.90	0.83
	sig. (2-tailed)	<0.0005	0.57	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	95% confidence interval	0.42- 0.63	-0.07 - 0.16	-0.88 - -0.83	0.83 - 0.90	0.66 - 0.83	0.48 - 0.70	0.87 - 0.92	0.86 - 0.92	0.87 - 0.92	0.80 - 0.86
IBID data sample iBID ND total score (N=13122)	correlation coefficient	0.24	0.09	-0.45	0.57	0.63	0.47	0.84	0.80	0.72	0.72
	sig. (2-tailed)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	95% confidence interval	0.23 – 0.26	0.072 – 0.10	-0.47 - -0.44	0.56 – 0.58	0.67– 0.64	0.46 - 0.49	0.84 - 0.85	0.80 – 0.81	0.72 – 0.74	0.70 – 0.72

The results presented in Table 5.9 and Table 5.10 suggest that there is consistency between the data collected by the services and the data in iBID when the data is analysed as a whole. Similarly, when the data is compared based on the ward type parallel patterns can be seen in Table 5.11. For the majority of the variables, the iBID sample data correlations were stronger, which if a relationship existed might be expected with a much larger sample size. The exceptions again were the ‘psychosocial support’ variable (which is similar for ICU but had weaker correlations for HDU and the ward) and the ‘procedure complexity’ variable (where the correlations were all weaker). It is not possible to explain the reasons for this from this data.

Earlier in Table 5.7, it was shown that there was a pattern to the variable sub-categories used to make up the iBID ND total score for each ward type with the part one collected comparison data. This was also looked at for the iBID sample data and it was found that most of the variables’ categories were used for each ward type. However, when the frequency of each of the variables’ categories were reviewed a similar pattern to the data collected in part one emerged (see Figure 5.1). The ICU contained more of the higher variable categories, the ward more of the lower categories and HDU a more even spread. Furthermore, the ‘procedure complexity’ and ‘psychosocial support’ variables tended to have a wider more equal spread of their categories compared to the other variables.

*Table 5.11 Spearman correlation coefficient of the daily collected and sample iBID ND scores of the iBID ND score split for each type of ward showing the difference in correlations when all cases included against when the zero-procedure complexity 0 were removed (N= number of cases, **= statistically significant at the 0.05 level, green = strong/very strong correlations, orange = moderate correlation, white= weak correlation, yellow = no correlation).*

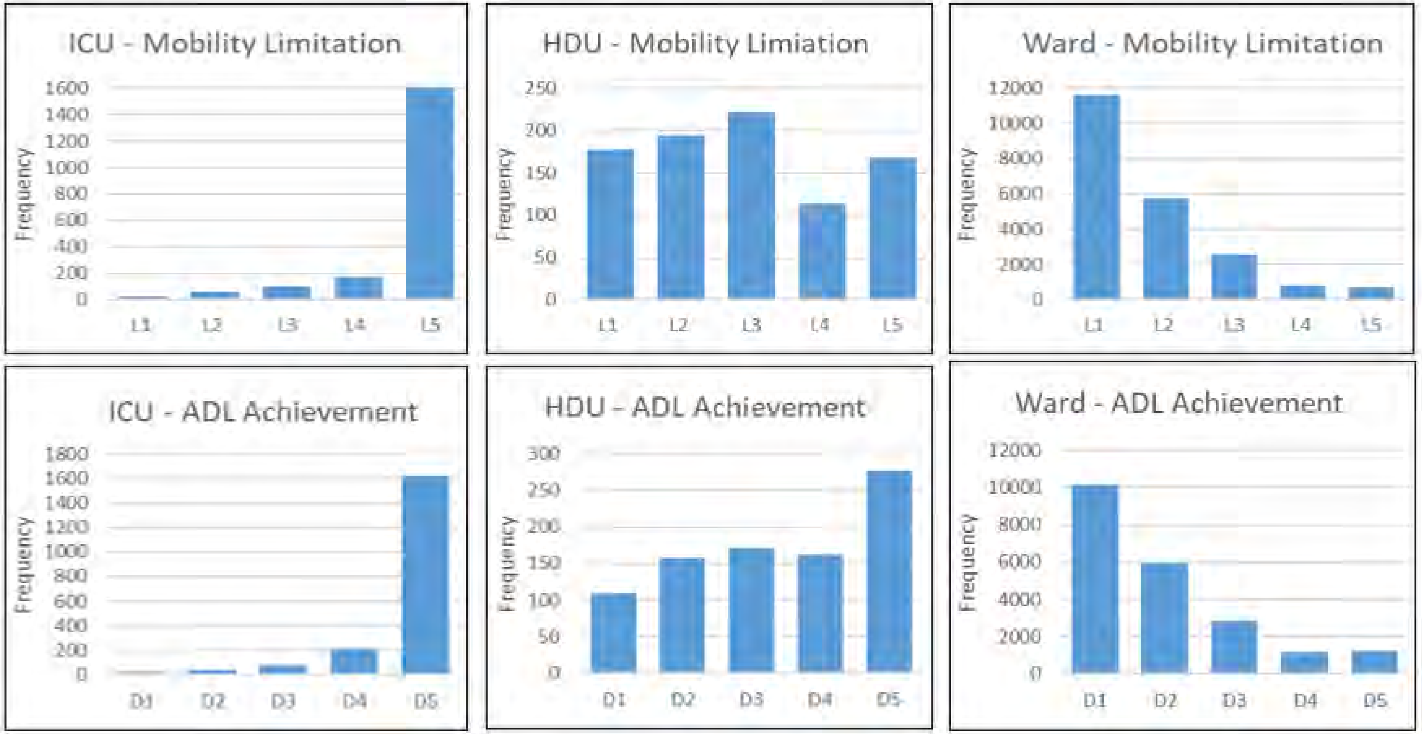
			Monitoring	Procedure complexity	Psychosocial support	ADL achievement	Mobility limitations	Basic care needs requirement	Therapy complexity total
Daily collected comparison data	BICU	All cases (N=92)	0.30**	0.77**	0.60**	0.14	0.40**	0.05	0.42**
		Without procedure complexity 0 (N=53)	0.55**	0.59**	0.71**	0.26	0.45**	0.18	0.40**
	BHDU	All cases (N=28)	0.36	.78**	.61**	0.36	.40**	0.15	0.62**
		Without procedure complexity 0 (N=16)	0.43	0.90**	0.45	0.83**	0.61**	0.53**	0.67**
	Burn ward	All cases (N=148)	Unable to compute as only one value recorded	0.67**	0.66**	0.47**	0.44**	0.51**	0.45**
		Without procedure complexity 0 (N=98)		0.72**	0.62**	0.61**	0.55**	0.59**	0.51**
iBID data sample	ICU	All cases (N=1371)	0.59**	0.70**	0.65**	0.41**	0.44**	0.29**	0.51**
		Without procedure complexity 0 (N=995)	0.67**	0.73**	0.79**	0.43**	0.46**	0.33**	0.57**
	HDU	All cases (N=538)	0.38**	0.60**	0.40**	0.86**	0.84**	0.74**	0.73**
		Without procedure complexity 0 (N=414)	0.39**	0.78**	0.41**	0.91**	0.84**	0.76**	0.73**
	Ward	All cases (N=16353)	0.34**	0.50**	0.42**	0.77**	0.72**	0.62**	0.63**
		Without procedure complexity 0 (N=11707)	0.35**	0.55**	0.43**	0.79**	0.74**	0.63**	0.63**



B1 Surgical Ward Level
B2 High dependency
B3 Intensive care
B4 Additional Intensive care
B5 Complex Intensive care

P0 - no dressing or procedure
P1 - simple small dressing <5% or ROS
P2 - single body segment dressing 5-10%
P3 - mod dressing 10-20% / small operation
P4 - multi segment dressing >20% / significant operation
P5 - near full dressing / major operation

S1 ward round contact - social
S2 explanatory chat
S3 significant support needed
S4 in depth discussion or NOK support
S5 intense observation or



L1 - fully mobile
L2 - some limitation supervision/assistance needed
L3 - significant limitation needing 1-2 assistants and walking aid
L4 - severe limitation hoist / tilting table / standing frame
L5 - totally immobile high pressure sore risk hoist only

D1 self caring - minimal input
D2 minimally dep assistance few tasks
D3 limited function assistance with some tasks
D4 severely limited assistance with most tasks
D5 fully dependant assistance with all tasks

Figure 5.1 Frequency bar charts for the iBID ND tool sub-variable categories from the iBID data sample separated into ward types. Showing that although most of the variable categories were used for each ward type, the ICU contained more of the higher variable categories, the ward more of the lower categories and HDU a more even spread.

5.3 Case Studies Results

To assess inter-rater reliability three case studies were given to all the participants to score using both the iBID ND tool and the SNCT as discussed in section 4.3.3.2. The return rate of fully completed case study score sheets from the three burn services was 60% (16 out of 27). (10/11 from burn service A, 3/6 from burn service B and 3/10 from burn service 3). These were added to the five score sheets from when the case studies were piloted giving a total of 21 sets of scores.

A Spearman correlation analysis was performed on the case study scores, as summarized in Table 5.12. The results are similar to the earlier SNCT and iBID ND comparison results (Table 5.2). The only category that was not as closely aligned was 'mobility limitations' where, for the case studies, there was a lower correlation (ρ = 0.69, CI = 0.51- 0.81 as opposed to ρ = 0.88, CI = 0.85- 0.90) although still a moderate strength correlation. It was also noted that the 'mobility limitations' was the only variable where there was no overlap in the confidence intervals for the two sets of results. However, due to the number of variables and allowing for multiplicity, there was no concern that two separate groups were being measured. In the case study results (Table 5.12), there is a statistically significant strong positive correlation between the SNCT scores and iBID ND total score (ρ = 0.82, CI = 0.71 - 0.89) which was comparable to the ND comparison results (ρ = 0.87, CI = 0.82 - 0.90), in Table 5.2, as might be expected if they are both measuring patient dependency. The similarity of the case study results and the collected comparison results gives confidence to the scoring consistency. Interestingly, the weakest correlation again was the 'psychosocial support' category with both the SNCT (ρ = 0.33, CI = 0.07 - 0.55) and iBID ND total score (ρ = 0.54, CI = 0.32 - 0.70). In fact, the 'psychosocial support' category was the only iBID ND category that has a weak to moderate correlation to all iBID variables and the SNCT. This suggests that 'psychosocial support' is influenced by other factors not captured elsewhere in the iBID scoring, nor the SNCT, which might also account for the lower inter-rater agreement if there is a range of psychosocial aspects that could be considered in deciding what support is needed. The importance and challenges of psychosocial care in burns in relation to these findings are discussed in detail in chapter 8 section 8.2.1

Table 5.12 The Spearman correlation coefficients and bootstrapped 95% confidence intervals results for the case study SNCT score against the iBID ND scores. (N= number of cases, green = strong/very strong correlations, orange = moderate correlation, white= weak correlation, yellow = no correlation)

		SNCT score	Monitoring	Procedure complexity	Psychosocial support	ADL	Mobility Limitations	Basic care requirements	iBID ND total score with basic are
IBID ND total score (N=63)	correlation coefficient	0.82	0.86	0.84	0.54	0.84	0.69	0.84	0.99
	sig. (2-tailed)		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	95% confidence interval	0.71 - 0.89	0.76 - 0.91	0.74 - 0.89	0.32 - 0.70	0.74 - 0.90	0.51 - 0.81	0.76 - 0.89	0.98 – 1.00
SNCT score (N=63)	correlation coefficient	1.000	0.84	0.75	0.33	0.73	0.68	0.84	0.82
	sig. (2-tailed)		<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	95% confidence interval	1.000	0.73 - 0.91	0.60 - 0.86	0.07 - 0.55	0.54 - 0.86	0.48 - 0.82	0.72 - 0.91	0.70 – 0.89

Having looked at the case study correlations the inter-rater agreement of the nurses was explored using the Krippendorff alpha statistical test as discussed in section 4.5.4.6. The results of the Krippendorff alpha test, shown in Table 5.13, demonstrate a good agreement between scorers (as per Altman's (1991) agreement levels discussed in section 4.5.4.6) for both the SNCT (α = 0.79, CI = 0.76 – 0.81) and iBID ND total score (α = 0.74, CI = 0.71-0.77). The SNCT appears to have a marginally better inter-rater score than the iBID ND tool score. This could be because there are only 5 categories to choose from for the SNCT whereas the IBID ND tool score is made up of more variables leading to a larger range for disagreement. Nonetheless, both show a good agreement between the nurses suggesting that the nurses interpreted their patient's acuity in a similar manner regardless of the burn service they work in or ND tool they use. However, as the nurses participating in this study were all senior nurses it does not necessarily follow that there would be the same agreement with junior nurses or others who had less experience in burn care.

Table 5.13 The Krippendorff alpha statistical test results and confidence intervals for the case study scores (A coefficient of one indicates perfect agreement and zero no agreement)

				The five categories that make up the iBID ND score						
		SNCT score	**iBID ND total score**	***Monitoring requirement***	***Procedure complexity***	***Psychological support***	***ADL achievement***	***Mobility limitation***	**Basic care needs**	**IBID ND total with basic care needs**
Krippendorff alpha	Coefficient.	0.79	0.74	0.76	0.77	0.32	0.67	0.79	0.79	0.74
	Bootstrapped 95% confidence interval	[0.76-0.81]	[0.71-0.77]	[0.71-0.80]	[0.73-0.81]	[0.24-0.40]	[0.61-0.71]	[0.77-0.82]	[0.76-0.81]	[0.71-0.77]

All the Krippendorff alpha metrics, apart from the ‘psychosocial needs' category, show good agreement (0.67-0.79) with tight confidence intervals. The ‘psychosocial needs’ category was the element that had the weakest agreement between scorers (α =0.32, CI = 0.24 – 0.40). From this study it is not possible to identify whether the reason for this is due to the case study design, nurses being inconsistent with their categorising of psychosocial needs or their lack of understanding of the variable categories. Furthermore, the ‘psychosocial needs' category also showed poor correlation with the SNCT and iBID ND tool in both the case studies (Table 5.12) and the ND tool comparisons (Table 5.2 and Table 5.4). The weaker correlation of the ‘psychosocial support’ score and SNCT may not have been unexpected, but the weak agreement between the nurses for the “psychosocial support” score was not expected. This could, as mentioned before, be due to the case study design or lack of clarity of the categories or it could be linked to the suggestion from the literature that nurses are aware of the importance of psychosocial care but do not always have the time, confidence, knowledge and skills to assess and meet their patients’ psychosocial needs adequately (Chen et al., 2017; Pehlivan and Küçük, 2016).

The ‘basic care needs’, although part of the iBID dependency categories is not included in the ND total score. It had one of the highest inter-rater reliability scores (0.79, CI 0.76-0.81), yet when added to the iBID ND total score neither the agreement score nor the correlation with SNCT were improved. The reason that the inclusion of the ‘basic care needs’ does not improve the correlation could be that the descriptors in this category overlap with descriptors in the other categories. The ‘basic care support needs’ variable categories are related to whether the patient is independent or whether they need help from one or more people. This will also be reflected in the ‘mobility limitation’ and ‘ADL achievement’ variable categories.

5.4 Post Data Collection Survey Results

Following the completion of the two-week data collection period for the comparison of the two ND tools, a link to the online post data collection survey was sent to all the participants. A follow-up email reminder one and two weeks later was sent to encourage participation and the service coordinators were also asked to remind the participants to complete the online surveys. The survey aimed to obtain the participants' views on using the SNCT and iBID ND tools. (See Appendix G for a copy of the survey questions). There were only nine surveys completed which was a 33% response rate. Although this response rate is in line with the average email survey response rates suggested in the literature (Cunningham et al., 2015; Nulty, 2008; Scott et al., 2011) it was a disappointing response rate. Moreover, as all but one response came from the same burns service the results may not be generalisable. On reflection maybe a paper survey may have been more successful as the participants could have completed without having to be at a computer. However in the current times, with many people having access to computers and smartphones it was thought that a digital survey would be quicker and easier for the participants.

All those that responded were experienced nurses who had been qualified for 10 years or more (range 10 -36 years and the mean 22). They were all band 6 or above and were frequently involved in assessing patient dependency but only one person had used both the iBID and SNCT previously. The question of how long they had been in burns may have given a better idea of their experience in burn care. However, as burn care is a small speciality, this potentially risked the ability to identify respondents.

Eight of the nine respondents thought it was important to assess patient dependency daily, with the ninth respondent not having a strong opinion. The two main reasons given were to identify changes in patient needs and to help evaluate workload and justify staffing levels. These reasons were summed up in one participant's response below

> *"The dependency of a patient will demonstrate the level and amount of care that patient requires. It is therefore a more accurate way of establishing your staff to patient ratio than just looking at the number of a patients you are caring for. You have to undertake it daily as a patient level of care will change on a daily basis."*

The participant that did not have a strong opinion explained their response as follows:

> *"staff need an understanding of why the tools need filling in"*

It is not possible to be sure if this person was referring to themselves or others. However, it could suggest that the reason they did not have a strong opinion was they did not have a good understanding of ND tools and workload planning. This is potentially supported further by their response to the next question on how important the respondent thought it was to have a scoring tool to assess nurse dependency'. They ranked it a two on the scale that went from 1 (not important) to 5 (very important). The remainder of the respondents ranked it a 4 or 5.

The next question asked the respondents to rank how easy or not they found the two tools were to use. None of the respondents found either tool difficult to use but more respondents ranked the iBID nurse dependency tool as 'easy' or 'very easy' to use than they did the SNCT, (see Figure 5.).

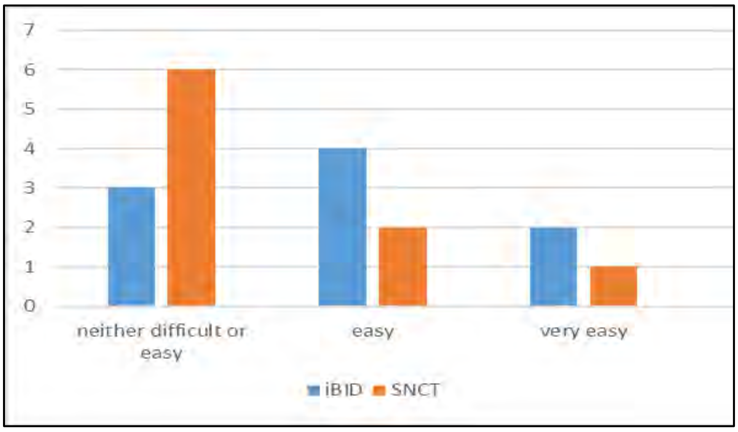


Figure 5.2 Comparison of how easy respondents found each tool to use. Using the results from the answers to question 5 "Please rank how easy you found the iBID dependency scoring tool to use?" and question 6 Please rank how easy you found the SNCT dependency scoring tool to use?

The respondents were asked in question seven which tool they preferred using and the reason for this. Four respondents preferred the iBID tool, three the SNCT and two respondents had no preference. Albeit, some of the respondents stated the reason for their choice was because they were more familiar with the tool, this was not mirrored across all respondents as some chose the tool that they were not using frequently. Two respondents stated the reason for preferring the iBID tool was it was more related to burn patients.

For those respondents who preferred the SNCT, they felt it was shorter and quicker to use but did not necessarily feel that it met the needs of burn patients the best. Figure 5. compares the respondents' ND tool preference with which tool met the needs of their patients with a burn injury better. Only one respondent thought the SNCT represented their patients' dependency needs the best compared with five that thought the iBID tool did. The reasons given for iBID was that it was more specific to burns and more detailed. Three respondents thought that both tools represented their patients' needs the same with one respondent saying:

"No tool can totally express our workload, any that could would be to unwieldy"

This view reiterates one of the conclusions from the literature review, that due to the many factors that affect ND no one ND tool has emerged as the 'gold standard' tool for predicting ND.

In questions 12 and 13 the respondents were asked how easy or difficult they found each of the tools' descriptions of level. None of the respondents found either of the tools difficult to use. One respondent did highlight the point that the scoring depends on who is doing the scoring and may differ between people. There is likely to be some subjectivity with scoring but the clearer the scoring criteria is the less this is likely to be.

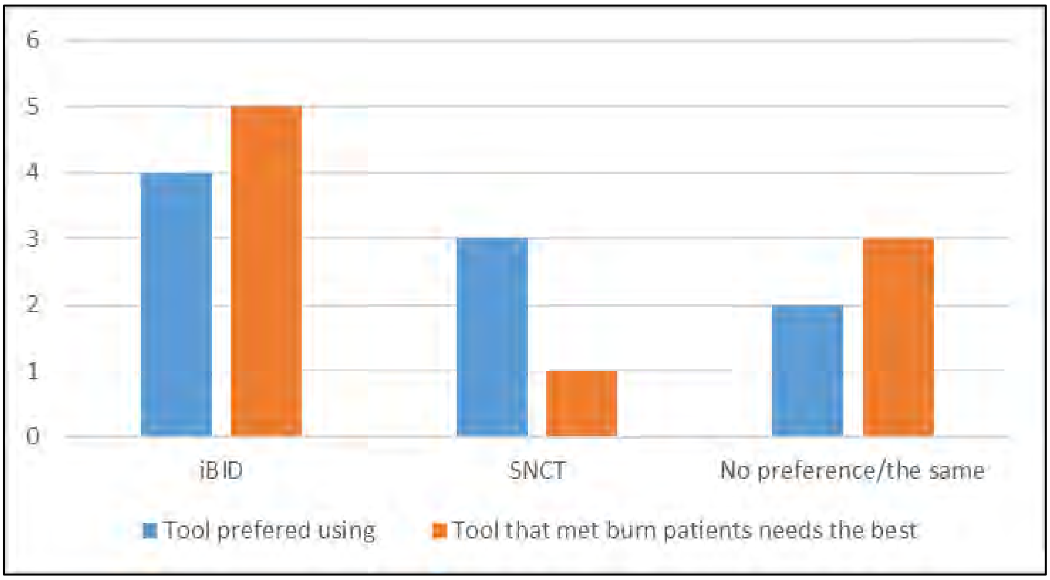


Figure 5.3 Comparison of respondents' tool preference (question 7) with the tool that they thought was more representative of patients with a burn injury ND needs (question 8).

The respondents were asked, "Is there any specific aspect/variable that you think is missing from the iBID tool?". Only one suggestion was made; colostomy care. This would certainly have an impact on nursing workload but is not be a common need in burn care.

In conclusion, the results from the post data collection survey indicate that the participants thought measuring ND was important and that they found both the SNCT and iBID ND tool usable. The iBID ND tool was seen to be more applicable to burn care. Nevertheless, these results are from a small sample so may not be generalizable to a larger population.

5.5 Daily Staffing Results

All three burn centres returned completed daily staffing levels forms for the data collection period. It was interesting to note that service C only had two days, out of the 14-day data collection period, where, in the professional judgement of the nurse in charge, they had enough staff. On a follow up conversation, they did say that they were very busy over this period which would account for this. The other two services felt that they had enough staff on more than half of the occasions. Service A had two days where, in the opinion of the nurse in charge, they did not have enough staff and two shifts where they felt there were too many. For Service B two-thirds of their shifts were adequately staffed. From the information returned, it is not clear exactly why there was not enough staff on some shifts. Events that affected the staffing levels were listed as less than normal rostered numbers, extra patients, increase in nursing needs, sickness of staff and large dressings.

When reviewing this data, it was realised that the overall bed occupancy and dependency of non-burn patients had not been asked for as part of the research. This meant that it was not possible to analyse the data any further and compare staffing numbers to dependency as originally intended. In hindsight, a more detailed survey with questions on the overall occupancy, dependency of other patients, and patient turnover may have enabled conclusions to be drawn about staffing numbers and the iBID ND total score.

5.6 Limitations of Part One of the Research - Comparison of Two ND Tools

This part of the research was a small-scale study and was only a snapshot of the ND of patients with a burn injury taken over a short time period of two weeks. However, it did involve burn centres from three of the four burn networks that input data into iBID so is arguably representative of UK burn services. The number of participants was also small but represents all the nurses who would normally score ND in the participating burn services. Additionally, due to the nature of burn injuries these patients can have long lengths of stay, meaning that resampling of the same patient was likely to have occurred which may have reduced the variation of dependency needs. It is recognised that this does potentially pose the risk of the results not generalizing to outside of this time period. However, as the aim was to compare the two ND tools and not patient acuity it was reasoned that this was acceptable.

It could be argued that the design of the case studies could have added bias. Nevertheless, as all participants scored all the case studies the bias would be the same for all. One of the burn services only scored their ICU patients which could have added location bias but this was counteracted as another of the burn centres did not have any ICU patients during this time period.

5.7 Summary

This chapter has described and appraised the results from part one of the research - the comparison of ND scores and the inter-rater agreement between the nurses using the two tools. Overall, the results showed that there was a positive correlation between iBID ND scores and the SNCT scores. The results also indicate that there was good inter-rater reliability between nurses when scoring ND regardless of the ND tool used. Taken together, these results suggest that the iBID ND tool could be used to measure aspects of ND. Thus, answering the first two research questions; - “does the iBID ND tool actually measure nurse dependency compared to another ND tool” and “do burn nurses score nurse dependency consistently”?

On the whole, there was good inter-rater agreement between nurses when scoring ND regardless of which ND tool was used. Thus, giving confidence to the reliability of the ND scores gained from iBID, although this was less so with the iBID ‘psychosocial support’ category. The weaker agreement for the iBID psychosocial support suggests that more training on meeting patient’s psychosocial needs and clarity on what each of the levels in that category means is required. These findings support the suggestion from the literature that psychosocial care could be better understood (Heath et al., 2018).

The next chapter will present part two of this research, the analysis of the iBID data sample. It will explain the process undertaken to analyse the iBID data sample and discuss the results obtained.

Chapter 6 Exploratory Analysis of a Data Sample from iBID

6.1 Introduction

The overarching aim of this research was to explore the historical ND data in iBID for information that would increase the understanding of the ND of patients with a burn injury and the feasibility of predicting ND from the iBID data. Chapter six focuses on the results related to the third objective of the research. Firstly, to identify if any relationships existed between the demographics and burn severity of patients with a burn injury and their ND scores and secondly, whether any of these relationships were sufficiently reliable as to enable the prediction of future ND. In doing so, this section of the research aimed to answer the research questions three and four.

3. Which burn severity/demographic variables show signals of a relationship with the iBID nurse dependency scores?
4. Can the iBID nurse dependency scores be predicted for in-patients with acute burns?

In this chapter, the results of the exploratory analysis of the iBID ND data sample are presented. It will first discuss how the data sample was processed and then explain the exploratory analysis procedure and results; justifying the various statistical tests used. The exploration of the data was approached from two perspectives. First by considering whether ND could be predicted and secondly looking at what the ND trajectory over time of patients with a burn injury might tell us. Figure 6.1 gives a diagrammatic overview of the exploratory analysis process.

No specific data analysis template was found in the literature which could be suitably applied to the iBID sample. Therefore, the researcher adopted the format shown in Figure 6.1 to analyse the data. The associations between the variables and the iBID ND scores were examined and regression analysis was performed to identify if a predictive model existed that could be used for ND in burn-injured patients. However, before this could take place, it was necessary to inspect the descriptive characteristics of the individual variables to understand the features of data in the sample that would affect the choice of statistics calculated. Additionally, the iBID ND total score trajectory over time, for different size burns was examined to see if the patient's pathway could be predicted by their ND requirements. Noteworthy findings were examined in more depth as explained in more detail later in the chapter.

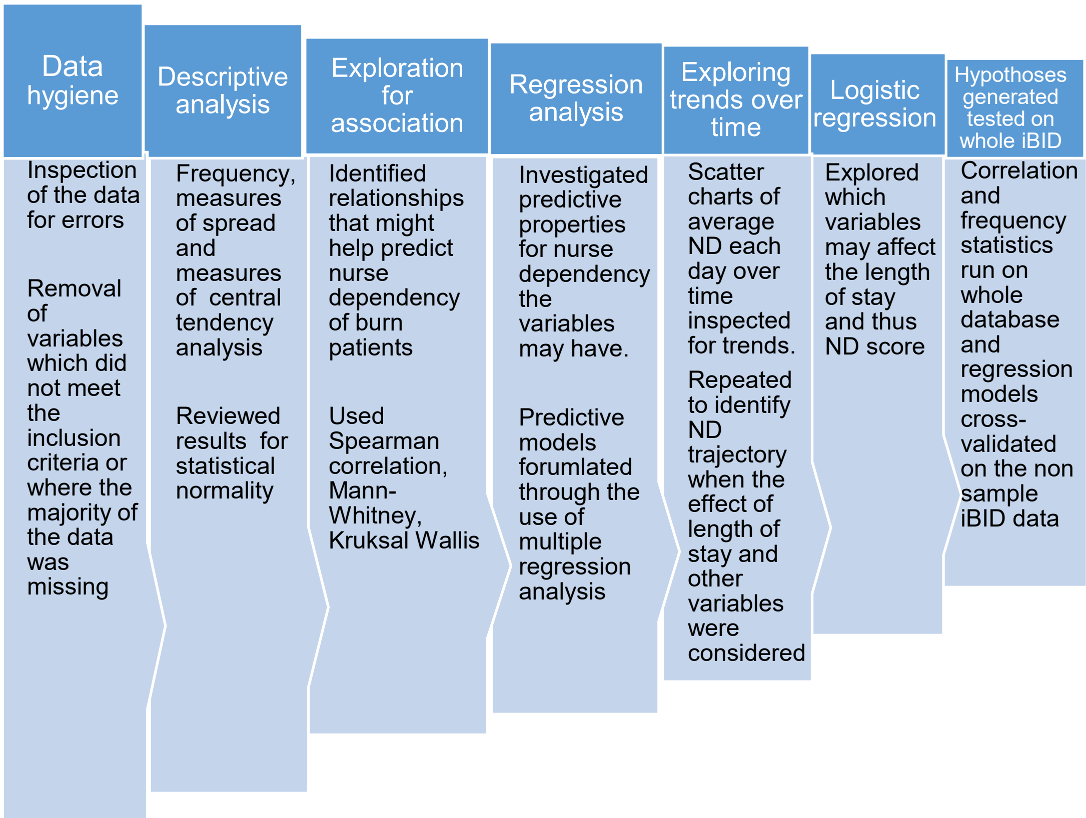


Figure 6.1 Analysis flow path of the iBID data sample analysis

To aid clarity, only a representative sample of the key statistical tests performed and their findings have been presented here. This chapter then concludes with a summary of the key findings of the iBID ND data sample analysis.

6.2 Predictive Regression Analysis

In this section, the processes of preparing the data and exploring the variables, so that regression analysis could be performed is discussed. Then the regression analysis and building of a predictive model is explained.

Correspondingly, the relevant results (in relation to the predictive modelling) are presented.

6.2.1 Variable exploration and data hygiene

Prior to regression analysis and predictive model building, the data required several actions to occur. First, preparation and coding of the data for use in SPSS. Secondly, a set of descriptive statistics performing so the characteristics of the data sample could be understood and the correct statistical tests determined and then carried out. Thirdly, the variables explored further to identify those that might be used in the predictive modelling.

6.2.1.1 Data hygiene of data sample

The data sample extracted from iBID was a raw data sample that had not been filtered or cleaned. Due to the setup of the iBID analysis system two spreadsheets, for the same group of patients, were received from the iBID manager. One containing demographic and treatment data about the injury itself and the other containing dependency data for the same patients. These spreadsheets were combined using the anonymised 'iBID main identity' data field that was consistent between both spreadsheets. This gave 39,458 dependency records for 5,000 unique patients. Due to the wide variety of burn care captured by the iBID data set, some of the fields are not required for all patients, and hence some variables had limited data. Once the empty, irrelevant and duplicate variable columns were removed a total of 94 variables remained

The individual records were scrutinised and any that did not meet the inclusion criteria, as set out in Table 6.1 Inclusion and exclusion criteria for the iBID data sample analysis, were removed. The data that was removed was examined for any discernible patterns that might indicate issues affecting the overall reliability of the data. For example, records where the ND total score was outside the range of 4-25, were examined for any characteristics that might explain the miscoding. No issues were identified. This filtering, summarised in Figure 6.2, left a total of 24,473 records (62%) for 3,679 patients (73%) of the original data. This, as discussed in section 4.5.4.4., equates to a sample size in excess of Tabachnick and Fidell's (2014) rule of thumb required for calculating the later regressions.

Table 6.1 Inclusion and exclusion criteria for the iBID data sample analysis

Inclusion Criteria	**Exclusion criteria**
• Patients with acute thermal injuries • In-patients • Complete set of dependency data making up the ND total score • ND total score between 4 and 25 inclusive. (any scores outside of this were not possible implying inaccurate data entry)	• Patients with vesiculobullous disorders and other non-thermal burn injuries • Out-patients and rehabilitation patients • Records with data missing from the variables that made up the ND total score. • ND total scores <4 and >25 (miss-coding) • Records with more than half of the demographic data missing.

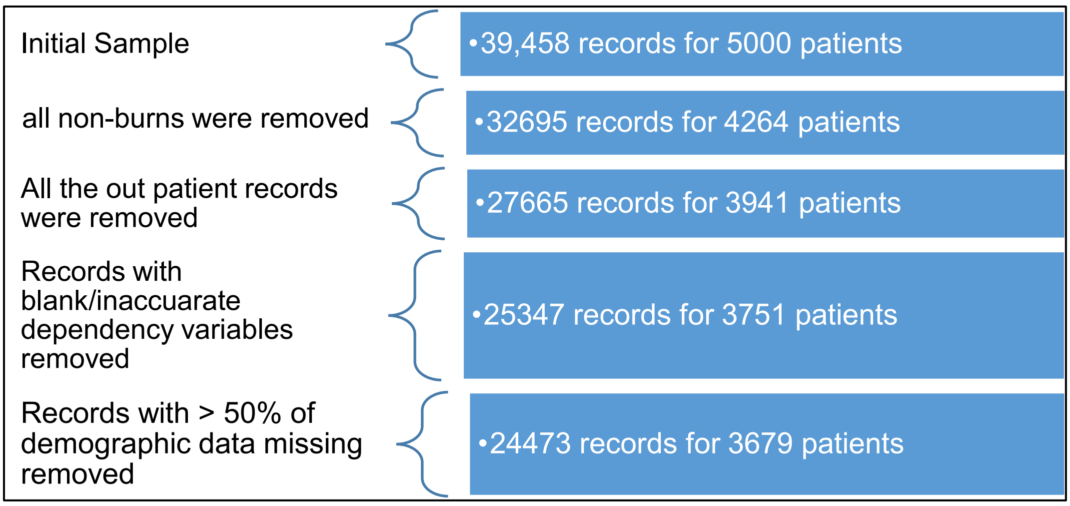


Figure 6.2 Total number of patients' records remaining in the iBID data sample following data hygiene process

It is recognised that for the less complex burns patients not all of the data fields (variables) may have been relevant and thus did not require completion; resulting in these fields being left blank. For the purpose of this research, any data fields that were blank or populated as 'unknown' were coded as 'missing'. The data was then uploaded to SPSS for analysis. The coding of the variables required to meet SPSS conventions is tabulated in Appendix H.

6.2.1.2 Descriptive statistics on variables of interest and relevant to the predictive modelling

A set of descriptive statistics were performed in order to understand the distribution (frequency or range of values), central tendency (estimate of the centre of the values) and dispersion (spread of the values around the central tendency) of the iBID sample data. The results of these descriptive statistics informed the choice of inferential tests which in turn supported the predictive regression modelling process.

Not all statistical tests are appropriate for all types of variables as they make different assumptions about the data (Pallant, 2010). The frequency and mode for the nominal and ordinal variables are presented in Table 6.2 and Table 6.3 respectively. The median was also calculated for the ordinal variables. Table 6.4 presents the descriptive statistics (comprised of the frequency, mean, standard error of mean, mode, median, minimum, maximum, standard deviation, variance, skewness and standard error of skewness) for the continuous variables.

The burn services are not obligated to fill in all variables, particularly if not a required value. The variables in Table 6.2, 6.3 and 6.4 are colour coded, to show which are required data fields (**green**), which are optional (**black**) and which are generated in iBID from the required fields (**orange**). The iBID data sample included both minor and severe injuries and all ages. Subsequently, some of the variables (such as fluid resuscitation) may not have been relevant to all cases, particularly for the smaller (<5%) burns which make up nearly half the sample. This would account for why a third of the variables appeared to have only approximately 50% or less of the data points completed. Additionally, variables such as inhalation injury, full-thickness burns and theatre visits may not have been filled in if there were none. These were classed as missing, which had an impact on which variables could be used in the subsequent regression analyses.

*Table 6.2 Frequency and mode of the iBID nominal variables. (**green** = required data fields, **orange** = generated in iBID from required fields, **black** = optional fields)*

Variable	Number of cases		Mode value
	Valid	Missing/not required	
Activity	23215 (95%)	1258 (5%)	food preparation
BCUF status	24061(98%)	412 (2%)	burn facility
Burn network	24473 (100%)	0 (0%)	North
Category of activity	24001 (98%)	472 (2%)	Accidental recreation
Comfort care only	10457 (43%)	14016 (57%)	No
Discharge destination	17321 (71%)	7152 (29%)	Home
Ethnic category	11046 (45%)	13427 (55%)	British
First aid type	9619 (35%)	14854 (65%)	Clean water
Fluid resuscitation	10334 (42%)	14139 (58%)	No
Gender	24428 (>99%)	45 (<1%)	Male
Inhalation injury	5953 (24%)	18520 (76%)	No
Injury time group	18120 (74%)	6353 (26%)	5-9pm
Injury time	18120 (74%)	6353 (26%)	6pm
Injury day	24397 (>99%)	76 (<1%)	Friday
Injury cause group	24463 (>99%)	10 (<1%)	Accelerant
Injury postcode district	14152 (58%)	10321 (42%)	M6

Variable	Number of cases		Mode value
	Valid	Missing/not required	
Injury week	24397 (>99%)	76 (<1%)	6 and 15
Intentional injury suspected	7472 (30%)	17001 (70%)	No
Expected fluid resuscitation	24472 (>99%)	1 (<1%)	No
Living space	22361 (91%)	2112 (9%)	Kitchen
Locality of accident	24052 (98%)	421 (2%)	Own Home
Ward type	24353 (99%)	120 (1%)	Burn ward
Month	24473 (100%)	0 (0%)	July
Neglect suspected	7010 (29%)	17463 (71%)	No
Outcome	24473 (100%)	0 (0%)	survived
PC area	24442 (>99%)	31 (<1%)	M
Network PC district	24082 (98%)	391 (2%)	North/North Wales
PC district	24442 (>99%)	31 (<1%)	DN
PC_F2.3M::SOA_LOWER	24473 (100%)	0 (0%)	3078
Race	10795 (44%)	13678 (56%)	Caucasian Mediterranean
Referral to social services	3637 (15%)	20836 (85%)	No
SC LAT	24072 (98%)	401 (2%)	Greater Manchester
SC region	24072 (98%)	401 (2%)	Northern England
SC hub	24072 (98%)	401 (2%)	Northwest
Source of burn injury	23616 (96%)	857 (4%)	teacup
Supervision lapse	11593 (47%)	12880 (53%)	No
Type of injury	24446 (>99%)	27 (<1%)	Scald

*Table 6.3 Frequency, mode and median for the iBID ordinal variables. (**green** = required data fields, **orange** = generated in iBID from required fields, **black** = optional fields). N.B. Where median and mode are unequal there is the possibility of skew.*

Variable	Number of cases		Median value	Mode value
	Valid	Missing		
ADL achievement	24473 (100%)	0 (0%)	D2 minimally dep assistance few tasks	D1 self-caring - minimal input
Basic care support needs	18400 (75%)	6073 (25%)	C1 Requires help from 1 person for most basic care needs	C0 Largely independent in basic care activities
BMI group	12892 (53%)	11581 (47%)	BMI o25	BMI Normal
TBSA group	23981 (98%)	492 (2%)	5-9%	1-4%
Core temp group	10973 (45%)	13500 (55%)	35-37	35-37
Expected outcome	24473 (100%)	0 (0%)	expected survivor	expected survivor
Group age(1)	24472 (>99%)	1 (<1%)	Adult	Adult
Group age(2)	24472 (>99%)	1 (<1%)	Adult	Adult
Group age(3)	24472 (>99%)	1 (<1%)	Middle aged	Middle aged
Inhalation severity	5540 (23%)	18933 (77%)	None	None
LOS ventilated group	3859 (16%)	20614 (84%)	7-13 days	14-30 days
Medical intervention	18329 (75%)	6144 (25%)	M2 Specialist medical intervention	M2 Specialist medical intervention
Mobility limitation	24473 (100%)	0 (0%)	L2 some limitation supervision/assistance needed	L1 fully mobile
Monitoring requirement	24473 (100%)	0 (0%)	B1 Surgical Ward Level	B1 Surgical Ward Level

Variable	Number of cases		Median value	Mode value
	Valid	Missing		
Procedure complexity	24473 (100%)	0 (0%)	P1 simple small dressing <5% or removal of sutures	P1 simple small dressing <5% or removal of sutures
Psychosocial support	24473 (100%)	0 (0%)	S1 ward round contact - social	S1 ward round contact - social
Skilled nursing needs	18394 (75%)	6079 (25%)	N1 Requires intervention from a RGN	N1 Requires intervention from a RGN
Therapy intervention	17563 (72%)	6910 (28%)	T1 Total therapy intervention / 4 hours per week (or > 1 hr/day)	T1 Total therapy intervention / 4 hours per week (or > 1 hr/day)
Therapy support	20690 (84%)	3783 (16%)	R1 Minimal review	R0 No input
Treatment complexity	20498 (84%)	3975 (16%)	Y2 single limb Rx (except hands) uncomplicated respiratory Rx	Y0 no input required

*Table 6.4 Descriptive statistics (bootstrapped) for the iBID sample continuous variables. (**green** = required data fields, **orange** = generated in iBID from required fields, **black** = optional fields).*

Variables	N (number of cases)		Mean	Std. Error of Mean	Median	Mode	Minimum	Maximum	Std. Deviation	Skewness
	Valid	Missing								
ABSI	24472 (>99%)	1 (<1%)	0.12	0.00	0.02	0.02	0.01	0.99	0.18	2.41
Age	24470 (>99%)	3 (<1%)	41.40	0.18	40.76	39.16	0.01	101.7	28.29	0.05
Baux	18474 (76%)	5999 (24%) (N.B. only complete d for ages > 17)	64.25	0.18	64.00	61.00	16.00	162.0	24.98	0.31
BOBI	24472 (>99%)	1(<1%)	0.04	0.00	0.02	0.01	0.01	0.95	0.06	4.83

Variables	N (number of cases)		Mean	Std. Error of Mean	Median	Mode	Minimum	Maximum	Std. Deviation	Skewness
	Valid	Missing								
Body mass index	12889 (53%)	11584 (47%) (N.B. only required for larger burns)	26.17	0.05	25.47	27.53	8.95	56.57	5.98	0.82
Burn areas-body	24473 (100%)	0 (0%)	1.55	0.01	1.00	>0.00 05	0.00	9.00	2.11	1.59
Burn areas-head and hands	24473 (100%)	0 (0%)	1.18	0.01	0.00	>0.00 05	0.00	7.00	1.66	1.57
Burn areas-legs	24473 (100%)	0 (0%)	1.52	0.01	1.00	>0.00 05	0.00	11.00	1.96	1.54
Burn areas-total	24473 (100%)	0 (0%)	4.25	0.03	3.00	1.00	0.00	25.00	4.21	1.97
Charlson comorbidity index	24473 (100%)	0 (0%)	1.45	0.01	0.00	0.00	0.00	10.00	1.81	0.89
Complications	24473 (2%)	0 (2%)	0.15	0.00	0.00	0.00	0.00	7.00	0.62	5.57
Core temperature	10973 (2%)	13500 (2%) (N.B. not required for the small burns)	36.25	0.01	36.40	36.20	29.10	39.60	1.30	-3.01
Dep days post-acute inj	24473 (100%)	0 (0%)	33.80	3.65	9.00	99.00	-32865 .0	35432 .0	571.0 6	36.46
Dep days post adm	24437 (>99%)	36 (<1%)	12.48	0.15	5.00	0.00	-291.0	304.0	24.17	2.78
FTDD TBSA	22356 (91%)	2117 (9%) (N.B. only completed if full thickness burns present)	6.35	0.10	1.00	0.00	0.00	95.00	14.55	3.59
GCS score	13498 (55%)	10975 (45%) (N.B. only required for the larger burns)	13.67	0.03	15.00	15.00	3.00	15.00	3.62	-2.52

Variables	N (number of cases)		Mean	Std. Error of Mean	Median	Mode	Minimum	Maximum	Std. Deviation	Skewness
	Valid	Missing								
Inhalation symptoms	24473 (100%)	0 (0%)	0.12	0.004	0.00	0.00	0	8.00	0.60	6.92
Injury hour	18120 (74%)	6353 (26%)	13.68	0.05	15.00	18.00	0	23.00	6.14	-0.52
Injury to healed days	12137 (49%)	12336 (51%)	30.15	0.27	20.00	12.00	1.00	428.0	29.40	3.61
LOS ventilated	3859 (16%)	20614 (84%)	21.57	0.44	13.00	2.00	1.00	110.0	27.04	2.11
LOS/TBSA	17918 (73%)	6555 (27%)	3.56	0.03	2.50	1.00	0.04	30.00	3.53	2.52
ND total score	24473 (100%)	0 (0%)	8.53	0.03	7.00	5.00	4.00	25.00	4.32	1.59
PC_D::PC_D_IMD2004	24074 (98%)	399 (2%)	26.24	0.09	24.00	17.00	0.00	96.00	13.76	0.65
PC_F2_3M_IMD2004	22903 (94%)	1570 (6%)	29.44	0.12	26.02	52.12	0.92	85.76	18.17	0.60
RC score total	24471 (>99%)	2 (2%)	3.42	0.02	3.00	0.00	0.00	15.00	2.78	0.90
Revised Baux	18046 (74%)	6427 (26%)	0.08	0.00	0.02	0.23	0.00	0.98	0.15	3.47
SFSD TBSA	22301 (91%)	2172 (9%)	4.62	0.05	2.00	0.00	0.00	95.00	7.16	4.06
TBSA	23979 (98%)	494 (2%)	10.50	0.10	5.00	1.00	0.00	95.00	15.87	2.86
Therapy complexity total	24471 (>99%)	2 (2%)	8.30	0.03	7.00	3.00	2.00	25.00	4.72	1.11
Total LOS	23280 (95%)	1193 (5%)	22.99	0.21	13.00	1.00	0.00	249.0	31.48	3.44
Total theatre visits	13592 (55%)	10881 (45%)	3.38	0.04	1.00	1.00	0.00		5.01	3.14

The distributions of the variables were assessed to ascertain whether they were normally distributed or not. A normal distribution is required for the use of parametric inferential statistics, as discussed in section 4.5.4. Individual bar charts were used to assess the frequency distribution for the nominal and ordinal variables and the skew statistic and histograms for the continuous variables.

Within the sample data, patient age was recorded both as a continuous variable and also categorically as three ordinal variables with a varying number of categories (2-factor, 3-factor and 6-factor). The different age grouping led to three dissimilar frequency bar charts as shown in Figure 6.3. There was an increase in the variance of frequency as the number of groups increased. For this research, the group age1 variable has been used. The three categories in this variable are ‘child’ (<16 years old), ‘adult’ (16-60 years old) and ‘older adult’ (>60 years old).

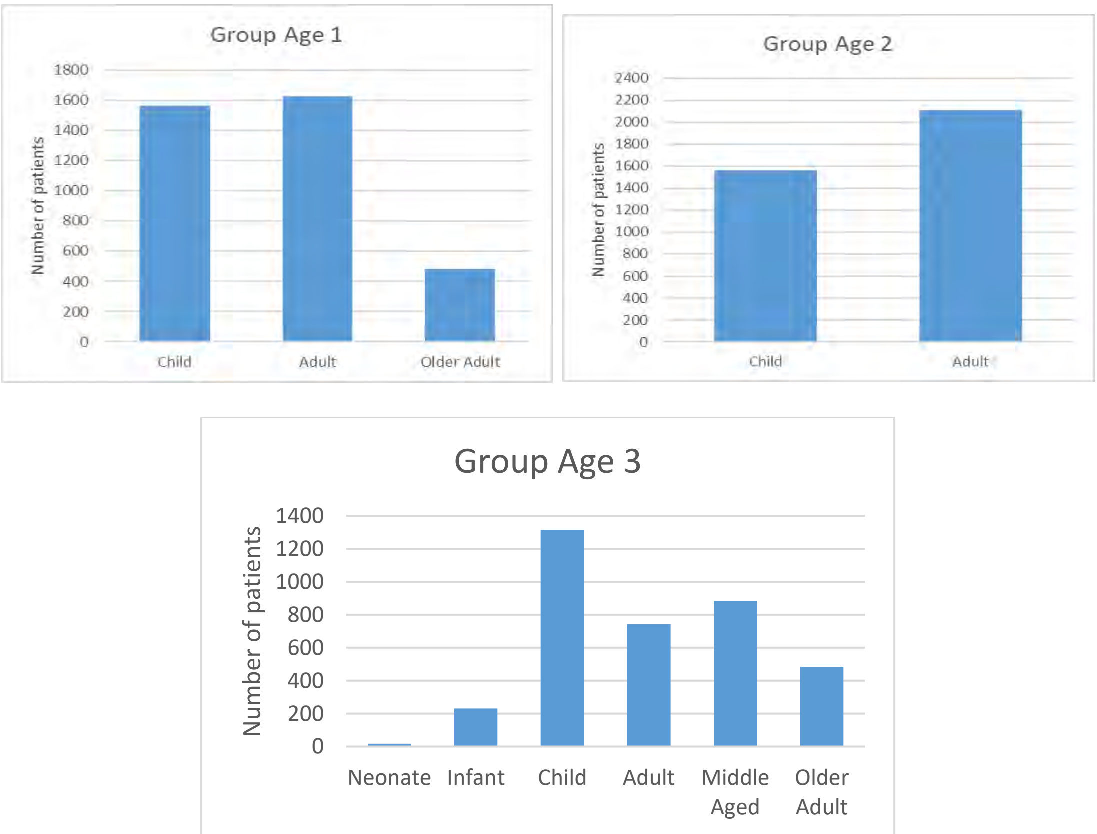


Figure 6.3 Frequency bar charts of the three ordinal variables of age groups showing the increasing variance of frequency as the number of groups increased

One point of note on reviewing the frequencies was that in this sample the northern burn network appeared to have twice as many data entries compared with other burn networks as shown in Figure 6.4. This is largely due to the northern network seeing more patients than the other networks and possible thoroughness in collecting the data as shown in the iBID generated reports.

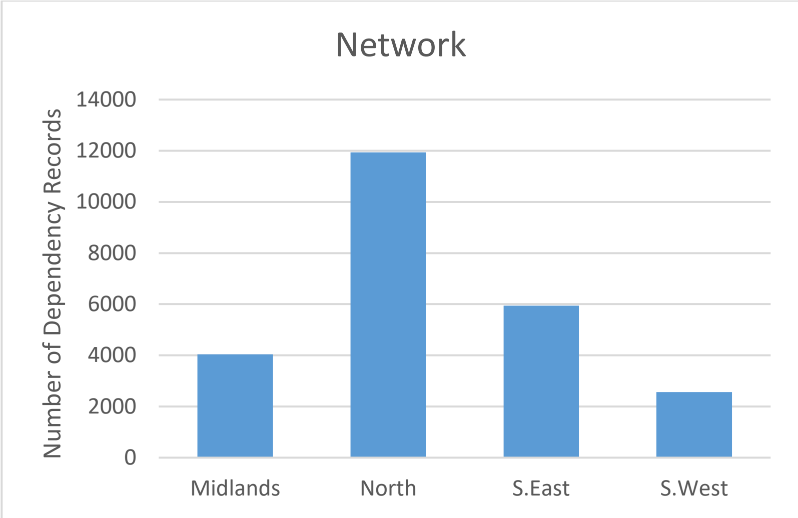


Figure 6.4 Frequency bar chart of the burn operational delivery networks illustrating an imbalance of data across the four networks

Similarly, to the uneven distribution of the nominal and ordinal variables, the majority of the iBID continuous variables did not have a normal distribution either. For a continuous variable to have a normal distribution with a symmetric profile, a skewness coefficient close to 0 would be expected. This was not the case for the majority of the iBID continuous variables. The variables closest were the ‘age’, ‘Baux index’ and ‘injury hour’ variables with skewness values < ±0.5 which Lehman (1991, cited in Pett, 2016) suggests are acceptable levels of skewness for normality. Likewise, an inspection of the distributions via histograms also revealed evidence of skewness, confirming that most of the variables did not follow a normal distribution. Further inspection showed that most of the variables are skewed to the left (negatively skewed). The exceptions were the ‘Glasgow Coma Scale score (GCS)’ and ‘core temperature’ that were skewed to the right (positively skewed) due to the clinical value of interest on admission in burn care typically being at the upper end of the range (for example a GCS score of 15 rather than 1 would be the normal score (Mehta and Chinthapalli, 2019)).

Altogether this lack of normal distribution of the variables supports the use of non-parametric tests for this data sample as the parametric assumption of a normal distribution is not met.

From inspecting these descriptive statistics, it was noted that the dependency days post-injury and dependency days post-admission had some entries with negative days which is not possible. This field is calculated automatically by the computer from dates entered into iBID which may account for the errors. Normally reports generated from iBID would filter out these anomalies which overall are very small (Dunn, 2020). This data sample was of the raw data so required the filtering out of the cases with negative admission days for analysis.

Taking the sample data set as a whole (including survivors and non-survivors) and following cleaning and filtering, the average iBID 'ND total score' for each iBID variable category was plotted as a bar chart to highlight any relationships that might exist. The variables of note were the 'TBSA groups', 'ward type' and 'group age1' which are presented in Figure 6.5 – 6.7.

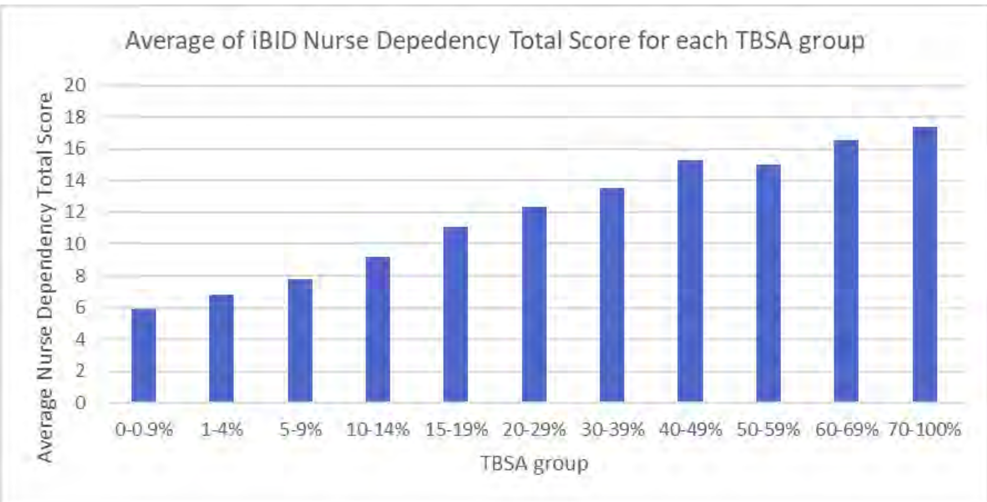


Figure 6.5 Average iBID ND total scores for TBSA groups, showing an increase in average ND score with increasing burn size

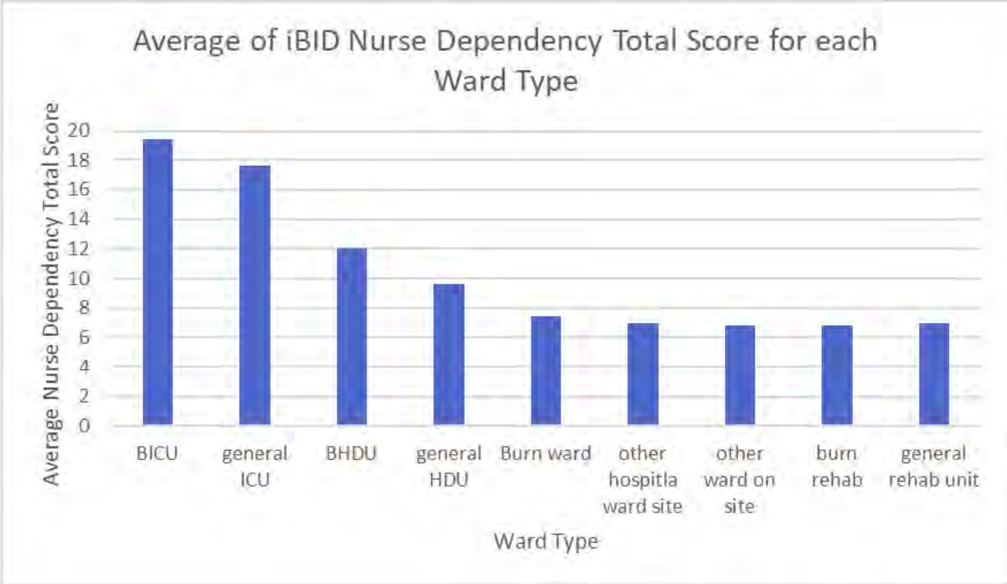


Figure 6.6 Average iBID ND total scores for each ward type, showing higher ND average scores in ICU and lower ones in the ward areas

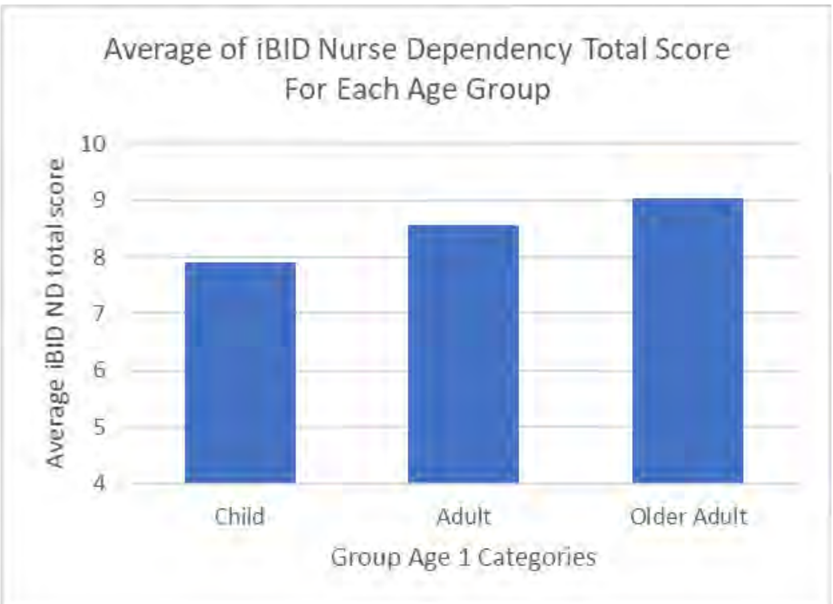


Figure 6.7 Average iBID ND total scores for Group Age1. There is a slight increase in dependency with age for the average iBID ND total score

The bar chart's in Figure 6.5 – 6.7 suggest a relationship between the ND total scores and some of the variables as would be expected. For example, as the burn size gets larger the average ND increases. Similarly, the critical care areas (ICU) have the highest average ND total scores compared to the other ward types. From a clinical perspective this is not surprising as patients admitted to ICU either have significantly larger burns, serious comorbidities or both and thus would be expected to have a higher average ND score. Across the demographics, there appears to be a trend with the older adult group having the highest average ND score and the child group the lowest. Albeit, with a difference of less than one iBID ND point this is unlikely to have much clinical impact.

Focusing on the spread of the iBID 'ND total scores' for each ward type, it might have been expected that there would be a clear delineation of ND scores between the areas (that is, all the lower scores being in the ward, the higher scores in ICU with HDU taking a middle set). Particularly as this occurred with the data collected in chapter five. However, Figure 6.8 for this data sample does not demonstrate a clear delineation between the ward types. Though predominately the majority of the lower scores may be in the ward and the higher ones in ICU, in practice there is a widespread of scores across the whole iBID ND total score range for each area. Thus, inferring that ND can vary considerably in all areas and it cannot be assumed that because they are on the ward their ND will be any less than a patient in ICU.

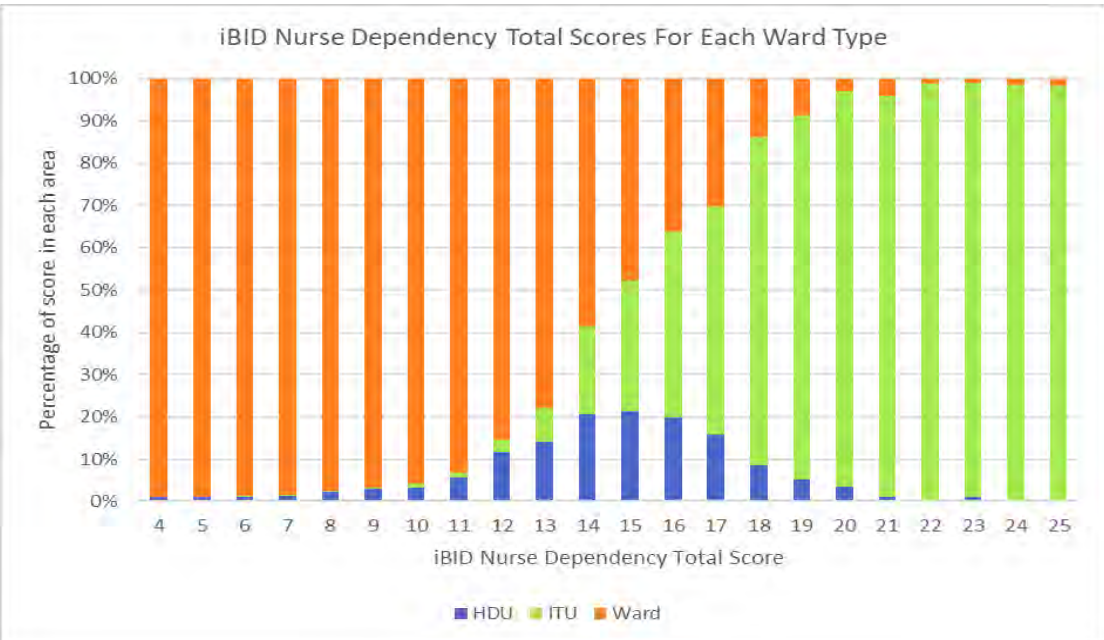


Figure 6.8 The spread of iBID ND total score values across the different ward types

In summary, the descriptive statistics highlighted that on the whole the continuous data was not normally distributed and though some of the variables having a large number of entries 'missing' no concerns over the data quality were identified. These descriptive statistics, although not conclusive by themselves, do indicate that a number of the variables within the iBID data set may have a bearing on ND. These relationships are investigated further in the next section to assess their effect on the ND total score and statistical significance, as well as their potential for use in predictive multiple regression modelling.

6.2.1.3 Extraction of dependent statistics

Following the descriptive analysis, reported in the previous section, the variables were analysed for evidence of any association/relationships with the iBID ND scores which would be the dependent variable in the linear regression predictive modelling.

The iBID ND total score is made up of the scores from five subcategories ('monitoring requirements', 'procedure complexity', 'psychosocial support', 'ADL', 'mobility limitations') as described in section 2.3.3.1. It is calculated daily for each patient, so there are multiple scores for each patient. However, not all the other variables would necessarily change over the patients stay. For example, the 'age', 'TBSA', 'type of injury' and 'gender' would not change and were static across the patients' stay. Whereas the 'ward type', 'medical intervention', 'therapy complexity total' and the iBID ND subcategories would all be expected to vary during their stay. Therefore, in order to analyse the iBID ND total score against the variables that were constant over the patients stay, an iBID ND total score value fixed at a point was required. Consequently, four sets of iBID ND total scores were identified to be used as the dependent variables. These were the average, maximum, minimum and first ND total scores recorded for each patient. Although there is no evidence to specifically support the choice of these points, they were chosen as potential intuitive clinical points of interest following discussions with burn nursing colleagues. The first ND score to give an indication of the patients ND on admission and possible predictive implications for the future. The average ND total score as a central tendency measure. The maximum and minimum ND total score that the patient might have during their stay to help decide on the minimum staffing numbers required. However, in hindsight, it may have been misinterpreted as to what the maximum and minimum ND total score might show. They gave an indication of the maximum and minimum score over the whole stay and not on a daily basis. For example, the minimum score would always veer towards four prior to discharge.

The descriptive results presented in section 6.2.1.2 revealed that the variables did not meet all the assumptions described in chapter four for the use of parametric statistical tests. Therefore, non-parametric statistical tests (Spearman correlation, Mann-Whitney U test and Kruskal Wallis test) were used to investigate associations and differences between groups in relation to the iBID ND total score. The Spearman correlation was predominately used for the continuous variables (such as the Abbreviated Burn Severity Score (ABSI), number of areas burned, length of stay) to identify if there was any relationship between the variables and the ND total scores. However, it can also be used with ordinal variables (for example, Age groups and TBSA groups) as it uses ranking in its calculation (Pallant, 2010). The Mann-Whitney U and Kruskal Wallis tests were used for the nominal and ordinal variables. If there were only two groups in the variable (for example, gender and outcome) the Mann-Whitney U test was used, otherwise if there were more than two groups (such as ward type and injury cause group) the Kruskal Wallis test was used. An explanation of these three techniques is given in sections 4.5.4.1 – 4.5.4.3. The next three sections (6.2.1.3.1– 6. 2.1.3.3) discuss the results of these three statistical tests. As would be expected, most of the iBID variables identified by the researcher and burn consultant as likely to have an effect on ND showed some statistically significant relationship with the ND total scores.

6.2.1.3.1 Spearman correlation results

A Spearman correlation was first performed of the iBID ND total score with those variables that could change during the hospital stay of a patient with a burn injury. The results of this are presented in Table 6.5. Secondly, a Spearman correlation was performed using the variables that remained constant during the patient's stay. These were correlated with the average, maximum, minimum and first iBID ND total scores. The resulting Spearman correlation coefficients are presented in Table 6.6.

First, considering the results of the Spearman correlation coefficients for the variables that could change during the hospital stay of a patient with a burn injury with the iBID ND total score (Table 6.5), it can be seen that all these variables showed a statistically significant correlation at the 0.05 level with the iBID ND total score. It is interesting to note that out of the five variables that make up the iBID ND total score, only the 'mobility limitations' (ρ = 0.78, 95% CI = 0.775 -0.788) and 'activities of daily living (ADL) achievement' (ρ = 0.821, 95% CI = 0.816-0.826) have a strong positive relationship (as defined in section 4.5.4.1) with the total score. The 'psychosocial support' (ρ = 0.490, 95% CI = 0.478 - 0.502) variable had the lowest. Of the other variables that could change during admission, the correlation of the iBID ND total score with the number of days post-admission was the lowest (ρ = 0.177, 95% CI = 0.163 - 0.191). From a clinical perspective, it might have been expected that the iBID ND total score would have had a strong negative linear correlation with the number of days post-admission; as the number of admission days increased and healing occurred the dependency would go down. However, it could be that the relationship was not a pure linear one, as it would not be unreasonable to expect the dependency to go up initially and then gradually reduce. Furthermore, if the patient developed complications or had other underlying conditions that may have changed their ND needs trajectory.

Table 6.5 Spearman correlation coefficient and bootstrapped 95% confidence intervals of the iBID ND total score with variables that can change daily. (N = number of data observations). The results highlighted green are a strong relationship, those highlighted orange moderate relationship and the remaining ones not highlighted a weak relationship with the iBID ND total score.

		dependency days post-admission	**Ward type**	**Monitoring**	**Procedure complexity**	**Psychosocial support**	**ADL achievements**	**Mobility Limitations**	**Basic care requirements**	**Skilled nursing needs**	**Medical intervention**	**Therapy complexity total**
iBID data sample (N=18278)	correlation coefficient	0.18	-0.44	0.56	0.50	0.49	0.82	0.78	0.71	0.41	0.28	0.71
	sig. (2-tailed)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	95% confidence interval	0.16 - 0.19	-0.46 - -0.43	0.55 – 0.57	0.49 – 0.51	0.48 – 0.50	0.82 – 0.83	0.78 – 0.79	0.70 – 0.72	0.39 – 0.42	0.26 – 0.29	0.70 – 0.72

Next, considering the Spearman correlation coefficients results for the variables that would be constant during admission with the average, maximum, minimum and first iBID ND total scores (table 6.6), it was seen that 94% had a statistically significant correlation at the 0.05 level. Of the statistically significant variables, the majority (82%) had a positive correlation, indicating that as the variable score increased in size so did the ND total score. The results were scrutinised further to check that the associations made clinical sense or if any anomalies in the expected associations existed. Particular observations of interest will be discussed next.

*Table 6.6 The Spearman correlations matrix results with the average, maximum, minimum and first ND total score. (N = number of data observations, * = Correlation is significant at the 0.05 level (2-tailed), ** = Correlation is significant at the 0.01 level (2-tailed). The yellow highlighted correlation coefficients are variables with a p-value > 0.05 suggesting that the variable is independent of the ND total score. The green highlighted correlation coefficients indicate a strong correlation and orange a moderate strength correlation.)*

Variable	N	Spearman Correlation Coefficient			
		Average ND total score	Maximum ND total score	Minimum ND total score	First ND total score
ABSI_MP	3678	0.152**	0.288**	-0.082**	0.167**
Age	3677	-0.110**	0.017	-0.217**	-0.095**
Avg Ther Complx	3679	0.753**	0.727**	0.473**	0.684**
Bauxindex	2116	0.365**	0.417**	0.152**	0.337**
Bobi_Mp	3678	0.152**	0.249**	-0.024	0.144**
Body_Mass_Index	1472	-0.027	-0.012	-0.072**	-0.011
Burnareas_Body	3679	0.216**	0.238**	0.064**	0.260**
Burnareas_Hh	3679	0.058**	0.056**	0.005	0.094**
Burnareas_Legs	3679	0.176**	0.231**	0.049**	0.163**
Burnareas_Total	3679	0.276**	0.332**	0.052**	0.312**
Charlson_Index	3679	0.015	0.120**	-0.094**	0.007
Comfortcareonly	1017	0.231**	0.218**	0.234**	0.215**
Complic_Total	3679	0.205**	0.215**	0.132**	0.202**
Coretemperature	1318	-0.093**	-0.084**	-0.042	-0.128**
DEP_DAYS_POST_ACUTE_INJ	3679	-0.017	0.121**	-0.188**	-0.106**

Variable	N	Spearman Correlation Coefficient			
		Average ND total score	Maximum ND total score	Minimum ND total score	First ND total score
DEP_DAYS_POST_ADM	3672	0.114**	0.304**	-0.204**	-0.003
GCSCORE	1677	-0.340**	-0.338**	-0.204**	-0.342**
INHALSYMPTOMS	3679	0.170**	0.188**	0.064**	0.186**
InjTm_Hr	2785	-0.01	-0.037*	0.034	-0.011
INJ TO HEAL DAYS	1791	0.166**	0.269**	-0.035	0.155**
LOS_TBSA	2134	-0.025	0.172**	-0.258**	0.004
LOS VENTILATED	144	0.047	0.440**	-0.226**	0.359**
PC_D::PC_D_IMD2004	3617	0.072**	0.053**	0.051**	0.085**
PC_F2_3M_IMD2004	3408	0.083**	0.064**	0.053**	0.091**
FTDD_TBSA	3383	0.184**	0.304**	-0.021	0.204**
SFSD_TBSA	3508	0.177**	0.197**	0.012	0.201**
Total TBSA	3614	0.338**	0.430**	0.038*	0.379**
RevBaux_MP	2041	0.376**	0.434**	0.151**	0.346**
Sum Dep	3679	0.452**	0.696**	-0.058**	0.488**
Therapy_Complexity_Total	3679	N/A	0.785**	0.552**	0.753**
Total_Theatre_Visits	1112	0.316**	0.375**	0.083**	0.311**
Total LOS	3428	0.257**	0.511**	-0.206**	0.307**

The negative correlation of the age variable could be explained by the fact that a very young child is naturally more dependant as they have not learnt to be self-caring like older children and adults. But this is further complicated as when parents are present they will take on much of the child's care and it is not clear in the iBID ND tool descriptors whether they take this into account when scoring children and differentiate between the care given by nurses and carers or not. Later in this exploratory analysis (sections 6.2.2.2 and 6.3.2.2), the difference between ages in relation to ND is examined further.

The remaining variables that showed a negative statistically significant correlation (‘body mass index’, ‘Charlson comorbidity index’, ‘days post-admission’, ‘LOS TBSA’, ‘LOS ventilated’, and ‘total LOS’) only showed a negative correlation when tested against the minimum ND total score. It is possible that the higher these variables’ score is the longer the patient is likely to stay in hospital and therefore potentially more likely to reach a point of requiring the minimal nurse input. The minimum ND total score correlations coefficients showed weak relationships (apart from with the ‘therapy complexity score’) suggesting that, although there might be statistical significance, the minimum ND total score may have limited clinical significance.

The ‘therapy complexity’ variable was the only variable that had a strong or moderate correlation with all the ND total scores, consistent with the earlier comparison against all the iBID ND total scores (Table 6.5). This strong positive relationship between rehabilitation therapy requirements and ND could be seen as indicating that the workload of nursing and therapists may be a predictor of the workload of each other.

The ‘Charlson Comorbidity index’ appears to be independent of the ND for the first and average ND total scores. This may be because other patient comorbidities, such as cardiovascular disease or trauma, are unlikely to have a bearing on the initial treatment of a burn. However, the presence of comorbidities may influence the total ND and thus have a bearing on the minimum and maximum values.

6.2.1.3.2 Mann-Whitney U test results

The Mann-Whitney U test results are shown in Table 6.7. The ‘intentional injury suspected’ variable for all ND total scores and the ‘neglect suspected’ variable for the minimum ND total score revealed no difference between their groups. All the other variables showed a statistically significant difference in ND scores between the two groups that made up the variable, suggesting that the variable had an effect on the ND total score. Only the resuscitation and inhalation injury variables demonstrated a high effect size. This is not surprising as both the need for fluid resuscitation and the presence of an inhalation injury in burn patients would increase their acuity and thus nursing workload.

6.2.1.3.3 Kruskal-Wallis test results

The Kruskal-Wallis test results (for the variables with more than two categories) are shown in Table 6.8. Again, the majority of the variables showed a statistically significant association at the 0.05 level with the ND total scores (that is at least one group has a different average value). However, the day that a person sustained a burn injury did not appear to have an effect on the ND; as the ‘injury day’, ‘week’ and ‘month’ did not show a difference between groups across the four ND total scores. The Spearman correlation results suggested that the actual time of the day the injury occurred might have a small influence on the maximum ND score. Yet the difference could statistically be due to the fact that there were lower numbers in the early hour groups which clinically should not affect patients’ ND needs.

From the results of the Kruskal Wallis tests in Table 6.8, a point of note is that although ‘age’ as a continuous variable did not appear to have a significant correlation with the maximum ND total score (Table 6.6), when grouped into children, adults and the older adult there was a statistically significant difference between the groups. A possible reason for the different test results is that before grouping any signal was too small to be identified as a correlation but grouping concentrated the effect enabling a signal to be detected. Equally, if the relationship was not linear it would be less likely to show up in a linear test such as a correlation test.

Table 6.7 The Mann-Whitney U test results, comparing the difference between the binary variable groups on the ND Total score (N = number of data observations, md=median, z= z-score, p=significance level, r= effect size. The yellow highlighted p-value suggests that there is no evidence of association between the variable and the ND total score at the 0.05 level. The green highlights indicate a large effect size and orange a medium effect size according to Cohen (1992))

Variable	Variable group		Average ND total score				Maximum ND total score				Minimum ND total score				First ND total score			
		N	md	z	p	r	md	z	p	r	md	z	p	r	md	Z	p	r
Age group 2	Child	1562	7	-10.79	<0.0005	60.65	8	-3.24	0.001		6	-16.37	<0.0005	0.27	7	-9.21	<0.0005	0.15
	adult	2116	6				8				5				6			
comfort care only	No	992	7	-7.37	<0.0005	0.23	9	-6.93	<0.0005	0.22	6	-7.47	<0.0005	0.23	8	-6.86	<0.0005	0.22
	Yes	25	20				21				20				21			
Fluid resus	No	828	6. 67	-15.87	<0.0005	0.5	8	-17.5	<0.0005	0.51	5	-5.23	<0.0005	0.16	7	-16.86	<0.0005	0.53
	Yes	182	12.08				19.5				6				17			
Gender	Female	1393	6.61	-3.66	<0.0005	0.06	8	-3.33	0.001	0.05	5	-2.24	0.025	0.4	7	-3.47	0.001	0.06
	Male	2278	6.33				8				5				7			
inhalation injury	No	298	10.26	-5.88	<0.0005	0.32	16	-5.7	0	0.31	6	3.43	0.001	0.19	15	-5.76	<0.0005	0.32
	Yes	30	19.11				21.5				14				21			
intentional injury suspected	No	1004	6.5	-0.64	0.52	0.02	8	-1.69	0.09	0.05	5	-1.6	0.11	0.5	7	-1.69	0.09	0.05
	Yes	53	6.4				8				5				8			
Expected fluid resus	No	3421	6.25	-21.05	<0.0005	0.35	8	-22.8	0	0.38	5	-8.98	<0.0005	0.15	7	-21.72	<0.0005	0.36
	Yes	257	11.62				18				7				16			
Neglect suspected	No	1022	6.43	-2.37	0.02	0.07	7	-2.39	0.02	0.07	5	-1.6	0.11		7	-2.38	0.017	0.07
	Yes	11	9.2				12				6			0.05	9			
Outcome	Died	80	18.92	-13.8	<0.0005	0.23	20	-13.57	<0.0005	0.22	16.5	-12.84	<0.0005	0.21	19.5	-12.39	<0.0005	0.2
	Survived	3599	6.38				8				5				7			
referral to social services	No	549	6.5	-3.87	<0.0005	0.15	7	-3.75	<0.0005	0.15	6				7	-3.27	0.001	0.13
	Yes	108	7.38				9				6	-2.96	0.003	0.12	8			
supervision lapse	No	1493	6.25	-8.73	<0.0005	0.21	8	-5.79	<0.0005	0.14	5				7	-6.85	<0.0005	0.16
	Yes	247	7.5				9				6	-8.4	<0.0005	0.2	8			

Table 6.8 The Kruskal-Wallis test results, comparing the difference between the variable groups' ND total scores for the variables with three or more groups. (N = number of data observations, X^2 = Chi-Square, p = significance level, df = the number of degrees of freedom used up by the model which in this case is the number of groups in the category minus 1. The yellow highlighted p-value suggests that there is no significant difference in the ND total score across the groups and thus there is insufficient evidence to reject the independence of the variable from the ND total score)

Variable	Average ND total score				Maximum ND total score				Minimum ND total score				First ND total score			
	N	df	X^2	p	N	df	X^2	p	N	df	X^2	p	N	df	X^2	p
Activity	3502	16	245.33	<0.0005	3502	16	144.05	<0.0005	3502	16	342.46	<0.0005	3502	16	216.33	<0.0005
ADL Achievement	3679	4	2182.22	<0.0005	3679	4	2253.47	<0.0005	3679	4	1943.4	<0.0005	3679	4	2297.05	<0.0005
Group age 1	3678	2	238.81	<0.0005	3678	2	167.44	<0.0005	3678	2	310.36	<0.0005	3678	2	154.6	<0.0005
Group age 3	3678	5	263.34	<0.0005	3678	5	192.67	<0.0005	3678	5	332.94	<0.0005	3678	5	171.35	<0.0005
Basic care support needs	2765	3	1177.74	<0.0005	2765	3	1121.82	<0.0005	2769	3	923.16	<0.0005	2766	3	1138.85	<0.0005
BCUF status	3615	4	596.74	<0.0005	3615	4	768.46	<0.0005	3615	4	173.17	<0.0005	3615	4	681.30	<0.0005
BMI group	1473	5	29.74	<0.0005	1473	5	14.05	0.02	1473	5	27.21	<0.0005	1473	5	19.1	0.002
TBSA Group	3615	11	663.03	<0.0005	3615	11	907.81	<0.0005	3615	11	107.53	<0.0005	3615	11	782.34	<0.0005
Category of injury	3603	11	206.77	<0.0005	3603	11	162.22	<0.0005	3603	11	155.57	<0.0005	3603	11	235.14	<0.0005
Core Temp group	1318	4	57.32	<0.0005	1318	4	60.34	<0.0005	1318	4	32.04	<0.0005	1318	4	60.63	<0.0005
Discharge destination	2480	12	273.51	<0.0005	2480	12	281.02	<0.0005	2480	12	220.72	<0.0005	2480	12	244.14	<0.0005
Ethnic category	1678	15	22.41	0.10	1678	15	24.999	0.05	1678	15	16.1	0.38	1678	15	32.06	0.006
Expected outcome	3679	6	220.1	<0.0005	3679	6	215.92	<0.0005	3679	6	176.23	<0.0005	3679	6	189.97	0.00
First aid type	1709	15	23.08	0.08	1709	15	28.14	0.02	1709	15	16.92	0.32	1709	15	27.71	0.02
Inhalation severity	305	3	33.02	<0.0005	305	3	32.1	<0.0005	305	3	13.05	0.005	305	3	34.01	<0.0005

Variable	Average ND total score				Maximum ND total score				Minimum ND total score				First ND total score			
	N	df	X^2	p	N	df	X^2	p	N	df	X^2	p	N	df	X^2	p
Injury day	3667	6	9.57	0.14	3667	6	8.06	0.23	3667	6	9.53	0.15	3667	6	6.94	0.33
Injury cause group	3674	5	100.21	<0.0005	3674	5	102.29	<0.0005	3674	5	78.83	<0.0005	3674	5	93.38	<0.0005
Injury PC District	2019	979	1037.48	0.95	3674	978	1083.84	0.01	3679	980	1028.61	0.14	3679	980	1061.34	0.04
Injury Time group	2785	5	11.63	0.04	2785	5	15.13	0.1	2785	5	16.33	0.01	2785	5	6.11	0.30
Injury week	3667	48	62.12	0.08	3667	48	55.43	0.22	3667	48	57.97	0.15	3667	48	57.77	0.16
Living space	3383	12	87.33	<0.0005	3383	12	81.83	<0.0005	3383	12	74.27	<0.0005	3383	12	82.42	<0.0005
Locality	3592	22	67.46	<0.0005	3592	22	70.15	<0.0005	3592	22	55.77	<0.0005	3592	22	57.8	<0.0005
Ward type	3669	7	528.48	<0.0005	3669	7	630.59	<0.0005	3669	7	167.09	<0.0005	3669	7	572.58	<0.0005
LOSVENT group	144	6	9.39	0.15	144	6	31.172	<0.0005	144	6	15.21	0.02	144	6	24.17	<0.0005
Medical intervention	2753	3	266.15	<0.0005	2753	3	318.68	<0.0005	2756	3	157.76	<0.0005	2747	3	303.85	<0.0005
Mobility Limitation	3679	4	1669.78	<0.0005	3679	4	1994.07	<0.0005	3679	4	1487.37	<0.0005	3679	4	1907.74	<0.0005
Monitoring requirement	3679	4	650.3	<0.0005	3679	4	868.61	<0.0005	3679	4	264.96	<0.0005	3679	4	793.91	<0.0005
Month	3679	11	18.3	0.08	3679	11	12.93	0.30	3679	11	13.58	0.26	3679	11	19.16	0.06
Network	3679	3	70.2	<0.0005	3679	3	56.26	<0.0005	3679	3	95.37	<0.0005	3679	3	106.15	<0.0005
PC Area	3672	114	414.63	<0.0005	3679	115	399.95	<0.0005	3679	115	320.24	<0.0005	3679	115	511.58	<0.0005
PC D PC A network	3620	5	68.51	<0.0005	3620	5	58.33	<0.0005	3620	5	91.79	<0.0005	3620	5	103.19	<0.0005
PC district	3672	1363	1599.6	<0.0005	3679	1364	1634.78	<0.0005	3679	1364	1481.9	0.01	3679	1364	1668.67	<0.0005

Variable	Average ND total score				Maximum ND total score				Minimum ND total score				First ND total score			
N	**df**	**X^2**	**p**	**N**	**df**	**X^2**	**p**	**N**	**df**	**X^2**	**p**	**N**	**df**	**X^2**	**p**	**N**
PC F2 3M SOA lower	3679	3128	3159.73	0.34	3678	3127	3186.21	0.23	3679	3128	3092.32	0.672	3679	3128	3172.7	0.28
Procedure complexity	3679	5	726.66	<0.0005	3679	5	1231.36	<0.0005	3679	5	996.82	<0.0005	3679	5	1211.38	<0.0005
Psychosocial Support	3679	4	832.36	<0.0005	3679	4	1141.55	<0.0005	3679	4	844.27	<0.0005	3679	4	1183.47	<0.0005
Race	1543	9	17.58	0.04	1543	9	10.18	0.34	1543	9	31.68	<0.0005	1543	9	18.44	0.03
SC region	3616	5	76.63	<0.0005	3616	5	41.63	<0.0005	3616	5	126.90	<0.0005	3616	5	121.66	<0.0005
SC LAT	3616	26	285.99	<0.0005	3616	26	248.36	<0.0005	3616	26	234.57	<0.0005	3616	26	357.42	<0.0005
SC SCHub	3616	11	213.77	<0.0005	3616	11	178.05	<0.0005	3616	11	194.41	<0.0005	3616	11	260.27	<0.0005
Skilled nursing needs	2764	3	212.19	<0.0005	2764	3	327.1	<0.0005	2766	3	69.53	<0.0005	2764	3	256.49	<0.0005
Source of Injury	3571	98	352.53	<0.0005	3571	98	378.34	<0.0005	3679	100	245.46	<0.0005	3679	100	331.47	<0.0005
Therapy complexity	2872	5	139.90	<0.0005	2872	5	195.84	<0.0005	2881	5	35.3	<0.0005	2736	5	138.40	<0.0005
Therapy intervention	2618	5	91.29	<0.0005	2618	5	140.16	<0.0005	2618	5	67.04	<0.0005	2596	5	94.54	<0.0005
Therapy support	2894	5	157.69	<0.0005	2894	5	274.95	<0.0005	2904	5	38.41	<0.0005	2761	5	127.97	<0.0005
Type of injury	3671	9	117.89	<0.0005	3671	9	168.48	<0.0005	3671	9	53.04	<0.0005	3671	9	123.4	<0.0005

The ‘LOS ventilated group’ did not show up as a statistically significant difference in the average ND total score across the groups, which is surprising considering that inhalation injury has a huge impact on burn mortality (Herndon, 2018). This result may be because over time the ND equals out and thus it does not show up in the average ND total score. However, there is a statistically significant difference between the length of stay ventilated for the maximum and first ND total scores.

In summary, the results of the Spearman correlation, Mann-Whitney and Kruskal-Wallis tests indicate that the ‘Intentional injury suspected’, ‘month’ and ‘injury day’ ‘injury week’ variables are the only variables where the null hypothesis (the variables are independent of ND) could not be rejected for all the dependant iBID ND total scores considered. Overall, the maximum and first ND total scores had more variables that showed evidence that there might be a relationship with ND than the minimum and average ND total scores. Within the healthcare environment, the ND of the majority of inpatients with a burn injury would be expected to plateau to a minimum ND before discharge irrespective of any presenting factors as they recovered from the burn injury. Therefore more signals of independence from the ND total score would be expected with the ND minimum total score.

6.2.2 Predictive model building

One of the aims and objectives of this study was to explore whether a predictive model for ND could be developed from the iBID ND data. Therefore once the variables that appeared to show some signals of a relationship with ND had been identified they were then explored further using multiple regression to establish which variables could be best used to predict a ND total score for burn inpatients.

The predictive modelling process was split into two parts. First, multiple regression was undertaken using all the relevant variables entered simultaneously with no researcher input into the order (section 6.2.2.1). Secondly, in section 6. 2.2.2, the predictive modelling was performed using a stepwise approach in order to establish whether a more refined predictive model for ND could be found.

6.2.2.1 Modelling with all parameters

Field (2018) argues that variables should be added into a multiple regression equation in an order of importance for predicting the outcome based on previous research. However, as this is the first piece of research on modelling predictors for burn ND in this context, it was not possible to use previous research as a guide. All the independent variables (predictors) could have been added into the linear regression equation at the same time, but this would have risked overfitting of the model with too many variables for the sample size. The flow chart in Figure 6.9 summarises how the variables were reduced down to the ones included in the predictive regression modelling (Table 6.11). This process is explained in more detail below.

The independent variables were initially chosen based on the following principles to ensure no singularity existed (no variable was a sub variable of another) (Pallant, 2010).

a. The individual sub-variables that made up the ND total score were excluded, such as mobility limitations and procedure complexity.
b. If there were several variables that in essence measured the same thing but classified differently, only one was used. For example, ‘source of injury’, ‘type of injury’ and ‘injury cause group’ are very similar so only one was chosen. The variable

with the fewest categories was chosen for the initial regression modelling.

c. Where several variables made up parts of a total, only the total or the parts were put in, not both, in order to reduce the risk of multicollinearity. For example, the total number of body areas burned was also divided up into three: number of burned areas on head and hands, number of burned areas on body and number of burned areas on legs. Initially, all the subparts were included but not the total and then the multiple regression was run again with the subparts swapped for the total to ascertain which gave the better prediction. The results of this process are shown in Table 6.10.

Once the variables had been filtered, using the principles detailed above, an initial set of multiple regressions was run, with all the filtered variables that had not shown signs of independence to the iBID ND total score included. However, it was discovered that this resulted in insufficient cases remaining for predictive modelling. The reason for this was because in SPSS regression cases are excluded listwise (that is only cases that had data for all the included variables were included in the analysis) which reduced the available sample size considerably when a sparsely populated variable (such as LOS ventilated) was included. Although excluding missing data pairwise (cases are only excluded if they are missing data for that particular analysis) can be used in some statistical tests, this is not possible in multiple regression as a case cannot be excluded for one part of the regression and not another.

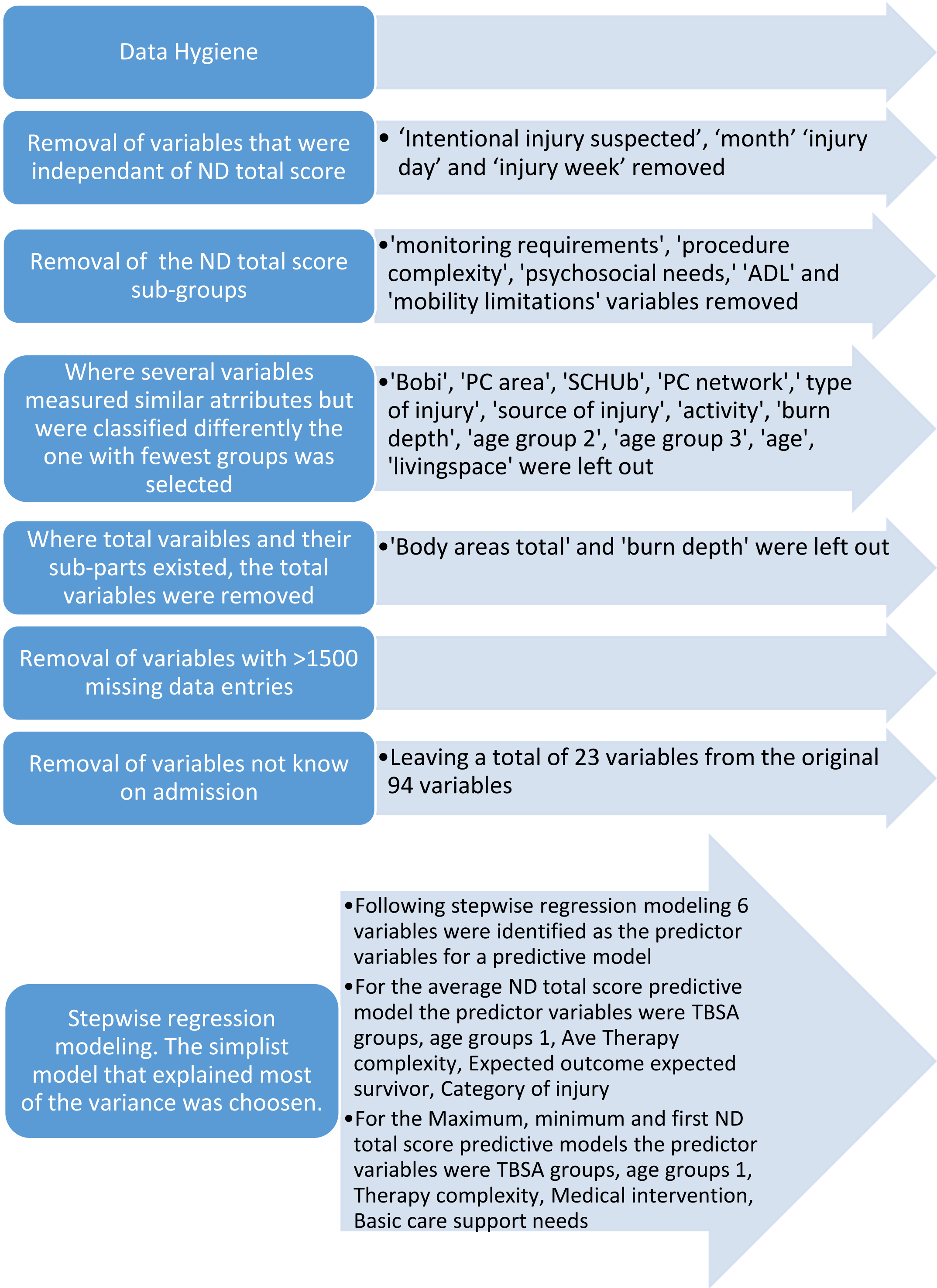


Figure 6.9 Flow chart showing the process for selection of variables for predictive modelling.

Using the results of the descriptive statistics that calculated the number of valid entries the multiple regression was re-run having removed variables that had more than 3000 data entries (81.5%) out of the possible 3679 missing. This was repeated several times until missing entries for each variable was <500 (<13.6%) to identify at what point there would be enough cases left in the model to meet Tabachnick and Fidell’s (2014) formula for sample size as discussed in section 4.5.4.4. The model summary for each iteration of the multiple regressions with different data entry limits is shown in Table 6.9, where it can be seen that only when the number of missing data entries per variable was less than 1500 did the model have an adequate sample size. It is acknowledged that this reduction in viable variables might increase the risk of a type II error (incorrectly accepting that there is no relationship when there is one). However, as this was an initial exploratory analysis it was felt that this was the appropriate way to manage the data to start with.

All the variables that had less than 1500 missing entries were reviewed further. As the aim was to develop a predictive model for ND, the variables included in the regression module needed to be variables that could be used on admission in a predictive model. Therefore, the two variables that would not be known until the end of the patient’s admission (‘discharge destination’ and ‘total LOS’), were excluded. When these two variables were removed, it meant that the variables for inclusion all had less than 1000 (< 27%) entries missing. Additionally, variables that had the potential to change throughout the patients stay were removed from the average ND total score model (for example, ‘ward type’, ‘medical intervention’, ‘basic care support needs’ and ‘skilled nursing needs’).

Table 6.9 Regression model summaries. This table shows the difference in the adjusted R squared, df (degrees of freedom) and N (number of cases remaining) when variables were excluded by the number of missing entries

	Average ND total score			Maximum ND total score			Minimum ND total score			First ND total score		
	Adj. R^2	**df**	**N**	**Adj. R^2**	**df**	**N**	**Adj. R^2**	**df**	**N**	**Adj. R^2**	**df**	**N**
Variables with < 3000 missing entries	Too few variables remaining for a model to be computed			Too few variables remaining for a model to be computed			1	2	2	1	4	4
Variables with < 2500 missing entries	0.842	79	99	1	64	64	0.690	82	151	0.916	107	214
Variables with < 2000 missing entries	0.774	96	426	0.856	84	252	0.608	94	427	0.823	108	852
Variables with < 1500 missing entries	0.848	104	1356	0.881	100	1378	0.754	103	1428	0.843	105	2494
Variables with < 1000 missing entries	0.835	93	1891	0.885	90	1891	0.728	95	2022	0.838	91	2494
Variables with < 500 missing entries	0.833	82	3145	0.843	82	3222	0.669	82	3452	0.827	82	3226

As stated earlier, some of the variables that essentially measured the same thing but were classified differently (for example, the mortality predictors ‘ASBI’ and ‘Bobi’) had been removed during the previous variable selection process. Therefore, the regressions were rerun several times, interchanging the variables with alternate groupings to see which improved the model the most. Table 6.10 shows how the adjusted R squared changed after each swap and the change in the number of degrees of freedom. Only three of the interchanges showed a negligible increase in the adjusted R squared (‘injury cause group’ with the ‘source of injury’ and the ‘network’ with ‘SCSCHub’ and ‘PC area’). All the other interchanges showed no improvement in how much of the variance in the ND score was explained by the regression model, which all suggested it did not matter which of the alternate groupings were used. Therefore, when there was a choice of two variables that gave the same information but were categorised differently, the one with the least categories was used to reduce the risk of overfitting the regression model. A list of the final included predictor variables for each regression analysis is shown in Table 6.11.

Table 6.10 Effect of interchanging similar variables. (The adjusted R squared, degrees of freedom (df) and the number of cases (N) after interchanging previously removed similar variables. Those that showed an improvement to the adjusted R square compared to the original regression are highlighted blue)

swap	Average ND total score		Maximum ND total score		Minimum ND total score		First ND total score	
	Adj R^2	df (N)	Adj R^2	df (N)	Adj R^2	df (N)	Adj R^2	df (N)
Original regression with < 1000 missing entries	0.84	87 (2021)	0.86	90 (2019)	0.73	88 (2024)	0.85	91 (2653)
Swap ABSI with Bobi	0.84	87 (2021)	0.86	90 (2019)	0.73	95 (2022)	0.85	91 (2653)
Swap the 3 body areas with total	0.84	85 (2021)	0.86	88 (2019)	0.73	93 (2022)	0.85	89 (2653)
Swap network with PC area	0.86	174 (2018)	0.87	177 (2016)	0.74	182 (2022)	0.86	184 (2029)
Swap network with SC SCHub	0.85	95 (1989)	0.87	98 (1987)	0.72	97 (1991)	0.85	99 (2611)
Swap network with PC network	0.84	88 (1992)	0.86	88 (1992)	0.72	97 (1994)	0.84	93 (2615)
Swap injury group with type of injury	0.84	91 (2020)	0.86	93 (2018)	0.73	98 (2021)	0.85	95 (2652)
Swap injury group with source of injury	0.85	170 (1988)	0.87	173 (1986)	0.73	180 (2022)	0.85	181 (2653)
Swap age 1 group with age 2 group	0.84	86 (2021)	0.86	89 (2019)	0.73	94 (2022)	0.85	90 (2653)
Swap age 1 group with age 3 group	0.84	90 (2021)	0.86	93 (2019)	0.73	98 (2022)	0.85	94 (2653)
Swap age 1 group with age	0.84	86 (2021)	0.86	89 (2019)	0.73	94 (2022)	0.85	90 (2653)
Swap category with activity	0.84	90 (1985)	0.86	93 (1983)	0.73	98 (1988)	0.84	85 (2602)
Swap TBSA with PSU FT/PT	0.84	77 (1850)	0.86	80 (1847)	0.72	85 (1851)	0.84	81 (2448)
Swap TBSA with PSU total	0.84	77 (2021)	0.86	88 (2019)	0.72	85 (2022)	0.84	81 (2653)
Swap locality with living space	0.84	77 (1942)	0.86	80 (1940)	0.72	84 (1942)	0.84	81 (2538)

Table 6.5 Final choice of predictor variables to be entered into the multiple regression model for the average, maximum, minimum and first iBID ND total scores

Dependent variable	**Average ND total score**	**Maximum ND total score**	**Minimum ND total score**	**First ND total score**
Independent variables entered into the regression models	• Group age 1 • ASBI, • Average Therapy complexity total • Bcuf • TBSA group • Burn areas body, • Burn areas head and hands • Burn areas legs • Category of injury • Complication total • Expected outcome • Gender • Inhalation symptoms • Injury cause group • Injury time group • Expected fluid resuscitation • Locality • network	• Group age 1 • ASBI, • Basic care needs • Bcuf • TBSA group • Burn areas body, • Burn areas head and hands • Burn areas legs • Category of injury • Charlson index • Complication total • Expected outcome • Gender • Inhalation symptoms • Injury cause group • Injury time • Expected fluid resuscitation • Locality • Ward type • Medical intervention • Network • Skilled nursing needs • Therapy complexity total	• Group age 1 • ASBI, • Basic care needs • Bcuf • TBSA group • Burn areas body, • Burn areas head and hands • Burn areas legs • Category of injury • Charlson index • Complication total • Expected outcome • Gender • *I*nhalation symptoms • Injury group • Injury time group • Expected fluid resuscitation • Locality • Ward type • Medical intervention • Network • Skilled nursing needs • Therapy complexity total	• Group age 1 • ASBI, • Basic care needs • Bcuf • TBSA group • Burn areas body, • Burn areas head and hands • Burn areas legs • Category of injury • Complication total • Expected outcome • Gender • Inhalation symptoms • Injury cause group • Expected fluid resuscitation • Locality • Ward type • Medical intervention • network • Skilled nursing needs • Therapy complexity total

6.2.2.1.1 Summary of the four regression models' results

Once the variables for the predictive modelling had been selected a regression analysis was run for each of the four dependant variables (average, maximum, minimum and first ND total score). For all four models, the independent variables were entered simultaneously into the regression equation. A summary of the results from these four multiple regressions can be found in Table 6.12.

Table 6.12 Summary of multiple regression results when the independent variables were entered simultaneously. (df = degrees of freedom, N = number of cases

	Average ND total score	Maximum ND total score	Minimum ND total score	First ND total score
Adj R^2	0.84	0.86	0.73	0.85
Df (N)	78 (2628)	89 (2019)	94 (2022)	90 (2653)
Durban Watson score	2	1.94	1.93	1.89
Largest cooks value	0.08	0.14	0.12	0.25
Coefficient constant (std. error)	3.58 (0.24)	5.54 (0.25)	4.53 (0.36)	4.56 (0.34)
Variables that had no significant effect on the model at the 0.05 significance level	• Comp total, • inhalation symptoms, • gender, • BCUF • injured time	• Comp total • inhalation symptoms • gender, • group age 1 • Charlson index, • injury cause group, • expected fluid resuscitation	• Comp total, • inhalation symptoms, • injury time • Injury cause group, • Charlson index, • ABSI, • TBSA (apart from 50% group)	• Comp total, • inhalation symptoms, • gender, • Group age 1 • ABSI, • injury cause group, • expected fluid resuscitatio n • BCUF

	Average ND total score	Maximum ND total score	Minimum ND total score	First ND total score
The largest magnitude of significant standardised coefficients (Beta value)	• ave therapy (0.68) • Age (adult -0.13/ older adult -0.10), • ASBI (0.10) • Expected >75% death (0.10) • Expected 25-50% death (0.08) • TBSA group 70-100% (0.8) • Network midlands (0.50) • Network SE (0.50) • Expected 50-75% death (0.04) •	• Therapy (0.41) • Ward type (BICU -0.11/GICU 0.8) • ASBI (0.6) • BCUF (BU-0.8) • basic care needs(C0- -0.17/ C2 – 0.10/ C3-0.10) • medical intervention (M3- 0.11) • network (SW- -.0.06)	• Therapy complexity (0.40) • Basic care needs(C1-0.24/ C2 – 0.09/ C3-0.12) • medical intervention (M3 – 0.15), • ward type ICU (0.12), • expected outcome >75% death -0.15/ 50-75% death -0.07 / <25% death – 0.7) • Network (mid 0.6) • expected fluid resuscitation • Burn area (HH -0.8, L -0.6)	• Therapy (0.421), • basic care (C1- 0.15/ C2 – 0.11/ C3- 0.19), • medical intervention (M3- 0.1), • Ward type (BICU – 0.1) • TBSA (0.02 – 0.9 • Network (SW- 0.6)
The largest magnitude of significant unstandardised coefficients (b)	• Expected outcome • ASBI	• Basic care • medical intervention 3, • expected outcome	• Basic care • Medical intervention • Ward type • Expected outcome • TBSA 50% group	• Basic care • TBSA • Ward type (rehab unit the same as BICU)

6.2.2.1.2 *Checking for signs for violated assumptions of multiple regression*

Before analysing the results of the multiple regression further, they were checked for any violations of the assumptions of multiple regression as discussed in the methodology chapter section 4.5.4.4. Checking for violations is an important step in providing confidence for any predictions that may arise, because if any of the assumptions have been violated then the model may be biased and misleading. No violations were found that raised concerns.

There was no VIF higher than 10 and no correlations >0.8 in the correlation matrix suggesting that the independent variables were not correlated with each other.

Inspection of the Durban Watson scores suggested that there was no autocorrelation (the residuals of the observations are not correlated) present in the regression models, as the scores for all four tests tended towards two. For all four of the regression tests, 97.5 % of the values were within 2.5SD which, combined with the cooks' distances all being less than one (the largest being 0.25), suggests that the outliers do not unduly influence the model.

The resulting histogram of standardised residuals, the normal P-P Plot and scatterplot of standardised residuals from the multiple regressions were scrutinised for signs that the residuals are not normally distributed. From the examples shown in Figure 6.10 for the average ND total score multiple regression model it can be seen that the histogram of standardised residuals and the normal P-P Plot (which closely followed a straight diagonal line) showed the residuals were normally distributed. The scatterplot was roughly rectangular in shape with most of the points congregating around zero and no clear patterns, apart from the expected set of lines due to the underlying variable having set intervals. Thus, indicating that the assumption of homoscedasticity (that the residuals across a predictor are similar) had not been violated. Similar results were seen for the other three models regarding the histogram, normal P-P Plot and scatterplot of standardised residuals.

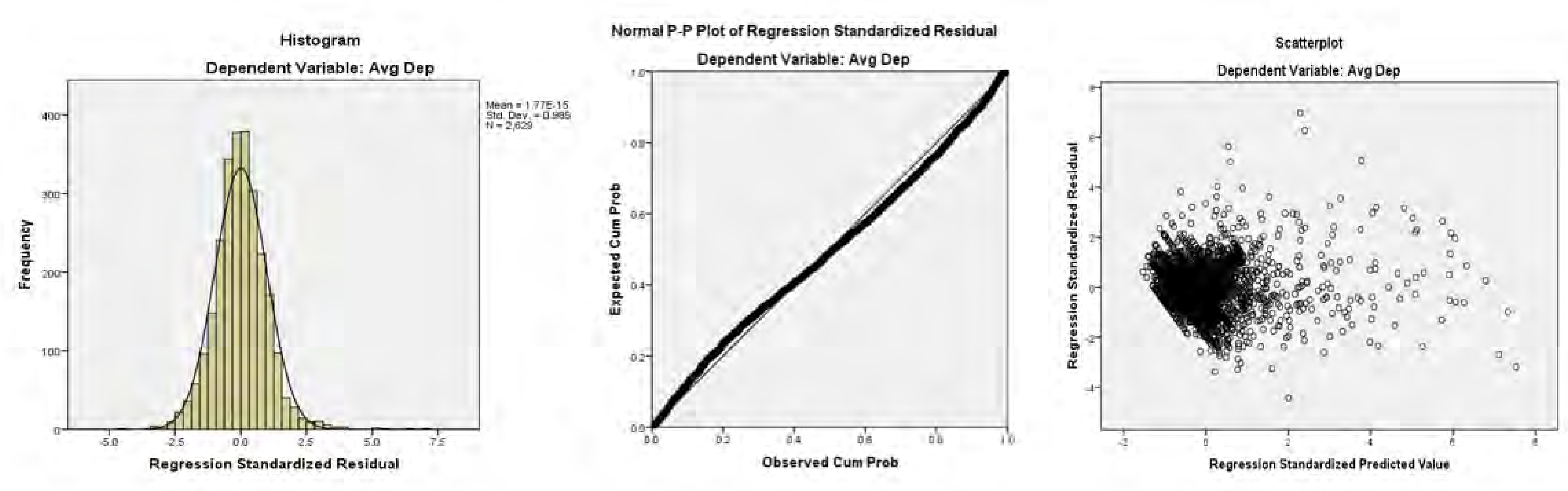


Figure 6.10 The average ND total score multiple regression histogram of standardised residuals, the normal P-P Plot and scatterplot of standardised residuals results taken from the SPSS output, indicating the assumptions of normality and homoscedasticity were not violated

On consideration of the above information, there was nothing to cause concern that the multiple regression assumptions had been violated for these models.

6.2.2.1.3 Regression coefficient results

Reviewing the variables that had no significant effect on the models at the 0.05 significance level in Table 6.12, it was noted that similar ones were excluded across all four models. Unexpectedly, one of these was ‘inhalation symptoms’. Clinically, an inhalation injury will escalate the acuity of a burn patient, so it would have been expected that these would have increased the ND. However, statistically, it may be that the effect of an increased number of inhalation symptoms is overshadowed by other factors included in the regression model such as TBSA, morbidity predictor or where the patient is being cared for (for example, BICU). The same is likely to be true of both the ‘fluid resuscitation’ and ‘number of complications’ variables, which also notably did not have a statistically significant effect on the predictive models.

There were several points of interest identified when examining the variables that showed a statistically significant predictive effect. These are listed below

- The average ND total score regression model appeared to have different key predictors that influenced the ND total score than the other three models.
- The ‘group age1’ variable was not statistically significant for the first and maximum ND total scores. However, when taking the overall stay into account as demonstrated by the average ND total score regression model, ‘group age1’ was a significant predictor. This is perhaps because the care would be the same regardless of age on admission and at the peak of their illness but in the long term the patient’s daily nursing needs may vary depending on the age group. Additionally, the older adult may stay in hospital for longer at their minimum score while social issues are sorted out (Santos et al., 2017). The average regression model predicts the highest ND total score for children, followed by the older adult group. The adult group, meanwhile, has the lowest ND total score.

- For the average ND total score regression model, the ‘expected outcome’ variable appeared to be a key predictor. The greater the patient’s probability of not surviving, the higher their average ND total score was.
- Gender did not make a statistically significant difference to the first, average and maximum ND total scores. Though when looking at the minimum score, males were predicted to have a higher dependency than females (Beta = 0.04).
- For the minimum, maximum and first ND total score predictive models, the ‘ward type’, ‘medical intervention’ and ‘basic care needs’ of the patient were predictors of ND. This is perhaps unsurprising as an increase in these variables indicates a more acutely ill patient or one that needs more help to meet their needs.
- The ‘burn operational delivery networks’ variable unexpectedly was a statistically significant predictor of ND. Clinically it would be expected, that regardless of which part of the country the patient was being cared for in, their ND would be similar. However, as discussed earlier, the casemix of severe and minor burns varies between networks which will affect this outcome.
- In all four of the predictive models, the ‘therapy complexity’ total score had the highest positive coefficient. This would suggest that the more need there was for therapy input the higher the ND is likely to be.

6.2.2.2 Modelling via a stepwise approach.

The multiple regression modelling in the previous section indicated that some variables did have predictive properties. In order to refine the predictive model further, the multiple regressions were repeated using a hierarchical and stepwise approach. As the literature suggests that burn size and patient age are key to predicting burn mortality and describing the acuity of a burn, these variables were entered into the regression model as the first two steps of the hierarchical approach (the ‘TBSA’ variable first followed by ‘group age 1’). The remaining variables were then entered in a forward stepwise manner as a third step, allowing SPSS to sequentially add the remaining predictors in order of correlation strength (Field, 2018). A summary of these results can be found in Table 6.13 with the full results in Appendix J. The results from the multiple regressions were then checked for violations to the assumptions of normality, linearity, multicollinearity, homoscedasticity, independence of residuals and undue influence of outliers on the model (as described in detail in sections 4.5.4.4 and 6.6.2). No concerns were identified.

It can be seen from Table 6.13, that the TBSA groups' which were entered at step one (stepwise model 1) explain nearly 50% of the variance in the 'average, 'maximum' and 'first' ND total scores. However, for the minimum ND total scores, only 28% of the variance is explained by the 'TBSA group', possibly because, regardless of burn size, the treatment plan will be aiming to reduce the ND to the lowest practical score. Other comorbidities, such as mobility limitations before the accident or recovery complications, are more likely to affect the minimum ND total score than the initial burn size. Of particular note, the lowest TBSA groups (0% and <1%) do not have a statistically significant predictive effect on ND in any of the predictive models.

At the next step, the 'group age 1' was entered after 'TBSA' (stepwise model 2). The addition of the 'group age' accounted for an additional 3-7% of the variance across all four of the multiple regression models. Thus indicating that age has a low predictive influence compared to TBSA. Perhaps because the nursing care required will depend more on the size of the burn and their condition irrespective of the patient age. Reviewing the subsequent stepwise models, the regression coefficients of the adult and older adult groups against the child on the maximum and first ND total score were showing as not statistically significant when more variables were added. It is difficult to say why they were significant for the average and minimum scores. A possible hypothesis is that age has more of a long term influence on the underlying dependency than on the daily iBID ND total score.

Table 6.13 Summary of multiple regression results when TBSA was entered first (Model 1), followed by group age 1 (Model 2) and then the remaining independent variables added stepwise. Model 6 which describes > 94% of the final model and the terminal model results are also presented (df = degrees of freedom. N = number of cases).

	Average ND total score				**Maximum ND total score**				**Minimum ND total score**				**First ND total score**			
Stepwise model stages	1	2	6	19	1	2	6	21	1	2	6	23	1	2	6	27
Adjusted R Square	0.47	0.51	0.82 (99% of final model)	0.84	0.49	0.52	0.84 (97% of final model)	0..86	0.28	0.35	0.69 (95% of final model)	0.73	0.48	0.51	0.83 (98% of final model)	0.85
Std. Error of the Estimate	2.04	1.97	1.17	1.13	2.64	2.57	1.47	1.40	2.09	1.99	1.38	1.29	2.52	2.45	1.45	1.36
Durbin-Watson	1.99				1.92				1.93				1.88			
Largest cooks value	0.15				0.08				0.24				0.05			
df (N)	11 (2628)	13 (2628)	17 (2628)	30 (2628)	11 (2021)	13 (2021)	17 (2021)	32 (2021)	11 (2022)	13 (2022)	17 (2022)	34 (2022)	11 (2033)	13 (2033)	17 (2033)	36 (2033)
Variables included in model 6	TBSA groups group ages 1 Ave Therapy complexity Expected outcome expected survivor Expected outcome >75% survivor Category of injury accidental recreation				TBSA groups group ages 1 Therapy complexity Medical intervention M3 Basic care support needs C0 Basic care support needs C1				TBSA groups group ages 1 Therapy complexity Medical intervention M3 Basic care support needs C0 Basic care support needs C1				TBSA groups group ages 1 Therapy complexity Basic care support needs C3 Basic care support needs C0 Basic care support needs C1			

	Average ND total score				Maximum ND total score				Minimum ND total score				First ND total score			
Constant of model / SE	6.56 (0.06)	6.99 (0.07)	5.56 (0.23)	6.19 (0.31)	7.73 (0.08)	8.10 (0.10)	8.31 (0.24)	7.71 (0.32)	5.81 (0.06)	6.45 (0.08)	7.23 (0.31	8.75 (0.4)	7.10 (0.06)	7.58 (0.08)	5.03 (0.10)	5.33 (0.16)
Variables that had no significant effect on the model at the 0.05 significance level	TBSA 0 - 0.9%	TBSA 0, 0 - 0.9%, Age older adult	TBSA 0,	TBSA 0,	TBSA 0-0.9	TBSA 0 - 0.9%	TBSA 0 - 0.9% Age adult and older adult	TBSA 0 - 0.9% Age adult and older adult	TBSA 0, 5-9%,	TBSA 0, 0 - 0.9%, 5-9%,	TBSA 0, 5-39%, 50-59%	TBSA 5-14, 40-49%, 60-100%.	TBSA 0 - 0.9%	TBSA 0, 0 - 0.9%, Age older adult	TBSA 0, 0 - 0.9%, Age adult and older adult	TBSA 0 - 0.9%, Age adult and older adult
Variables not used by SPSS in the regression model	• BCUF • complications total • gender • inhalation injury • inhalation symptoms • injury cause group • Injury time • Expected fluid resuscitation				• Charlson index • complications total • gender • inhalation injury • inhalation symptoms • injury cause group •				• ASBI • Charlson index • complications total • inhalation injury • inhalation symptoms • Injury time				• complications total • gender • inhalation injury • inhalation symptoms • injury cause group • Expected fluid resuscitation			

Following the third step, the stepwise entry of the independent variables, the number of regression models created ranged from 19 (average ND total score) to 28 (minimum ND total score). It was noted that the 6th stepwise model, in all four multiple regressions, described 94% or more of the variance of the final model. Tabachnick and Fidell (2014) advise seeking the best model with the fewest variables. Therefore model 6 was considered in more detail on the basis that adding more variables did not markedly improve the variance of the model, yet had the potential risk of overfitting of the model; with the model describing the random error rather than the relationship between variables.

Breaking down stepwise model 6, it only added four more variables to each of the 4 regression models. For the maximum, minimum and first ND total scores these were ‘therapy complexity score’, ‘medical intervention 3’, ‘basic care support needs 0’ and ‘basic care support needs 1’. The inclusion of these particular variables demonstrates that the nursing needs of the patient may be related to the required input from other members of the multidisciplinary team. However, for the average ND total scores, it was the ‘accidental recreation activity’, ‘expected outcome of expected survivor’ and ‘expected outcome of >75% survivor’ category variables alongside the ‘average therapy complexity score’ variable, that had the biggest predictive influence.

From these results, it can be seen that some of the variables do have a predictive influence on the iBID ND total score. Looking at the result of stepwise model 6 in the stepwise regression model the simplest regression models that explain the most variance would consist of the following variables:

> **Average iBID ND total score predictive model** – ‘TBSA groups’, ‘group ages 1’, ‘ave therapy complexity’, ‘expected outcome’ and ‘category of injury’

Maximum, Minimum, and first iBID ND total score predictive model - 'TBSA groups', 'group ages 1', 'therapy complexity', 'medical intervention' and 'basic care support needs'

6.3 Nurse Dependency Trajectory

In the earlier regression analyses, it was shown that the TBSA can account for nearly 50% of the variance in the change of the ND total score. If the ND of patients with a burn injury could be formally linked to the initial TBSA this would benefit those planning nurse staffing. Consequently, the trend in the ND total scores over a patient's stay was explored further using a pivot table. The aim was to see if a ND could be predicted over a time span (the 'ND trajectory') and conversely, what might be able to be predicted through an individual burn-injured patient's ND trajectory as their admission progressed.

First, this section will present the results of plotting the daily average of the iBID ND total scores per TBSA group on a graph to identify the ND trend. Secondly, the effect of some of the dominant predictive variables (identified via the predictive modelling) on the ND will be discussed. Specifically exploring whether these can be used to predict the ND trajectory or whether the ND total score can be used to predict those patients that are more likely to stay in for longer than others.

6.3.1 Nurse dependency as a function of time

Having plotted the average ND total score for each day post-admission for each TBSA group, as expected it was found that all the TBSA groups showed a downward trend in the daily averaged ND total scores from admission to discharge (Figure 6.10). It is acknowledged that this is the average ND total score for the day so there will be some patients who have a lower or higher ND total score. Additionally, factors other than just the size of the burn will have an impact on the ND and treatment of all TBSA groups (such as the presence of an inhalation injury or comorbidities), causing variation of the ND score within TBSA groups. With this in mind each TBSA group was scrutinised individually along with the 95% confidence intervals; an example of which is shown in Figure 6.11 for the TBSA 30-39% group ND total score trend.

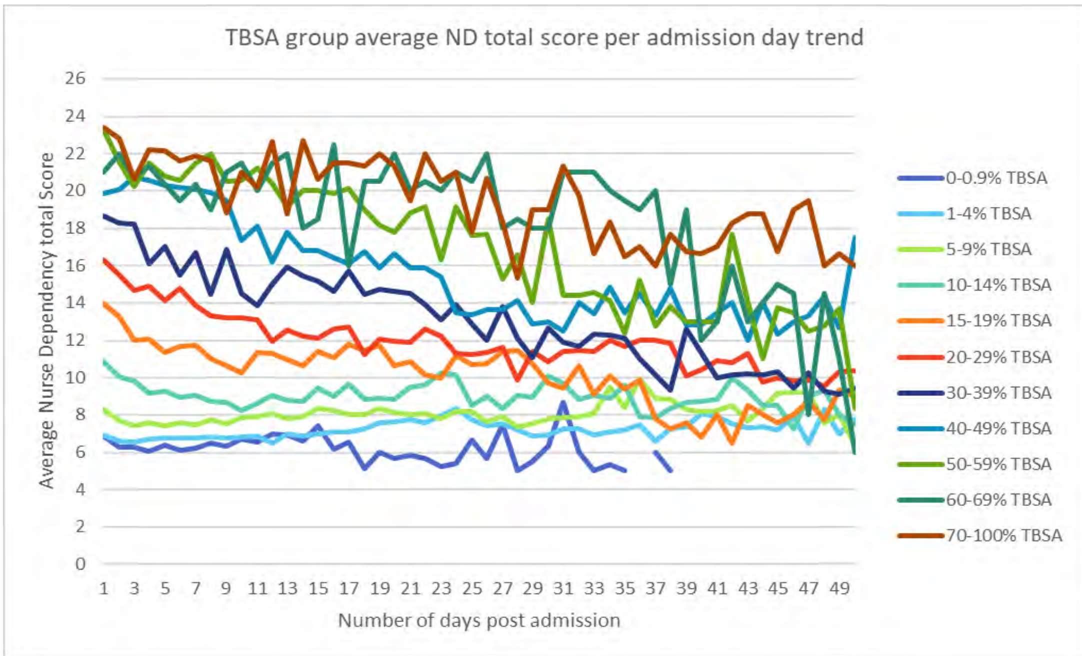


Figure 6.10 Average daily ND total score trend for each TBSA group.

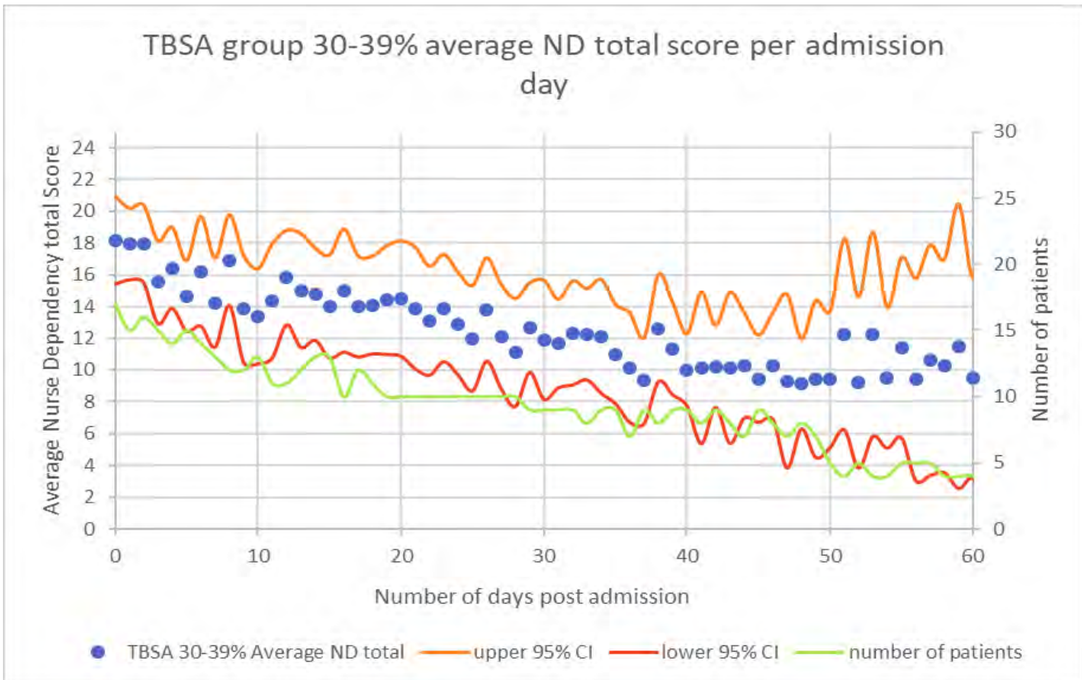


Figure 6.11 TBSA 30-39% group average ND total score per admission day trend. Noting that the CI became wider at the 40-day mark and as the number of patients got smaller.

When inspecting the confidence intervals, it was noticed that initially they were close together but the precision reduced (confidence interval widened) as the sample size (number of patients in the TBSA groups) reduced. The widening of confidence intervals also appeared to coincide with the length of stay exceeding 1 day per percentage TBSA (in the case of Figure 6.11 example after 40 days). This is likely to be because the majority of burn patients, if their recovery goes well, will be discharged within approximately one day per %TBSA (Gillespie et al., 1987). Nonetheless, it is recognised that other confounding factors may also increase the patients' length of stay such as inhalation injury and other comorbidities and complications arising (Dolp et al., 2018; Taylor et al., 2017) as well as social issues such as safeguarding and suitable accommodation for discharging too particularly if the cause was a house fire or the patient was an older adult (Madni et al., 2019).

Additionally, it was observed that once the length of stay exceeded one day per %TBSA (1day/TBSA), the averaged ND score appeared to go up before coming down again. From this observation, it was hypothesised that the ND trajectory might be different for patients that were discharged within 1day/TBSA and those that were not. Therefore, the analysis was repeated looking at the ND trajectory of those that met the 1day/TBSA length of stay rule and those that exceed (breached) it were considered separately. An additional 10% was added to the 1day/TBSA equation result to give some leeway in the length of stay for management differences. Figure 6.13 shows the 30-39% TBSA groups ND trajectory for patients whose total length of stay was less than 1day/TBSA and Figure 6.14 for those that had a longer length of stay. It was seen that both groups (patients whose length of stay met the 1day/TBSA rule and those that breached it) gave clear linear trends of the ND total score decreasing with the length of stay, as would be expected, but a different trajectory as shown in Figure 6.14 where they are plotted on the same graph.

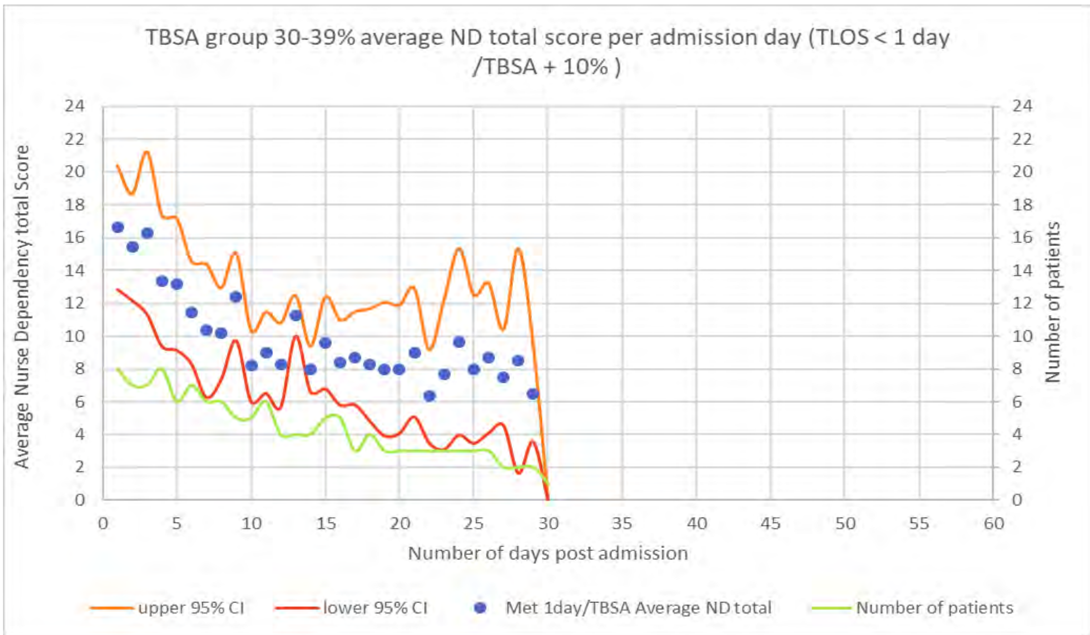


Figure 6.12 Average ND trend for the 30-39% TBSA whose length of stay was less than 1 day per TBSA plus 10%. The average ND score on the first day was 14.

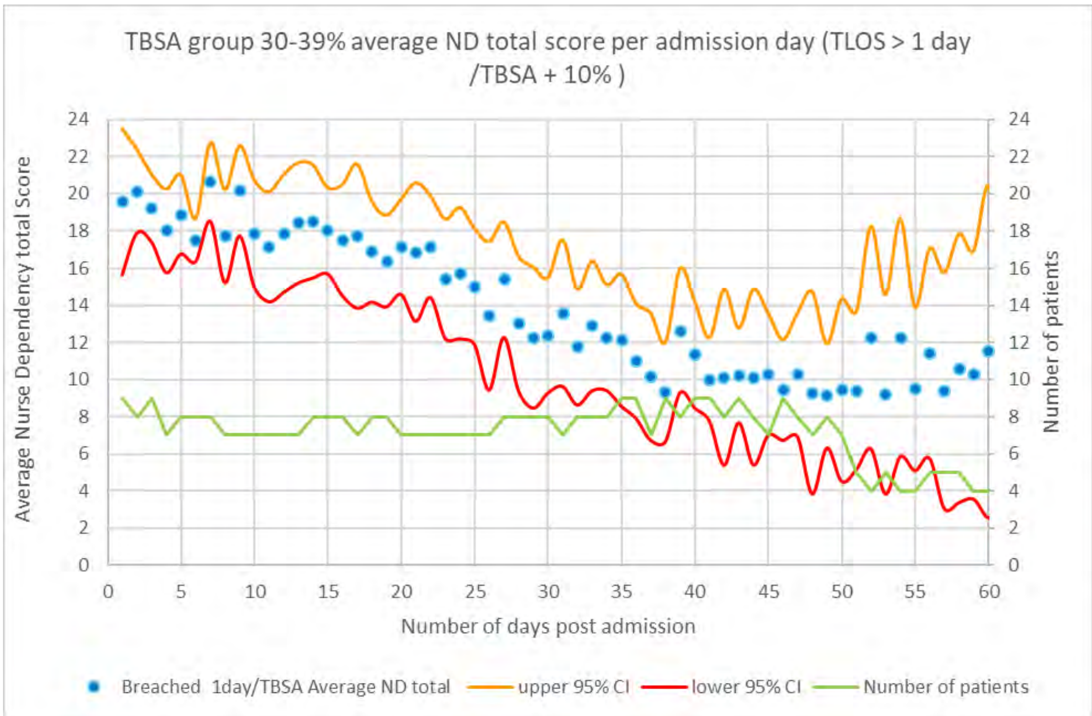


Figure 6.13 Average ND trend for the 30-39% TBSA whose length of stay was more than 1 day per TBSA plus 10%. The average ND score on the first day was 19

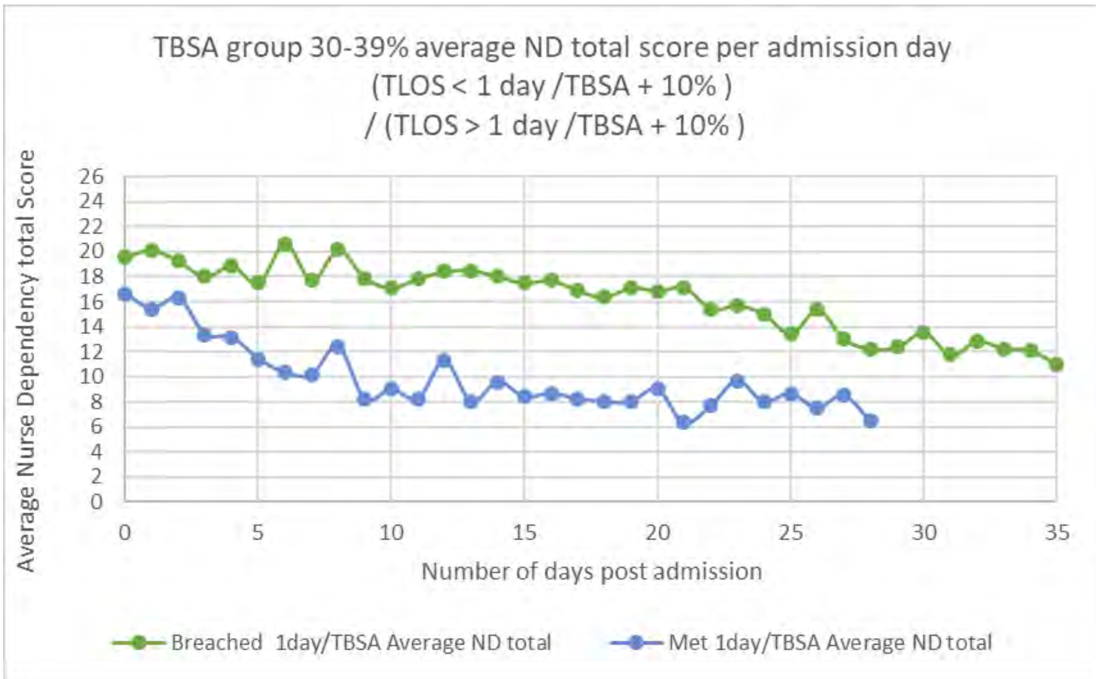


Figure 6.14 Average ND trend for the 20-29% TBSA comparing the average ND daily total score for patients with a burn injury who met and breached the 1 day per TBSA plus 10% length of stay rule. (This figure combines figures 6.13 and 6.14 to show the difference in the ND trajectories for the two groups)

A similar pattern was seen with all TBSA groups but it was noted that as the burn size increased so did the starting ND total score. For patients that were discharged by 1day/TBSA, the initial average ND total was 6.7 in the 1-4% TBSA group, increasing for each TBSA group until for the 50-100% TBSA group the initial average ND total score was 22 (Table 6.). However, for all TBSA groups, the iBID ND total score decreased to between 4 and 10 at the end of their hospital stay irrespective of their burn size. It was also noticed that for those that breached the 1day/TBSA rule the starting average ND was higher (Table 6.) and there was a slower decrease in the dependency trend as shown earlier in Figure 6.14. This may be because of other comorbidities or complications causing a higher acuity, or social issues all leading to a longer length of stay.

If these patterns of the daily ND average for the different TBSA groups and the breach/meet the 1day/TBSA rule group can be confirmed in the whole iBID database this will provide a better insight into a patient's projected ND needs and accordingly nursing workload. Hence it could be used in the planning of nurse staffing and in supporting the argument for the required nurse staffing levels.

Table 6.14 TBSA group and initial average iBID ND total score for patients with a burn injury who met and breached the 1day/TBSA+10% length of stay rule.

Initial average iBID ND total score / **TBSA group**	**Met 1day/TBSA rule**	**Breached 1day/TBSA rule**
1-4	6.6	7.1
5-9	7.1	8.5
10-14	9.7	12.2
15-19	11.7	16.2
20-29	13.8	18
30-39	16.6	19.6
40-49	20.4	21
50-100	22	23.9

6.3.2 Effect of dominant regression factors on the ND average score trajectory

Having identified that there was a difference between the averaged iBID ND total score trajectory for patients that were discharged by 1 day/TBSA and those that stayed longer, the impact of different variables on the ND trajectory was explored to see if they could help with predicting of ND.

6.3.2.1 Survival outcome

Abdelrahman et al. (2018), in their study, noted that those patients who did not survive had higher cumulative ND scores than those that survived. Therefore, with the benefit of retrospective iBID data, it was possible to examine the comparative trajectories and initial ND total scores for those patients who were discharged within the 1 day/TBSA rule, those that breached the 1 day/TBSA rule and those that did not survive for any insight into different ND needs. From the examples shown in Figure 6.15 and Figure 6., it can be seen that patients who did not survive tended to have a higher ND total score on admission which also did not appear to reduce.

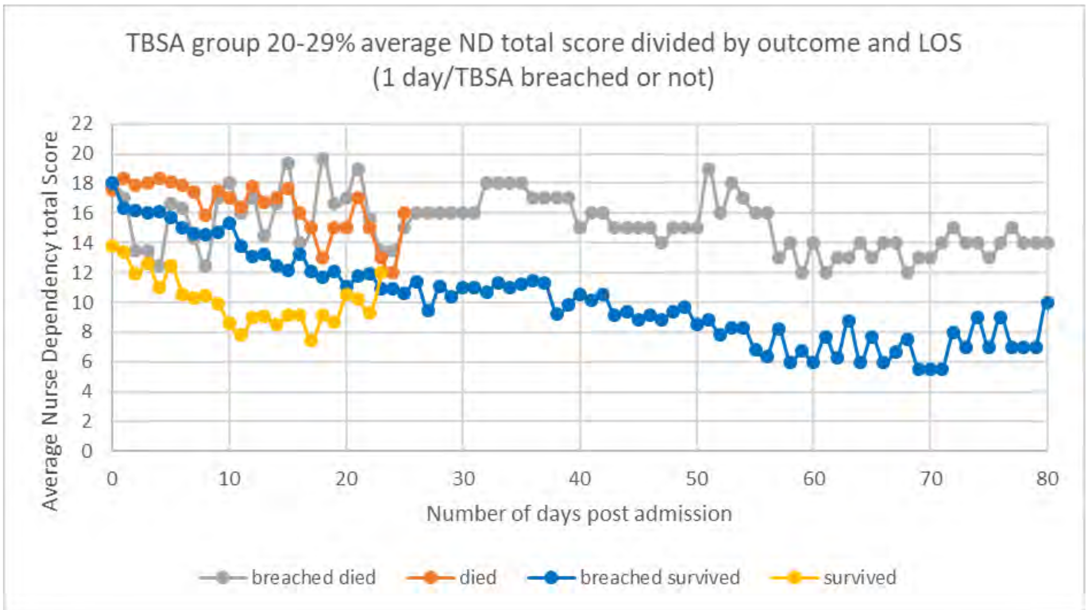


Figure 6.15 The average ND total score trend for the 20-29% TBSA group separated by outcome (died/survived) and length of stay

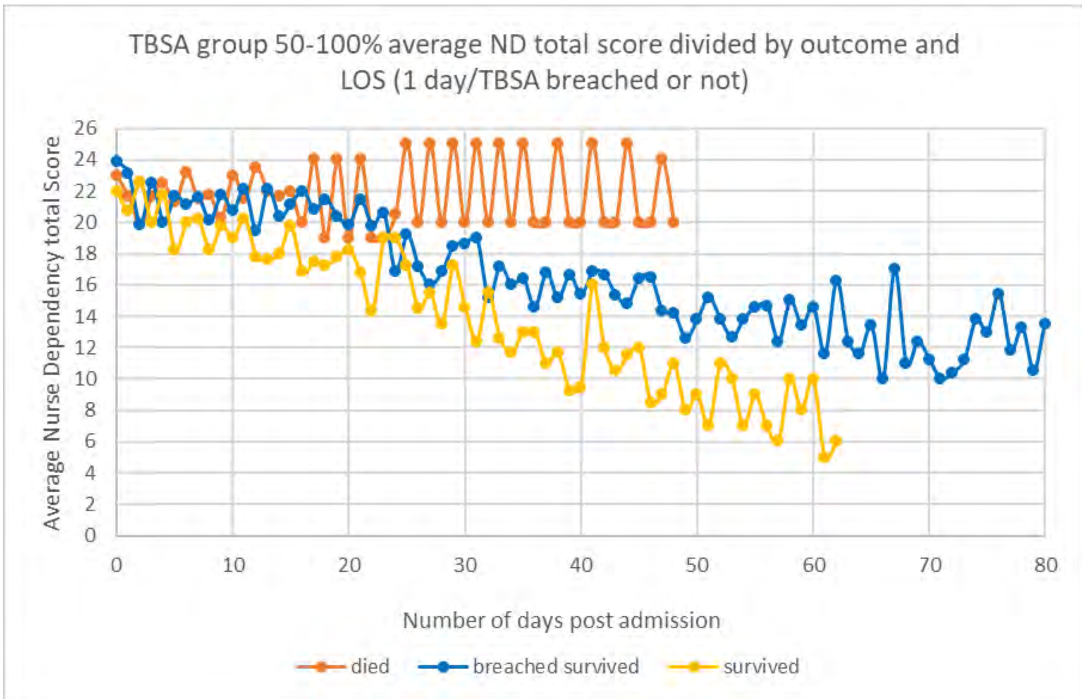
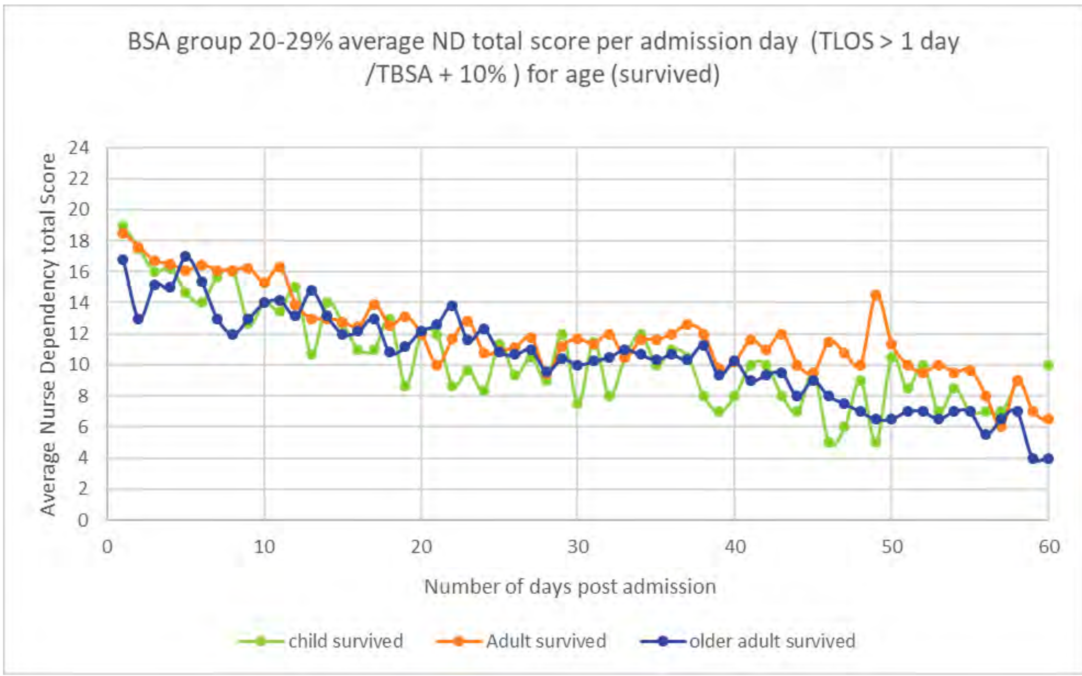


Figure 6.17 The average ND total score trend for the 50-100% TBSA group separated by outcome (died/survived) and length of stay

6.3.2.2 Age

The earlier stepwise predictive model in section 6.2.2.2 indicated that there may be a difference in the average ND total scores according to the age group. Consequently, for those that survived, the trajectory of the average ND total score for child, adult and the older adult was explored. The two examples in Figure 6.18 show a similar trajectory for each age group.



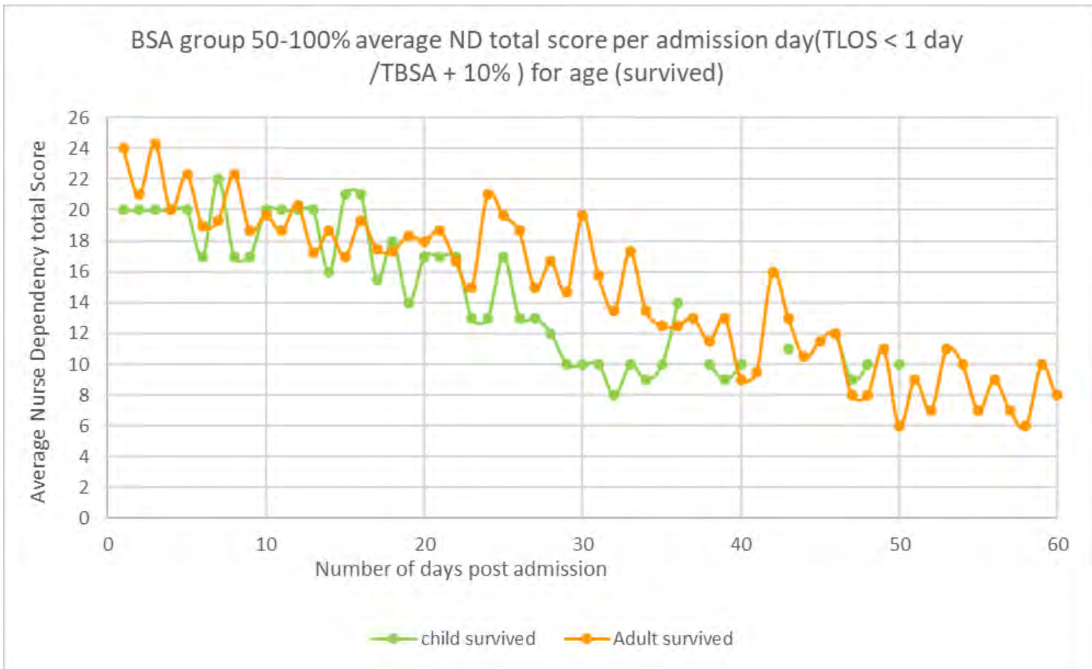


Figure 6.18 Examples of average ND total score trend of TBSA groups separated by age groups (N.B. in this sample of data range there were no older adults)

On first glance, these trajectories do not appear to explicitly support the regression analysis discussed in section 6.2.2, the results of which suggested that the average ND score was higher for children. However, on further examination, it can be seen that over their whole stay adults may still have a lower average ND score than children but in context this is because they are likely to be in for longer with more lower scores at the end of their stay. Nevertheless, the sample size of many of these age subgroups is small, hence the results need to be viewed with caution and may not be transferable.

6.3.2.1 Expected outcome groups

As indicated previously, at the start of section 6.6, the TBSA is only a rough indicator of burn severity and other factors may increase the severity. The iBID mortality predictor takes into account the size of the burn, age, inhalation injury and comorbidities and it is used to calculate the probability of surviving the burn injury (expected outcome variable). As the expected outcome was a variable that came up in the multiple regression model as a predictor of the average ND score it was hypothesised that it might be a better predictor than TBSA for ND. Therefore, similar to the TBSA groups the daily average ND total score was plotted on a scatter graph for each of the expected outcome groups as shown in Figure 6.16 and Figure 6..

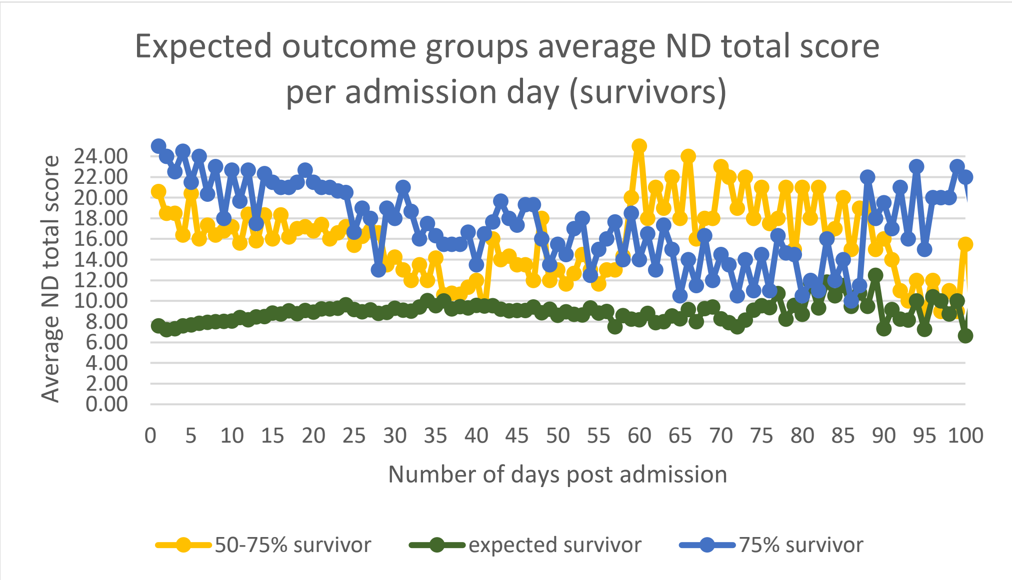


Figure 6.169 Average ND total trend for expected outcome groups for patients that survived and were discharged

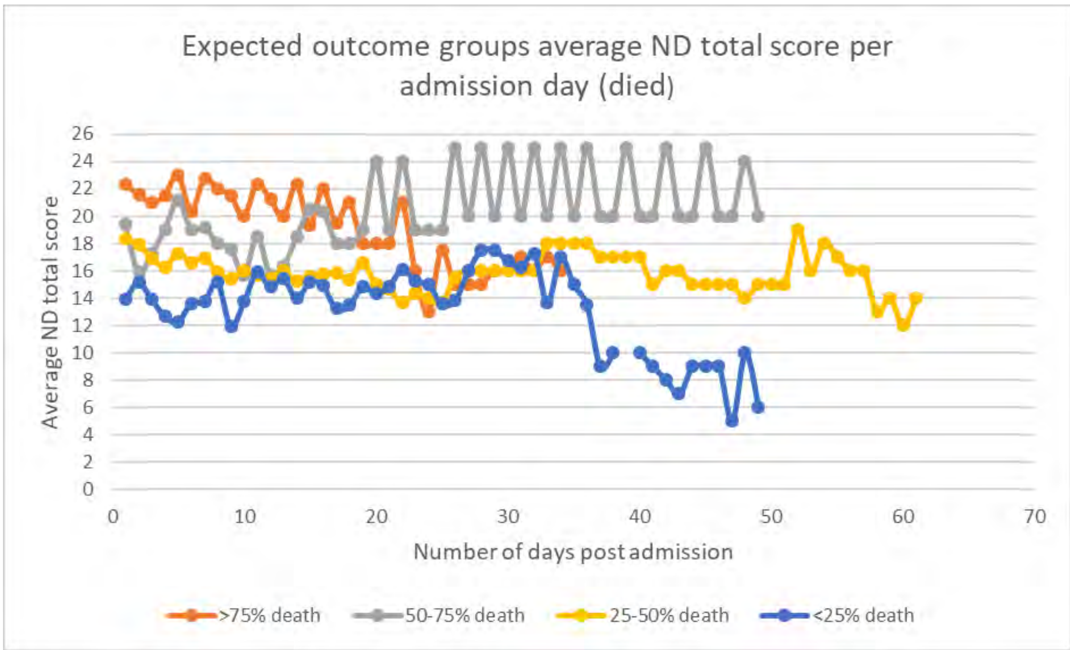


Figure 6.20 Average ND total trend for expected outcome groups for patients that died

It can be seen that there is a difference in the ND total score trajectory for the different expected outcome groups. For those that survived, the higher the projected probability of not surviving the higher their ND total score was. This is likely to be due to factors such as the size of the burn and inhalation injury, which are likely to lead to a higher probability of not surviving. These factors are also likely to increase the patient's acuity and thus also their ND. Practically, though the expected outcome group may be a predictor of the ND, additional calculations would be required to decide what group the patient was in. Currently, this algorithm for the expected outcome is not published outside of iBID and would be more complicated to calculate than using the TBSA. Additionally, the expected outcome groups were decided on in line with the UK Trauma registry (Dunn, 2018) so further research would be needed to confirm these groupings as predictive.

6.3.3 Logistic regression – can we predict who will breach.

It has been identified that there is a difference in the ND score trajectory for patients with a burn injury depending on the size of their burn. Additionally, there appeared to be a difference in the ND trajectory of patients who met the

1day/TBSA rule and those that breached it, regardless of the burn size. Those that breached the 1day/TBSA rule had a higher ND throughout which did not appear to reduce as quickly as for those patients that were discharged by 1day/TBSA. To explore this further, logistic regression was performed with all the iBID sample variables that would be available to nursing staff on the patient's admission, to identify if any factors existed that might help to predict which of the two groups a patient with a burn injury might fall into (≤ 1day/TBSA vs > 1day/TBSA).

Starting with the 58 variables that would have been known on admission, only half of these demonstrated statistical significance as a result of a logistic regression analysis. However, a number of these were differing measurements of the same attribute. Once the duplicates were removed, only ten variables had more than a two per cent improvement from the null hypothesis model (which predicted that a patient would breach 1day/TBSA as this was the larger group). The other variables were either not statistically significant or the improvement from the null hypothesis was so small and was therefore unlikely to make a difference clinically. Table 6.15 gives a summary of the results of the logistic regressions performed for these ten variables. Not all the categories in each of the variables were statistically significant.

The amount of variation in whether the length of stay breached 1day/TBSA that was explained by the predictor variables in the logistic regression models was small. The Nagelkerke R squared ranged from 0.018 – 0.135, suggesting that less than 13.5% of the variation in the length of stay is explained by the predictors. The one exception was the patients' home PC district, where the Nagelkerke R squared was 0.545 suggesting that the place a patient with a burn injury lives accounts for 50% of the variation. However, although the model was statistically significant as a whole none of the individual categories were. This is likely to be due to the low numbers in many of the categories signifying that this may not be a reliable result.

Table 6.15 Logistical regression results of potentially the most clinically significant variables on the likelihood that the 1day/TBSA will be breached. OR = odds ratio

Variable	N/df	Chi square	Nagelkerke R squared	Cases correctly classified % (null hypothesis %)	Most likely variable to cause a breach (OR)	Least likely variable to cause a breach (OR)
Activity	3489/ 16	95.26	0.036	58.1 (55.9)	Transport	Amusement/ Entertainment (0.155)
Group age 1	3663/2	141.13	0.051	59.5 (55.9)	older adult (93.25)	Child
TBSA group	3601/ 11	671.69	0.228	56.9 (63.6)	0-0.9% group (36.33)	
Total number of areas burned	3664 /1	83.09	0.030	58.6 (55.9)	An increase in the number of burned areas was associated with a reduction in the likelihood of breaching the 1day/TBSA rule	
Injury cause group	3660/ 5	172.40	0.062	60.1 (55.9)	Hot water system	Accelerant
network	3664/ 3	67.44	0.024	57.7 (55.9)	North (1.56) compared to midlands	Others not sig
PC district	3665/ 1363	1913.09	0.545	76.0 (55.9)	No group has a particularly significant effect compared to the reference group but the overall model is significant	
FT/PT	3273/ 2	347.22	0.135	66.7 (56.4)	two groups	FT not sig. PT larger PT area less likely to breach
Specialist commissioning local area teams	3602/ 26	155.67	0.057	59.4 (56.1)	Greater Manchester (2.86)	Cumbria (1.84) (most areas not significant)
Type of injury	3657/ 9	190.53	0.068	58.6 (55.9)	Contact (2.53)	Scald (0.72) (N.B. not all groups sig)

The way that a burn injury occurs appears to have some impact on whether they are likely to be in hospital for longer than 1 day/TBSA. If the activity being undertaken was transport-related this had the greatest likelihood of the ‘activity’ categories to breach the 1 day/TBSA rule, whereas if the activity was one of ‘amusement/entertainment’ this was the least likely. Scalds were the least likely category of the ‘type of injury’ variable to breach the rule and contact burns the most likely. Chemical and electrical burns were more likely than flame burns to be in longer than 1 day/TBSA. Although scalds were the least likely of causes to breach the 1 day/TBSA rule, when the burns were categorised into ‘injury cause’ groups the ‘hot water system’ group was the most likely to have a longer stay along with the ‘spill’ and ‘contact’ groups. This initially appears to contradict the ‘type of injury’ group but could relate to the size of the burn, because a hot water system scald is likely to be much larger than a scald from a drink which would be more common.

Age appears to have some predictive element. Older adults are more likely to breach the 1 day/TBSA rule and children the least likely. This could, arguably, be expected as older adults are likely to have more complications and comorbidities (Klein et al. 2014). Also, their level of frailty may have an impact (Ward et al., 2018). Another reason for this difference could be that children can be discharged sooner as they can be cared for by their parents.

The size of the burn appears to only have a statistically significant impact with the very small burns. Initially, the logistic regression was run with all burn sizes and only burns less than 1% had a statistically significant result of being highly likely to breach the 1 day/TBSA rule. This is not surprising as you would not expect such small burns to be admitted. If they are admitted there would be other physiological or psychosocial issues that would affect their stay, such as other injuries or safeguarding issues. Also, being in hospital for even one day would mean they are breaching the rule. The regression was run again with burns less than 1% removed. This showed a slightly different picture. The ‘1-4%’, ‘5-9%’ and ‘10-14%’ groups were statistically significant with the ‘5-9%’ and ‘10-14%’ being less likely than the

‘1-4%’ of breaching the 1 day/TBSA rule. This suggests that very small burns (<5%) if admitted are more likely to breach the 1 day/TBSA rule and with the larger burns requiring resuscitation, factors other than the burn size may affect the length of stay in these cases.

Although, as discussed earlier, the ‘PC district’ results are unlikely to be helpful given the small numbers in each of the groups, there may be some signal coming from the geographical area. Breaking the geographical areas into larger and fewer areas, the results for the specialist commissioning teams suggest there is a statistical significance. The ‘network’ results suggest that the northern network is the most likely to breach the 1 day/TBSA rule and with the specialist commissioning groups it is Greater Manchester. More research would be needed to identify whether this was a clinical issue or more than likely is linked to areas of deprivation. However, looking back at the variable frequency distribution tables (see Figure 6.4) the northern network and Greater Manchester stand out as having a greater proportion of data entries than the other areas which could account for the differences.

6.4 Summary

This chapter has discussed the statistical analysis process that was performed on the iBID data sample and presented the results. This has yielded a plethora of statistical results which have been used to try and answer the last two research questions; which variables showed a relationship with ND and whether these variables could be used to predict ND.

Although, initially there appeared to be a large dataset, when examined a third of the variables had at least half of their data points missing due to the range of case severity and because not all fields were required for all patients. This had the effect of reducing the size of the sample and made some variables unusable for predictive modelling. The majority of burn injuries were in the lower TBSA range which led to an inevitable skewing of distribution for variables such as ward type and ND scores. For this and other reasons (regarding the variable 'types'), most of the variables did not have a normal distribution, meaning that the data was treated as not meeting the parametric assumptions throughout the analysis.

In answer to the third research question (which burn severity/demographic variables show signals of a relationship with the iBID ND scores), the analysis showed that many of the variables initially chosen to be explored do have a statistically significant association with ND albeit to varying degrees. However, what is less certain is to what extent these associations are clinically significant. There were a few variables (‘intentional injury suspected’, ‘ethnic category’, ‘first aid’, ‘injury day’, ‘injury week’, ‘injury PC district’, ‘month’ and ‘PC lower’) that were independent to the ND score in any format that was explored here. All the others showed some relationship as shown in section 6.2.1.3. The strongest predictive signals for ND in this data sample came from the ‘TBSA’, ‘therapy complexity’, ‘outcome’ and ‘length of stay’. Other variables showing strong predictive signals from the regression analyses are medical intervention, basic care support, injury type, age, activity and injury cause group.

The multiple regression model findings indicate that aspects of ND scoring can be predicted for a patient with a burn injury, which goes part of the way to answering research question four (can the iBID ND scores be predicted for in-patients with acute burns?). These predictive models suggest that the average, first, minimum and maximum ND total scores can be predicted from this sample data, with the TBSA group explaining up to 49% of the variance in the ND total scores. The maximum and first iBID ND total scores predictive models can be further improved with the addition of the ‘group age’, ‘therapy complexity’, ‘medical intervention’ and ‘basic care’ variables as predictors. Taking the variance of the ND total scores explained by these two models to 84% and 83% respectively. For the average ND total score predictive model different predictive variables were identified; 82% of the variance in the ND score was explained by the addition of the ‘group ages’, ‘average therapy complexity', 'category of injury' and 'expected outcome' variables to the 'TSBA group'.

Other points of note that have arisen from this exploratory analysis of the sample are listed below. However, further analysis is required on the whole database before any firmer conclusions can be reached

- Of the variables that will change throughout the patient's stay; the 'mobility' and 'ADL' sub-variables of the iBID ND total score have the highest correlation with the ND total score. Whereas, the 'psychosocial support' had the lowest. Surprisingly, the number of days post-admission only had a weak correlation, which was the opposite of the expected negative correlation suggesting that the relationship of ND with the number of days post-admission may not be linear.
- There were no strong relationships between the minimum ND total score and the variables identified in this sample. This was not surprising as irrespective of their injury or demographics there is a baseline minimum ND total score for all inpatients.
- In regard to ND, there was no statistical difference between groups for the day of the week or month of injury.
- There was a high correlation of the ND total score with the therapy complexity score. The therapy complexity score was also shown to be a key predictor of ND from the regression models. Signifying that the greater the therapy input required the higher the ND needs. The 'medical intervention' required was also a predictive factor in the regression models for the first, maximum and minimum ND total scores. Thus, indicating that ND may also be influenced by input required from the rest of the multi-disciplinary team as well as the patient's nursing requirements.
- There is a clear pattern to the average ND total score over the length of a burn-injured patient's stay for each of the burn size groups. The starting ND total score increases with the size of the burn. Additionally, for patients who were not discharged within 1 day /TBSA plus 10%

rule, their starting ND total score was higher and reduced at a slower rate than for those patients who were.

- The average ND total score trajectories show that patients who do not survive have a higher average ND total score than those who do. This is supported by the predictive model for the average ND total score in which the ‘expected outcome’ variable predicts a higher average ND total score as the probability of not surviving increases.
- The logistic regression showed small signals that some of the variables (‘age’, ‘activity’, ‘TBSA group’ and ‘injury type’) may indicate a higher probability that the patient’s stay will be longer than 1 day/TBSA. Injuries caused by entertainment activities and spills, along with scald burns, are the least likely to breach the 1 day /TBSA stay. Whereas contact burns and burn injuries caused by transport activities and hot water systems are the most likely to breach it. The size of the burn does not affect whether the 1 day /TBSA rule is breached or not; except for very small burns (<5%) which were more likely to be hospitalised for longer than 1 day /TBSA. This is not surprising as normally these burn injuries are unlikely to be admitted unless they are full-thickness burns or have other factors, such as an inhalation injury or social issue, which would affect their length of stay.

Clinically, the most practical finding of these results was the graphical representation of the average ND total score trajectory over time for each burn size group. Logically it shows that the larger the burn the higher the ND score. However, the ability to quantify this increased ND will aid nurses in evidencing their nurse staffing needs when caring for patients with differing sizes of burn injuries, taking into account their day post-admission. For example, three patients with a large burn early into their care will require far more nursing time than three patients with small burns later in their stay.

These results do suggest the ability to predict the iBID ND total score as a precursor to forecasting nurse staffing numbers. However, the data used for these predictions was only part of a larger population and caution is particularly required in interpreting the average ND total score trends for the larger TBSA groups because the numbers in each group were small compared to the smaller burn size groups. Hence, more research needs to be done to gain any confidence in these predictions. The next, final, stage of this research was to test out the generalisability of these predictive findings from this analysis of the iBID data sample, on the whole iBID database. Chapter seven will present the results of this final stage of the research.

Chapter 7 Testing of Hypotheses on the Whole iBID

7.1 Introduction

Following on from chapter six and the analysis of burn ND from the iBID data sample, the third part of this research tested the findings from the sample on the larger database to confirm reliability. This chapter accordingly presents the process and results from the testing of the hypothesis/models generated from the sample data on the larger iBID database dataset. Furthermore, having analysed the data from iBID, a narrative data quality evaluation of iBID as a Database using the PARENT framework (Zaletel and Kralj, 2015) (described in section 2.3.2) was performed and is presented in this chapter.

The variables that had been identified from the iBID sample analysis results as having a predictive effect in the regression model and ND trends, along with the ND data, were requested from the whole of iBID. The subsequent iBID ND dataset contained data from the start of 2013 to the end of 2019. The 2020 data was excluded as this would have had included data from the services during the COVID-19 pandemic period when patient pathways and treatment were altered.

The new dataset was cleaned in a similar manner as described in section 6.2. After which it contained 153,141 ND records for 21,211 unique burn-injured inpatients in total for analysis.

7.2 Statistical Analysis Results

The sample data from iBID had demonstrated that there were relationships between ND and many of the variables extracted from iBID. This next part of the research aimed to ascertain whether or not the results from the sample analysis could be generalised to a wider population. Four aspects of the previous results that potentially could be the most meaningful to clinical practice were looked at: the frequency and spread of the ND scores, the correlation of the iBID sub-variables with the iBID total score, the average daily ND score trends and the regression models for the first, average and maximum ND total scores.

7.2.1 Frequency and spread of ND total scores

First, the frequency of the data of the variables that had shown a relationship with ND in burns were reviewed to ascertain if the sample was representative of the wider database population. A similar spread of data was seen with the largest number of burns being in the less than 10% TBSA categories and the lower iBID total scores. Again, when the iBID ND total score was examined in relation to the ward type a similar pattern to the sample was seen; with the ICUs having the higher average scores and the ward having lower ones as shown in Figure 7.1.

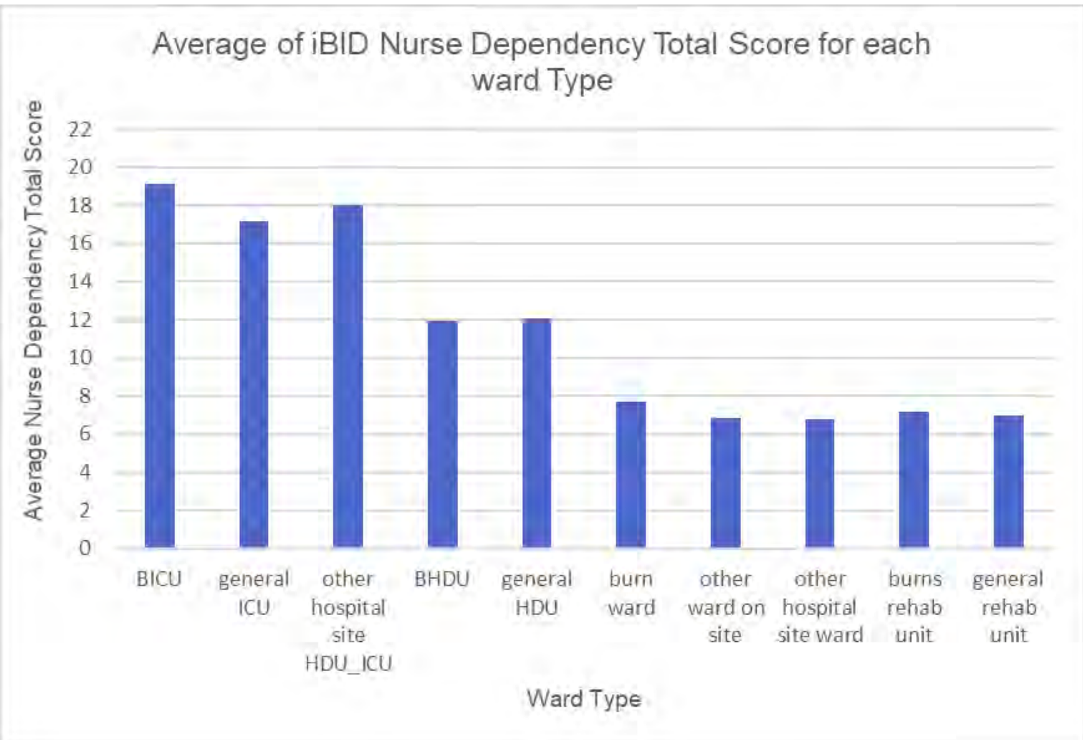


Figure 7.1 Average iBID ND score for each ward type

However, when the spread of the iBID ND total score across the ward types was investigated, it was noticed that the spread of score for each area continued to be diverse (see Figure 7.2). The ICU predominantly had the higher scores and the ward the lower iBID ND total scores, but the ward ranged across the spectrum of scores, similar to the iBID data sample. Thus confirming that ND is not just related to the acuity of the illness but also may vary considerably in each area.

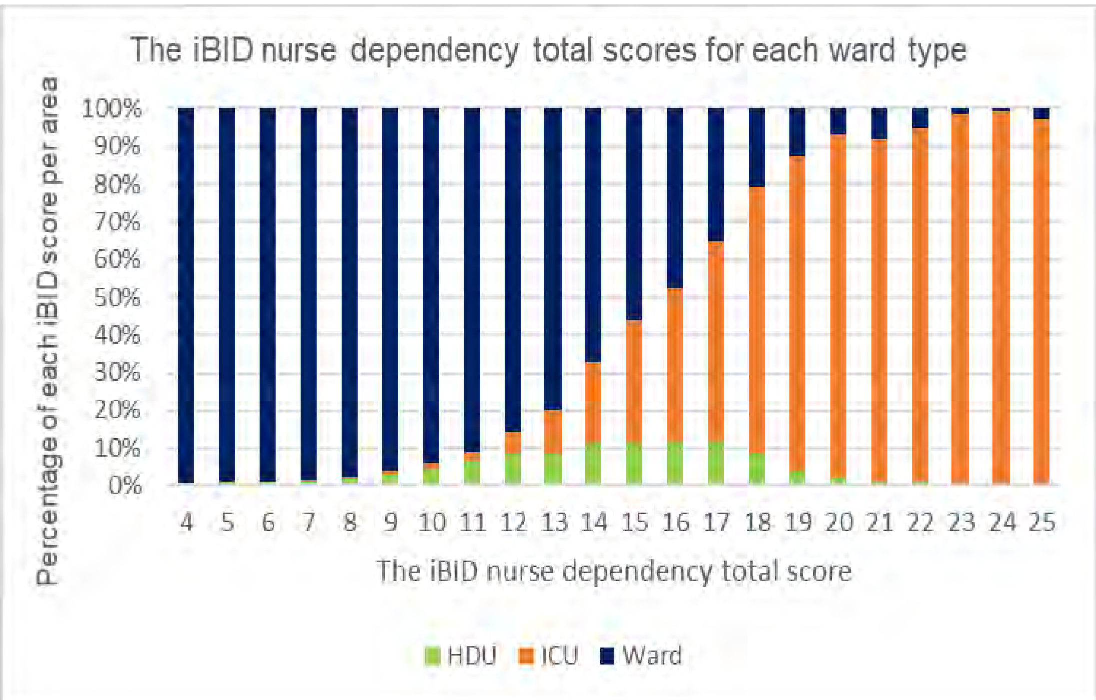


Figure 7.2 Percentage of each iBID ND score in ICU, HDU and ward

7.2.2 Correlations

Similar to section 6.4.1, the Spearman correlation test was run with the iBID total score, the sub-variables that made up the iBID ND total score and other variables that would change during admission (Table 7.1). The resulting correlations obtained were very similar to those values found in the sample data. The ‘procedure complexity’ and ‘psychosocial support’ variables continue to be the sub-variables of the iBID total score that had the weakest correlations. Yet when the zero ‘procedure complexity’ cases were removed the correlation increased to $\rho = 0.629$ similar to what was seen in the comparison of SNCT and iBID ND tool data and the iBID sample data (section 5.2.1, Table 5.10).

Table 7.1 Spearman correlation coefficients and bootstrapped 95% confidence intervals of the iBID ND total score with variables that can change daily for the data from the whole database compared with the iBID sample. (N = number of data observations, the results highlighted green are a strong relationship, those highlighted orange moderate relationship and the remaining ones not highlighted a weak relationship with the iBID ND total score)

		Ward type	Monitoring	Procedure complexity	Psychosocial support	ADL Achievement	Mobility Limitations	Basic care requirements	Therapy complexity total
iBID data from whole database (N= 123,299)	correlation coefficient	-0.46	0.58	0.50	0.47	0.84	0.80	0.73	0.72
	Significance (2-tailed)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	95% CI	-0.46 - -0.45	0.58 – 0.58	0.49 – 0.51	0.49 – 0.50	0.83 – 0.84	0.80 – 0.80	0.72 – 0.73	0.72 – 0.72
iBID sample (N= 18,278)	correlation coefficient	-0.44	0.56	0.50	0.49	0.82	0.78	0.71	0.71
	Significance (2-tailed))	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
	95% CI	-0.46 - -0.43	0.55 – 0.57	0.49 – 0.51	0.48 – 0.50	0.82 – 0.83	0.78 – 0.79	0.70 – 0.72	0.70 – 0.72

7.2.3 Average nurse dependency trajectory

Following the iBID data sample analysis, it was noted that there was a trend in ND for several variables, notably the burn size groups (see section 6.6). It was hypothesised that if the trends could be replicated from the larger whole iBID population then a table could be formulated to aid workload prediction for a group of patients. Additionally, if there was a differentiation between the ND trajectory for patients that were discharged before 1 day/TBSA and those that were not, this could aid the clinicians in identifying any problems that may be leading to an increased stay.

From Figure 7.3 it can be seen that, with the larger dataset, there was still a difference in the daily average iBID ND total scores for each of the TBSA groups. Furthermore, there was a difference between the average ND total score for those who were discharged before 1 day/TBSA and those that breached this guidance, similar to the sample analysis. Figure 7.4 shows the split of those that met the discharged before 1 day/TBSA rule and those that breached it, for the 50-100% and the 15-19% TBSA groups using the whole database.

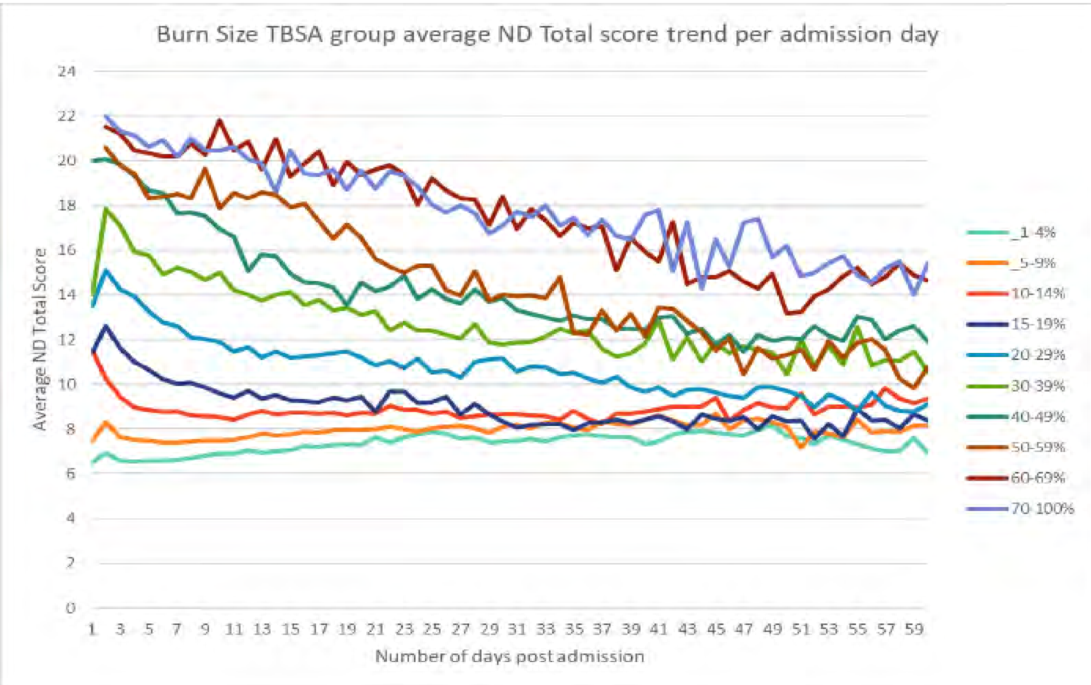


Figure 7.3 The average ND daily trend for the burn TBSA groups.

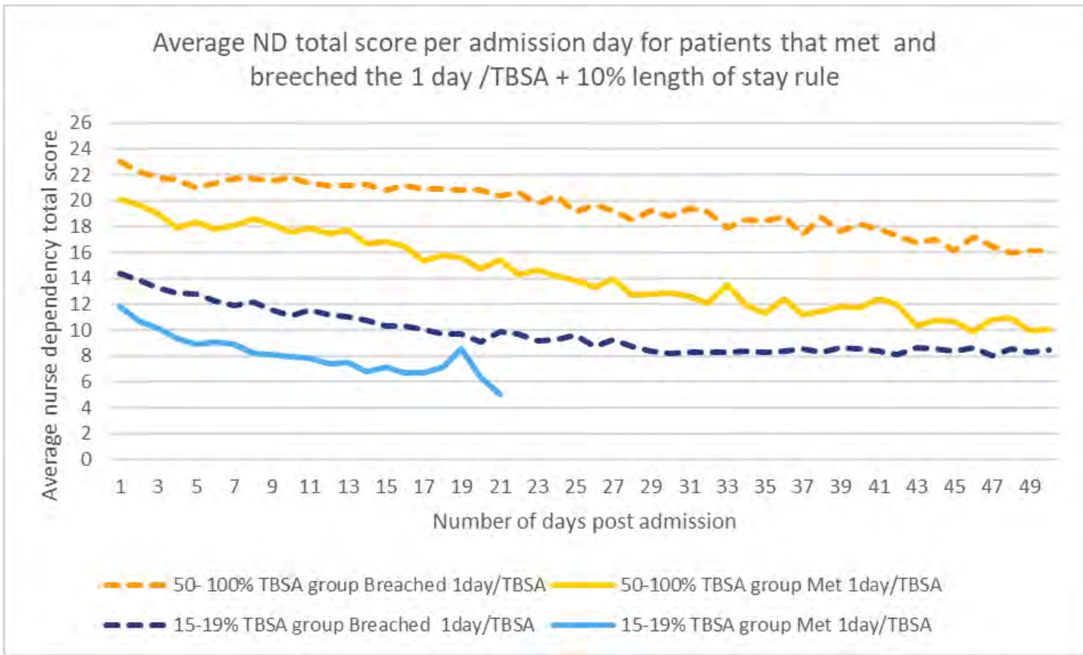


Figure 7.4 The daily average ND total Score for the 50-100% TBSA and 15-19% TBSA group spilt into those that met 1 day/TBSA plus 10% (solid line) and those that did not (dotted line).

Having established that there was a definitive trend in the average daily ND total scores a set of tables (Table 7.2) were developed that could be used to predict the likely ND for patients with a burn injury on a given day and to help identify whether the patient was following the one day/TBSA trajectory or not. Nevertheless, it is recognised that this can only be a guide to what the likely overall ND score might be and not a definitive prediction because this is an average score and may vary from patient to patient.

The daily average ND total score was also reviewed for the effect of the ‘outcome’, ‘age’ and ‘expected survival probability’ variables’ on the ND trajectory. Very similar patterns to the smaller iBID sample were seen. Thus, suggesting that these variables could be investigated further in the future to establish if their effect on ND can help identify and prevent complications that would affect the outcome of patients with a burn injury.

Table 7.2 The average daily ND total score for the different TBSA groups divided into those that met the 1day/TBSA plus 10% rule and those that breeched it

	Met 1day/TBSA plus 10% rule							
Days post admission	**1-4%**	**5-9%**	**10-14%**	**15-19%**	**20-29%**	**30-39%**	**40-49%**	**50-100%**
1	7	8	10	12	15	18	20	22
2	6	7	9	11	14	17	20	21
3	6	7	8	11	14	16	19	21
4	6	7	8	10	13	15	19	20
5	6	7	8	9	12	15	18	20
6	5	7	8	10	12	14	18	19
7		7	8	10	11	14	18	20
8		7	8	9	11	13	17	20
9		6	8	9	11	14	16	20
10		6	7	9	10	13	15	19
11		7	7	8	10	13	15	19
12			7	8	9	12	15	19
13			7	8	10	12	15	19
14			7	8	9	12	15	18
15			7	8	9	12	14	19
16			8	8	9	12	14	18
17				8	9	12	13	17
18				9	8	11	13	18
19				10	8	11	13	17
20				9	8	10	13	17
21				5	8	10	13	17
22					8	10	14	17
23					8	10	13	16
24					7	10	13	16
25					7	10	14	16
26					6	10	12	16
27					6	10	13	16
28					5	10	12	15
29					6	11	13	15
30					7	11	13	15

	Breeched 1day/TBSA plus 10% rule							
Days post admission	**1-4%**	**5-9%**	**10-14%**	**15-19%**	**20-29%**	**30-39%**	**40-49%**	**50-100%**
1	7	9	12	15	17	20	22	23
2	7	8	11	14	16	20	21	22
3	7	8	10	13	16	18	20	22
4	7	8	10	13	16	19	21	21
5	7	8	10	13	15	18	20	21
6	7	8	10	12	15	18	20	21
7	7	8	10	12	15	18	20	21
8	7	8	10	12	15	18	20	22
9	7	8	9	12	15	19	20	21
10	7	8	9	11	14	17	20	22
11	7	8	9	12	14	18	18	21
12	7	8	9	11	14	17	20	21
13	7	8	9	11	14	17	19	21
14	7	8	9	11	14	17	18	21
15	7	8	9	11	14	16	17	21
16	7	8	9	11	13	17	17	21
17	7	8	9	10	13	16	18	21
18	7	8	9	10	13	17	16	21
19	7	8	9	10	13	16	18	21
20	8	8	9	9	12	17	17	21
21	8	8	9	10	13	15	17	20
22	8	8	9	10	12	16	17	21
23	8	8	9	10	12	15	16	20
24	8	8	9	9	12	15	16	20
25	8	8	9	10	12	14	15	19
26	8	8	9	9	11	13	16	20
27	8	8	9	10	12	15	16	20
28	8	8	9	9	11	13	16	19
29	8	8	9	9	11	13	16	20
30	8	9	9	9	11	13	15	19

7.2.4 Predictive modelling

In chapter six (section 6.5) regression analysis was performed on the average, first, maximum and minimum ND total scores. The minimum ND total score was initially included as it was thought that if a patient's minimum score could be predicted then the minimum nurse staffing requirements could be identified. However, on examination of the results and reflection, it was realised that the regression model would only predict the lowest score during the whole of the patient's stay and this would not be particularly useful as all patients would be moving towards the lowest ND score during their admission. Therefore, only the predictive models for the average, first and maximum ND total scores were validated against the iBID 'held-out' data (data from the whole of iBID excluding the sample data that the regression models had been trained on).

For each of these three predictive models, model six of the stepwise regressions (see section 6.5.3) was the one chosen to validate as they were the simplest ones that still explained over 97% of the variance that the final model did. The cross-validation was performed by a statistician on the new unseen data from iBID using the R statistical software (R Core Team, 2017).

The results of this validation are shown in Table 7.3 and Figures 7.5 - 7.7. It can be seen that the maximum and First ND total score models explain a similar amount of the variance in the predictions to the actual data as the training model, suggesting that the models can be generalised. Additionally, the standard deviation of the module residuals are smaller than the null model residuals, as would be expected if the model had some predictive value. However, the Average ND total score model has a lower variance explained by the module and a larger SD, suggesting it cannot be generalised as much. This is perhaps not surprising as there are likely to be many other confounding factors that would occur over a patient's admission to complicate the ND requirements. For example, complications, different social needs and individual motivation as well as psychological and emotional considerations such as grief.

Nevertheless, the Q-Q plot and residual scatter graphs suggest that all the models are reasonable. Though there is some tailing shown on the Q-Q plot, suggesting that the residuals are not normally distributed, the tails are small apart from the maximum ND total score model. While mathematically the variance might be stabilised for the model, this would involve taking logarithms of the data which would make it harder to interpret. As this was an exploratory analysis it was decided that there was little benefit at this time to use the logarithms of the data, instead recognising that the model may be slightly flawed but was easier to interpret. The residual scatter graphs are generally oblongs with the points centred around the zero as would be expected with a normal distribution.

Table 7.3 Results from the cross-validation of the iBID sample original multiple regression models from chapter six on unseen data.

Regression model 6	Average ND total score	Maximum ND total score	First ND total score
Variance explained by model	55.4%	75.2%	80.8%
SD of model residuals	1.94	1.85	1.50
SD of null model residuals	2.90	3.72	3.43

Following on from the promising results of the cross-validation the models' variables were scrutinised further. It was noted that these variables were mostly composed of subjective variables that had been derived mostly from the judgement of clinicians about the therapy requirements, medical interventions and care needs for the first and maximum ND total scores. Therefore the stepwise regression analysis was run again on the original data sample but this time with only the objective variables that would be known on admission. Table 7.4 presents the results of models 1, 2, 6 and the final model of this stepwise multiple regression.

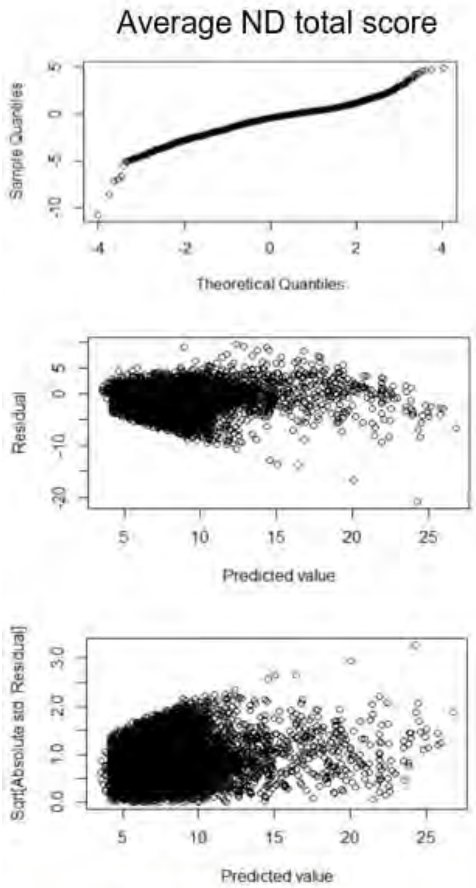


Figure 7.5 QQ Plot, and scatter graphs of the residuals vs the predicted value and the standardised residuals vs the predicted value for the Chapter six average ND total score regression model 6 validation.

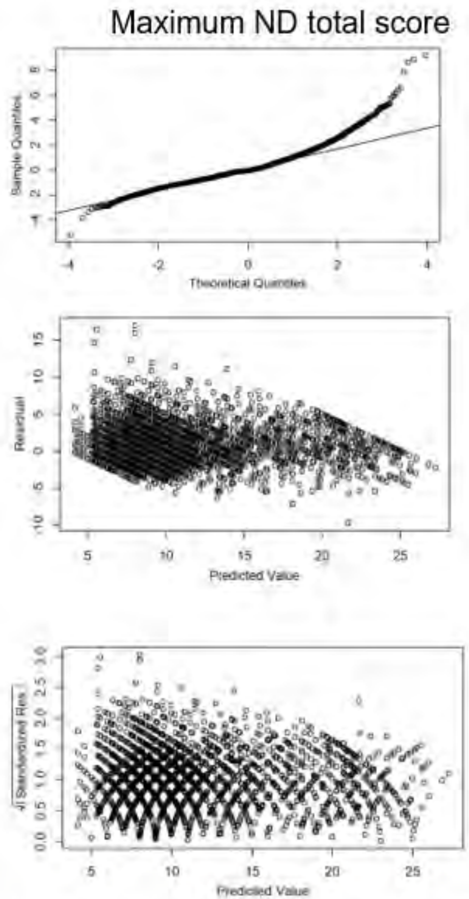


Figure 7.6 QQ Plot, and scatter graphs of the residuals vs the predicted value and the standardised residuals vs the predicted value for the Chapter six maximum ND total score regression model 6 validation

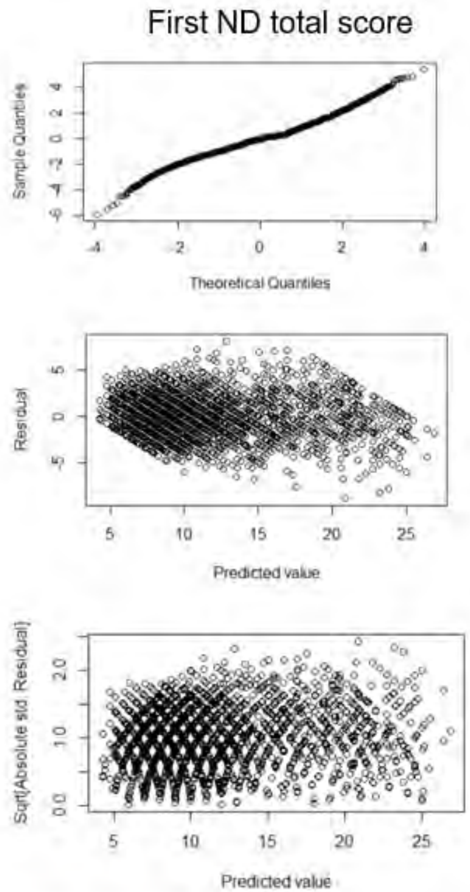


Figure 7.7 QQ Plot, and scatter graphs of the residuals vs the predicted value and the standardised residuals vs the predicted value for the Chapter six first ND total score regression model 6 validation

Table 7.4 Results of the repeated stepwise multiple regression using only the objective variables known on admission. TBSA was entered first (Model 1), followed by group age 1 (Model 2) and then the remaining independent variables added stepwise. Model 6 which describes > 96% of the final model and the terminal model results are also presented (df = degrees of freedom. N = number of cases).

	Average ND total score				Maximum ND total score				First ND total score			
Model	1	2	6	14	1	2	6	14	1	2	6	13
Adjusted R Square	0.45	0.49	0.53 (98% of final model)	0.55	0.51	0.53	0.56 (98% of final model)	0.58	0.49	0.50	0.54 (96% of final model)	0.56
Std. Error of the Estimate	2.05	1.98	1.89	1.86	2.70	2.64	2.54	2.50	2.59	2.55	2.44	2.40
Durbin-Watson	1.97				1.99				1.89			
Largest cooks value	0.27				0.14				0.18			
df / N	11/ 3482	13/ 3482	17/ 3482	25/ 3482	11/ 3482	13/ 3482	19/ 3482	25/ 3482	11/ 3482	13/ 3482	17/ 3482	24/ 3482
Variables included in model 6	TBSA groups group ages 1 Mortality predictor Category – accidental recreation Inhalation injury Category –self-inflicted				TBSA groups group ages 1 Inhalation injury Category – accidental recreation Networks – South West Total number of burn areas				TBSA groups group ages 1 Inhalation injury Category – accidental recreation Total number of burn areas Networks – Northern			
Constant of final model / SE	6.56/ 0.48	6.94/ 0.06	6.58/ 0.07	6.51/ 0.09	7.68 / 0.06	7.80 / 0.08	7.00 / 0.11	6.94 / 0.14	6.94/ 0.06	7.31/ 0.08	5.92/ 0.12	5.92/ 0.12
Variables that had no significant effect on the model at the 0.05 level	TBSA 0 - 0.9%	TBSA 0, 0 - 0.9%,	TBSA 0, 0 - 0.9%, Age older adult	TBSA 0, 0 -0.9%, Age older adult	None	None	None	None	TBSA 0 - 0.9%	TBSA 0, 0 -0.9% Age older adult	TBSA 0, 0 - 0.9%,	TBSA 0, 0 -0.9%, Age older adult

The results of the multiple regression using the objective 'known on admission' variables showed that these regression models were not able to predict as much of the variance in the iBID ND total scores as the multiple regressions that used the more subjective variables that utilise clinical judgement. Table 7. shows the difference in the adjusted R^2 of the original models from chapter six and the new models that use the objective variables. The difference is about a third less for all the objective models. Therefore, suggesting that clinical judgement plays a role in predicting ND.

Table 7.5 Comparison of the adjusted R2 for the original chapter six multiple regression models using all the variables and the revised known on admission multiple regression models using only the objective variables 'known on admission'.

Regression model	**Average iBID ND total score**	**Maximum iBID ND total score**	**First iBID ND total score**
Adjusted R^2 for the original chapter six multiple regression models using subjective variables	0.84	0.86	0.85
Adjusted R^2 for the 'known on admission' multiple regression models using objective variables	0.55	0.58	0.56

Validation of the 'known on admission' models was performed on the unseen 'held-out' data from iBID to quantify the predictive power of these models. The reduction in variance explained by the model on the validation data (shown in Table 7.) indicates the objective 'known on admission' variables explain less than the subjective variables. Demonstrating that the more subjective variables, which are based on clinical judgement that would take into consideration local knowledge and additional aspects of care, have more predictive power. It was also noted that similar to the validation of the original models the average ND predictive model did not perform as well as the first and maximum ND models.

Table 7.6 Results from the validation of the iBID sample multiple regression models on the iBID 'held out' data

Regression model	Average ND total score	Maximum ND total score	First ND total score
Variance explained by model with variables using clinical judgement	55.4%	75.2%	80.8%
Variance explained by model with objective variables 'known on admission'	35.0%	53.7%	53.3%

In addition to the variance, the Q-Q plot and residual scatter graphs also demonstrate the 'known on admission' model fit on the iBID held out data is not as good as the model using all the variables. See figures 7.8 – 7.10. The residual scatter graphs have a downward slant rather than being all centred around zero, suggesting there may be some homoscedasticity and thus there is less reliability of the predictive model. Similarly, the Q-Q plot shows even more pronounced tails suggesting that the residuals may not be normally distributed.

Since the initial iBID sample was obtained, iBID now contains information on the deprivation of the area the patient lives. As there is evidence that the areas of higher deprivation are more likely to sustain a burn injury (Marsden et al., 2016), it was hypothesised that this may also increase their ND. Consequently, a regression analysis was performed using the deprivation decile as the independent variable. The results showed that there was no significant change to the model with deprivation as the independent variable. This suggests that there are likely to be other factors that affect ND once the burn has occurred, such as the size of the burn.

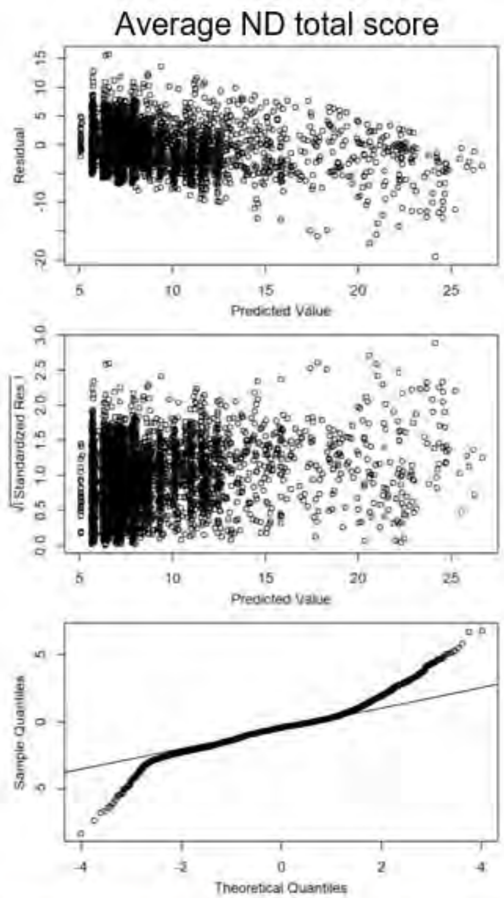


Figure 7.8 Scatter graphs of the residuals vs the predicted value and the standardised residuals vs the predicted value and QQ Plot for the Average ND total score objective 'known on admission' regression model cross-validation.

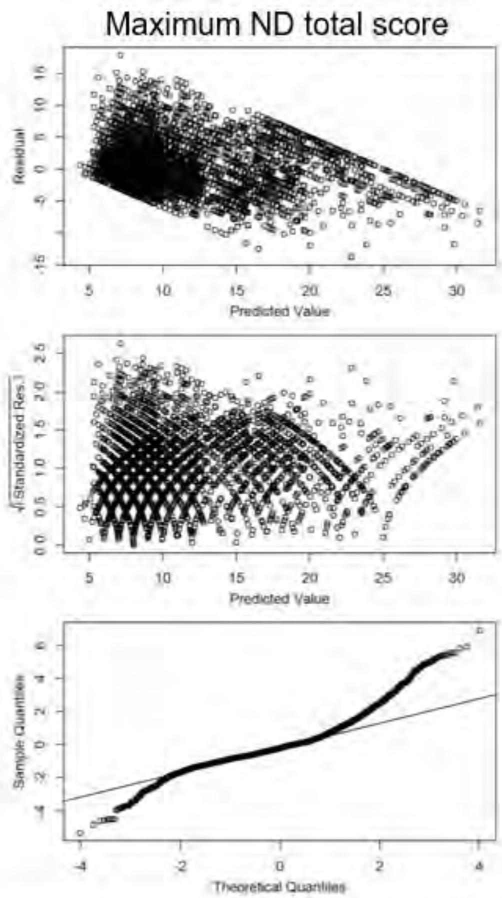


Figure 7.9 Scatter graphs of the residuals vs the predicted value and the standardised residuals vs the predicted value and QQ Plot for the maximum ND total score objective 'known on admission' regression model cross-validation.

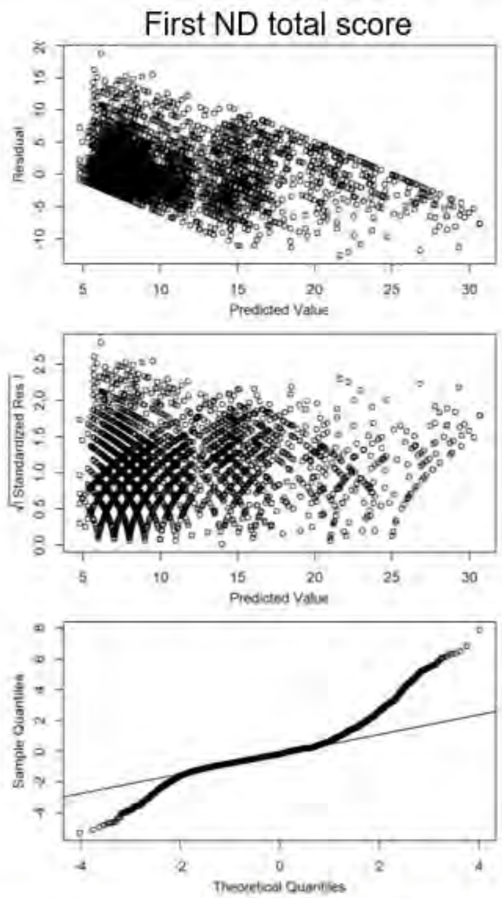


Figure 7.10 Scatter graphs of the residuals vs the predicted value and the standardised residuals vs the predicted value and QQ Plot for the first ND total score objective 'known on admission' regression model cross-validation.

.

7.2.5 Statistical analysis conclusion

This part of the research aimed to ascertain whether the hypotheses from the sample analysis could be generalised to a wider population. The results appear to suggest that on the whole they can. In particular, the following points of interest are highlighted below.

The results show that there is a relationship between the iBID ND total scores and the type of ward patients with a burn injury are being nursed in, albeit the spread of scores is greater in the ward. There is also a relationship between the ND scores and TBSA. This relationship (between TBSA and ND total score) can be extrapolated into a predictive trajectory and used to indicate what the overall ND iBID score might be for a group of patients. However, more research would need to be undertaken in order to quantify this in relation to nurse staffing levels.

Considering the Spearman correlations, the results confirm that there is a strong correlation of the iBID ND total score with the 'therapy complexity total score' and 'Basic care requirements'. The iBID ND total score also has a strong correlation with the two of the subcategories that make up the iBID ND total score that relate to the patient's independence ('ADL' and 'mobility limitation'). This suggests that at one level ND may be influenced more by how independent the patient is, rather than their acuity. The 'psychosocial support' subcategory continued to have the weakest correlation.

The results of the multiple regression cross-validation suggest that the variables which contained an element of clinical judgement were better at predicting ND than pure objective measures. Thus suggesting that clinical judgement that utilises local knowledge of the environment and the patient adds something more than can be achieved with purely objective measures. This idea that clinical judgement adds veracity and 'sensitivity' to the ND predictions is supported by both Griffiths et al. (2020_a) who used nurses' professional judgement to verify the SNCT staffing levels and Rauhala and

Fagerström (2004) who use nurses' professional assessment to confirm the optimal nursing care intensity levels for the RAFAELA ND method. Nevertheless, currently these predictive models would have limited use clinically as they would not be simple to calculate in practice and it is debatable how useful it would be to know a ND score that could actually be a range of values. Especially as there is no quantifying of the iBID ND score. A one point change in one subcategory may not be equal to a one point change in another subcategory. Nor even between levels in the same subcategory. Thus without this quantification of whether each point equates to something similar, judgements about staffing needs cannot be made. Consequently, more research would be required to quantify the iBID ND scores before the predictive modelling would be of clinical value.

7.3 Narrative Data Quality Evaluation of iBID

Chapter two gave a brief overview of medical data registries in general and in particular iBID. One of the primary challenges of medical registries is ensuring the quality of the raw data (Eldh et al., 2014; O'Reilly et al., 2016); iBID is no exception. As analysis of iBID data is pivotal to this research, a review of the quality and integrity of the iBID was undertaken using the PARENT quality dimensions framework (Zaletel and Kralj, 2015) to gauge the potential impact on the overall reliability of the eventual findings. The information to make the following assessment was gained from the iBID website (which at the time of writing had not been updated since 2017), combined with personal experience of the clinical use of iBID reports and the iBID data for this research, and further augmented by personal communication with the Medical Director of iBID.

7.3.1 Governance

Under governance, the purpose and functional procedures for registry operation concerning iBID will be considered. The purpose, intended use, and aims of iBID are clearly set out in the National Burn Care Review (National Burn Care Review Committee, 2001) and on the iBID website (international Burn Injury Database [iBID], 2019). The database is owned by NHS England and adheres to the NHS and General Data Protection Regulations (GDPR). The governance of the database is overseen by the Burn Care Informatics Group which is made up of user representatives from key stakeholders. However, one of the consequences of iBID initially being developed by clinicians for clinicians was that there was originally no detailed formal database specification and to date, NHS England has not developed one.

There are appropriate procedures and methods for registry operation in place. However, these are not as transparent as for some other medical databases, such as the ‘Trauma Audit and Research Network’ (TARN) and the ‘Intensive Care and National Audit and research Centre’ (ICNARC) which are managed outside of the NHS and have different governance structures. IBID is currently funded by NHS England but as with many NHS services, this funding is granted on a year-to-year basis which hinders long term projects. Within this constraint, resource planning is overseen by the Medical Director and the Burn Care Informatics Group.

Training is available to the burn services as and when required from the National iBID Coordinator and additionally over the years several study days have been held for users and to help develop the database. Additionally, there is online support information that is very detailed but not easy to navigate. Typically, the training is directed to the burn services iBID data clerks and there is little, if any, formal training given to the wider burns community which leads to different levels of understanding and confidence in the database.

The iBID registry potentially has the ability to interface with other clinical registries. However, this ability is blocked by the expense of developing these interfaces that are compliant with the necessary information governance standards and protocols. This is a common problem that is facing many NHS data systems (Warren et al., 2019; Williams and Karpelowsky, 2019). Despite this, as with all speciality-based registries, the compatibility with other systems is still potentially limited as the data is specific to the speciality, in this case to burns.

7.3.2 Data quality

Assessing the quality of data is not a simple exercise as there are many elements that need to be considered. Williams and Karpelowsky (2019) divide them into intrinsic (completeness, accuracy, consistency), contextual (relevance, timeliness) and representational (accessibility and comprehensibility) elements.

Intrinsic – One of the key benefits of utilising electronic data collection tools is that essential fields can be marked as mandatory or required with defined input parameters. In practice, iBID has a core set of data points that users are mandated to fill in and other data points which are optional but which many services do fill in. Reports are then generated every quarter on how complete the core set of data is for each service. These are sent to the individual services to enable them to improve their records. The need to comply with data entry is in the commissioning service specification and NHS contract for burn services. However, compliance is not pursued by NHS England commissioners.

The iBID registry is set up so that, where possible, the majority of data entered is via drop-down boxes for uniformity rather than free text. There are mechanisms in iBID for checking the validity of absolute data such as dates but there is no automated mechanism for checking the data against the patient notes or demographic databases. When cleaning and analysing the data for this study there did not appear to be many obvious inaccurate values. However, it was not possible to check whether the value was accurate on entry or correctly represented the clinical situation. The lack of a definitive coding dictionary has the potential to introduce inconsistencies in the more subjective fields.

Contextual – iBID is a database that has been designed to collect data specifically related to patients with a burn injury. As such, on reviewing the data variable it appears to measure exactly what it was designed to measure; burns, their causes and aspects of their care. The data topics were initially agreed upon by burn clinicians. Since then, they have then been reviewed by the relevant NHS commissioning Clinical Reference Group every three years and some used as part of the Quality Dashboard for burns (NHS England, 2019). The data has also been used to inform national and local burn audits and as part of peer reviews, as well as providing evidence for burn prevention initiatives. The database is designed so that services can input the data in real-time. When this is done, the data is near real-time for use by the local services and via the central database. Formal reports are sent out quarterly from the central iBID team to each service, which for most needs would be adequate. If a bespoke or urgent report is required, then this can either be produced locally or on request to the central iBID team.

Representational – The individual services can access their own data at any time and format their own reports, although not all services have data clerks with the skills to do this. A web portal within the N3 NHS network has been developed for burn services to directly generate reports from the central database, but it has been used minimally since it went live in 2017 (Dunn, 2020). Some burn services have suggested that the quarterly iBID burn data reports could be clearer but have not proposed how this could be achieved. Previous experience has highlighted the need for care in interpreting some of the reports produced as there has been confusion regarding the reporting periods presented compared to the reporting periods of the individual Burn Services.

Standard definitions that can be compared over time are used and where possible, to aid comprehension, variables that are widely used and common with other databases, such as the critical care minimum data set and the Clinical Frailty Scale, have been introduced. Nevertheless, there is still the potential for some subjectivity concerning diagnosis and treatment as with all clinical systems.

7.3.3 Information quality

One of the most common criticisms levelled at many clinical registries is that data is gathered with no meaningful benefit. Hence, the parameter "Information Quality" within the PARENT framework aims to measure the usefulness of a database. Regarding the usefulness of iBID, it informs the NHS quality dashboard (NHS England, 2019) for burn outcomes and provides specialist burn care statistics for quality and strategic planning locally and nationally. Additionally, data from iBID has been used in over 600 conference presentations and peer-reviewed papers within the medical and burn injury prevention fields. All demonstrating that the data collected within iBID is beneficial. However, not all the fields are routinely used, for example, the ND data. Hence, part of this research study was to evaluate the quality of the ND data and whether the iBID ND tool did actually measure ND.

Reviewing the output format; material for the dashboard and individual service audit reports are published in a concise and consistent manner. For ad-hoc queries, the system's software allows services to export their own data to analyse in the manner and timeframes that they wish. However, not all services have staff with the analytical skills required to do this and therefore rely on the central reports which may not present the customised view of the data that they desire.

From a believability perspective, analysis of the iBID data in this research study has produced findings that are generally consistent with what might feasibly have been expected from a clinical perspective, thus suggesting that the iBID data is believable. Some burn services have suggested that the data does not match their own data but on further investigation by the central iBID team, this can often be attributed to different reporting timelines or the way the data has been input.

The age-old adage of ‘Garbage in – Garbage out’ is as true of iBID as any database. Over the years there has been variability in the amount and quality of data some services have entered which naturally will affect the output, there is no discernible pattern to these variances identified at the level provided for this research. Internally, there are some variables automatically calculated in iBID from an algorithm that is not always understood by the users. Consequently, the data may be accurate but how it is interpreted is another issue, as misinterpretation can have a negative effect on how the database is perceived. To counteract this, education and a universal understanding of the terminology and process is required for the best results.

7.3.4 Ethical issues, security and privacy

IBID adheres to GDPR and NHS Digital’s information governance framework to ensure that the data is kept confidential and is used only for the designated purposes. General reports for wide circulation do not include patient identifiable data. However, audit reports going back to the individual burn services do have record identifiers, so the burn service can check the information against their original patient records. The originating burn service retains access to data that they have input. There is a process for any requests for data for research or practice development outside of a service. These are considered on a case-by-case basis by the central team and medical director with the ability to refer to the clinical reference group if any ethical concerns exist regarding the request. A record of requests and use of the data is kept by the iBID central management team.

Apart from the services that have access to their own data, data is only released for a specific purpose to a named person in a secure manner.

Overall, there is no evidence to suggest that the security and ethical process are not robust and appropriately restricted. However, some of the burn care community would argue that the restrictions are too tight and easier access should be available.

7.3.5 Conclusion of the data quality evaluation of iBID

The above review of the various quality dimensions of a medical registry in relation to iBID is summarised in Table 7.7The quality performance of iBID in relation to the European PARENT medical registry's quality framework. As a medical registry, in line with many others, iBID is not perfect in terms of quality, accuracy and believability. However, on the whole, the information appears as accurate as it can be taking human factors into consideration. Even so, it is the only national burns database for England and Wales that is available with ND data and therefore was the most appropriate database to analyse for this research.

Table 7.7The quality performance of iBID in relation to the European PARENT medical registry's quality framework.

PARENT Framework	**Achieved/present**		
	Yes	**Partially**	**No**
Governance			
procedures and methods for registry operation	✓		
education and training		✓	
resource planning and financial sustainability		✓	
interoperability as a quality dimension			✓
self-assessment		✓	
Data quality			
Accuracy		✓	
Completeness		✓	
Interpretability and accessibility		✓	
Relevance	✓		
Timeliness	✓		

coherence		✓	
data standardisation		✓	
Information quality			
surveillance (health statistics)	✓		
outcomes		✓	
scientific publication	✓		
PARENT Framework	**Achieved/present**		
	Yes	**Partially**	**NO**
Ethical issues, security and privacy			
adherence to privacy legislation	✓		
ensuring data and information security	✓		
ethical and privacy issues with secondary use of data	✓		

7.4 Summary

In this chapter, the data quality evaluation of iBID using the PARENT framework was presented along with the results of the testing out of the sample analysis results on all the iBID ND data till the end of 2019. Overall, the evaluation of iBID showed that the ND information in iBID appeared to be of reasonable quality and as the only burn injury national database for England and Wales it was a suitable database to use. However, clearer information and transparency about iBID and how to use it on its website would be beneficial.

The results of the statistical analysis on the whole database suggest that the conclusions from the iBID data sample were generalizable to the wider population. The key findings are:

- There is a relationship between ND and the type of ward the patient is on. With a wider spread of ND scores on the ward.
- There is a relationship between ND and TBSA. The TBSA groups can account for nearly 50% of the variance in the iBID ND scores on their own.

- There is a pattern to the daily average iBID ND total scores for each TBSA group; with the daily average iBID ND total scores being higher for patients that breach the 1 day/% TBSA and are likely to remain high for patients that do not survive.
- The iBID ND total score subcategories that relate to burn-injured patients' independence ('ADL' and 'mobility limitations') had a strong positive correlation with the ND total score. Whereas the 'psychological support' subcategory had the weakest correlation.
- The deprivation variable did not appear to have a statistically significant predictive impact on ND.
- The multiple regression models that used subjective variables (such as 'therapy complexity', 'medical intervention' and 'basic care needs') had a better predictive performance than objective variables (such as 'injury group', 'injury category', 'inhalation injury', 'network'). Suggesting that clinical judgement is required to add veracity and sensitivity to ND prediction. However, without some form of quantification to the iBID score, the predictive models are of limited clinical value.

Chapter 8 Discussion

8.1 Introduction

The iBID is a medical registry, as discussed in chapter two, that collects data on burn injuries including the ND of inpatients with a burn injury. It is the only national burn specific registry in the UK and therefore by default it was the only appropriate database to use to explore the ND of patients with a burn injury in the UK. Nevertheless, the result of the analysis would only be relevant and useful if iBID was found to be a credible database. As part of this research, the database was evaluated against the PARENT quality dimensions framework (Zaletel and Kralj, 2015) (section 7.3). The results from this showed that although iBID, like many other medical registries, may not be perfect it was a suitable database to analyse for this research.

This chapter will use the research objectives of this study as a framework to discuss the key findings of this research. The results will be discussed in more depth in relation to practice and the literature.

8.2 Quality of the Nurse Dependency Data in iBID

The nursing care data within iBID contains ND information in the form of the iBID ND tool scores, which consists of five subcategories that are scored and totalled to give an iBID ND total score, as demonstrated in section 2.3.3. The first objective of this research study was to evaluate the quality of this ND data in iBID.

As with any medical registry, the quality of data entered can vary leading to potential bias in analysis (Cox et al., 2018). Since this was anonymised, dynamic data, captured at a specific point in time (for each patient), it was not possible for the researcher to retrospectively check the accuracy of the recorded ND score. However, 85% of the data sample records contained a complete set of the iBID ND scores that fell within permitted values, thus not signifying a problem in the quality of the data. The data quality evaluation undertaken in section 7.3 did not raise any specific concerns that may lead to the mistrusting of the accuracy of the iBID ND dependency data and furthermore, the results of the statistical analyses were consistent with what might be expected. Considering all of this together suggests that the iBID data was of acceptable quality for a preliminary exploration. Additionally, the part of this research study in which the fictitious case studies were scored independently by the participants using the iBID ND tool, further validated the quality of the data, with 'good' to 'very good' inter-rater reliability scores for all the sub-categories apart from 'psychosocial needs'. This suggested that the users had a similar understanding of the process and that the scoring systems, on the whole, were reliable and suitable for the task.

An emerging topic in the health information technology literature is the application of an understanding of human factors and ergonomics to information technology and usability (Carayon and Hoonakker, 2019). There are many definitions of the terms 'human factors' and 'ergonomics' but in essence, it is the understanding of human performance in relation to the task they are undertaking to reduce error, increase efficiency and enhance safety (Human Factors and Ergonomics Society, 2021). These principles highlight the need to ensure that the definitions within the iBID ND tool and database are aligned to existing nursing processes and understanding, in order to ensure the overall system is accurate, clear and easy to use. Furthermore, there needs to be a balance between sufficient description to make the ND accurate but not so much as to confuse the user (Kalakoski et al., 2019).

Carayon and Hoonakker (2019) point out that often there is a disconnect between health informatics designers and the end-user. In other words, the link between nursing actions and IT data is not fully understood by either party and therefore often leads to poor utilisation of the systems. Although iBID was not specifically designed with human factors in mind, the ND data was developed by burn specialists for their own benefit. Thus, compared to nurses adapting and using a generic scoring tool to fit their purpose, there should be a greater likelihood of higher quality data. This is again borne out by the case study and comparison of two ND tools research which suggested that the iBID ND tool was easy to use and has good inter-rater reliability. Nevertheless, a human factors approach is something that could be taken further to both identify the barriers to data completion and to understand the thinking processes behind nurses' understanding and scoring of the iBID ND tool sub-categories.

8.2.1 Psychosocial needs

Meeting the psychosocial needs of patients with a burn injury is seen as an essential part of their care, due to the psychological and social challenges of the trauma and resultant scarring (Heath et al., 2018; Herndon, 2018; Wisely et al., 2007). Furthermore, it has been shown that good psychosocial support can improve burn wound healing (Wisely, 2013) reduce pain and improve patient outcomes (Chen et al., 2017). The importance of psychological support is further highlighted both in the burn care service specification (National Commissioning Board, 2013) and the national burn care standards (Burn Standards Review Group, 2018), emphasising the requirement for psychosocial training for all members of the multi-professional team to enable the psychosocial needs of patients with burn injuries to be met in a timely manner. Therefore, it was predictable that the iBID ND tool would include a sub-variable related to psychosocial support. Yet, despite this, two key findings emerged from this research suggesting that psychosocial support needs may not be well understood. First, there was a lower correlation of the 'Psychosocial Support' sub-variable with the ND total scores it made up part of. Second, the inter-rater reliability for the 'Psychosocial Support' score in the case studies was weak.

The anomalies in the 'psychosocial support' score, although not expected, on reviewing the relevant literature should not be surprising. Back in 1997, Frost et al. (1997) identified that nurses agreed that the psychosocial aspects of care is essential but this was less evident in their clinical practice; as the nurses either lacked the time, the skills or confidence to identify and intervene to meet their patients' psychosocial needs adequately. A phenomenon that still continues today in different specialities of nursing (Chen et al., 2017; O'Sullivan and Mansour, 2015; Pehlivan and Küçük, 2016; Turner et al., 2017) and is also the case in burn care (Guest et al., 2018). Similarly, Hill et al. (2015) found that the provision of psychosocial care was complex and psychosocial needs were not always identified or dealt with. They found that nurses responded in four ways – 'dealing with the need' (less than half of the cases in their study) or 'ducking', 'deferring' or 'diverting' when lacking confidence or time. This difficulty in determining and meeting the psychosocial needs of patients is further supported by Mersin et al. (2019) who identified the difficulty for nursing students in assessing and planning to meet patients' psychosocial needs compared to their physical needs. Recognising that the teaching of psychosocial needs was more difficult and there was a lack of role models. Similarly to Frost et al. (1997), the increased time needed and the increase in workload was identified as a barrier to meeting psychosocial needs, alongside concerns that delving into the patients' psychosocial needs could be seen as a violation of their privacy. Yet nurses are in the ideal position to provide some psychosocial support as they build up trust and therapeutic relationships with their patients as part of their normal role (Adenike et al., 2020; Legg, 2011). Therefore, their confidence and communication skills need to be enhanced and the time required recognised in nursing workload to enable these relationships to be built.

A lower inter-rater score for the 'psychosocial support' variable was found in this study compared to the other variables that made up the iBID ND total score. The reasons for this are likely to be multifaceted. Identifying and meeting patients' psychosocial needs is complex as every patient will react differently. They have different support mechanisms triggering various coping mechanisms and reactions to the impact of the trauma on their social situation, body image acceptance, grief and treatment (Garimella et al., 2017). All of these factors will necessitate different interventions and approaches. Furthermore, additional support is required for the family whose reaction will vary depending on their situation and closeness (Knol et al., 2020). This all makes it difficult to identify and address the psychosocial needs of patients with a burn injury, especially if they are not ready to open up to support or are in denial. All of which may be why nurses lack confidence in identifying and meeting psychosocial needs and why there may be different views to what is required, leading to a lower agreement.

Another confounding factor might be the debate about who should undertake the psychosocial assessments; psychologists, nurses or social workers (Blakeney et al., 2008). In particular, the NHS England (2019) Specialist Services Quality Dashboard has an outcome (indicator reference number BRN07) specifying that; following burn injuries all patients should have their psychosocial needs assessed, further highlighting the importance given to the psychosocial care for burn patients. However, this quality outcome is not always met which has led to discussions in one burn network's multi-disciplinary team audit meetings as to why? In line with the literature, the time required to meet burn patients' psychosocial needs has been highlighted as a barrier along with questions regarding whose role it is to undertake these assessments. Again this highlights that, despite agreement on the importance of this outcome and acknowledgement that good psychosocial care is required in hospital and on discharge to enhance patients' recovery and quality of life (Garimella et al., 2017), the addressing of the psychosocial needs of patients with a burn injury is complex.

The other reason that there is poorer agreement of 'psychosocial support' could be that the categories are not clear and the understanding of what they mean or who should be undertaking what role/tasks varies. This conclusion links to the earlier human factors discussion. However, from this study alone, it is not possible to identify the reason for the poor agreement between nurses in 'psychosocial support' scoring, for example, whether it is due to the case study design, nurses being inconsistent with their categorising of psychosocial needs or lack of understanding. Nonetheless, the first step in exploring this further would be clarifying the 'psychosocial support' categories definitions and more training on how to allocate the score, to eliminate different interpretations as a reason for the inconsistency of scores between nurses.

8.3 Measuring Nurse Dependency

When this research study was first considered it was soon realised that although the iBID ND tool had been in use it had never formally been reviewed or validated in any way. Therefore the second objective of this research was to establish whether the iBID ND tool did actually measure ND. To explore this the iBID ND tool was compared against the SNCT as the most widely used ND tool in the UK (Ball et al., 2019) and the only one endorsed by NICE (2014). The results demonstrated that there was a positive correlation between the scores of the two ND tools and thus in line with other ND tools validation methodology (Fagerström, 2000; Rothen et al., 1999; Sjöberg et al., 2000; Smith et al., 2009), it is argued that the iBID ND tool did measure at least some aspects of ND.

8.3.1 Comparison of tools

For the two ND tools used in this research, their developers were coming from different premises when they formed the tools. The SNCT is based on a critical care classification (Department of Health and Social Care, 2000) and focuses predominantly on the monitoring requirement for each level with some additional patient activities added to specific levels. Although the SNCT levels of care suggest that there is a hierarchy of care this is not evident in all the activities for each level. Whereas the iBID ND tool is based on some key activities with an increasing ranking of needs in each category. For example, with wound management iBID has six levels of procedure complexity while the SNCT only mentions wound management in one level (1b) so does not allow for the additional workload of wound management in the other levels. The same issue arises with psychosocial care. The SNCT mentions it in the 1b level in regards to enhanced psychological support for a poor prognosis or clinical outcome but it does not appear to take into consideration ongoing increase psychological and social needs that may also be relevant to the other levels. The iBID ND tool, on the other hand, does acknowledge that there are different levels of workload for all its sub-categories that could differ at different times for individual patients. But, unlike the SNCT, there are no time weightings allocated.

Although the two ND tools are different, there was a strong positive correlation between them, in that as the ND score increased on one it increased on the other, suggesting that the iBID does measure some aspects of ND in line with the SNCT. As mentioned in chapter two, the iBID ND tool, unlike the SNCT, but in line with many other ND dependency tools, had never been formally evaluated. There is still only a minimal evidence base on which to compare and evaluate any ND tool against (Griffiths et al., 2020$_b$) despite this being identified previously as a need on several occasions over the years (Edwardson and Giovannetti, 1994; Fasoli and Haddock, 2010).

8.3.2 ND tool gold standard comparisons

Having established that the iBID ND tool does measure ND it is important to ascertain how it compares to the gold standard for ND tools. However this is a problem as no definitive gold standard exists, perhaps as Fasoli and Haddock (2010) suggest because no one size fits all thus no consensus exists. They do suggest several characteristics of an ideal patient classification/ND tool that had emerged from their literature review which the iBID ND tool can be compared against. Firstly, they suggest ND tools should be parsimonious, simple and add minimally to the nursing workload. The iBID ND tool meets these three characteristics as it is relatively simple and clear in its design, does not take up too much time to score patients' ND (as evidenced in the post data collection survey section 5.4) and is not costly to use. Secondly, Fasoli and Haddock (2010) suggest a ND tool should be based on expert nurse judgement which the iBID ND tool is, both in its conception and in its use in scoring the patients. Thirdly they suggest that the ND tool should be a reflection of nursing work and include indicators to measure patient complexity. Although the iBID ND tool does not measure every aspect of nursing care delivered, it does reflect some of the key elements related to burn care, in particular dressings and psychosocial care which the literature suggests is not as prominent in more generic tools (Driscoll, 1991; Sjöberg et al., 2000). The iBID ND tool also considers the various levels of complexity of care required for each of its sub-variables. Consequently, it is argued that the iBID ND tool does fit within the 'sound design principles' suggested by (Fasoli and Haddock, 2010) for ND tools although, like most ND tools, it does not address the issue of what the optimal required nursing care and staffing levels should be.

Hoogendoorn et al. (2020) undertook a systematic review of ND tools for critical care in which they formulated a system for assessing the content validity, reliability and validity of the tools they were comparing as described in Table 8.1. They excluded burn ICUs from their study, recognizing the difference in care needs of burn patients. However, there is no reason that their generic ND tool assessment criteria cannot be applied to all ND tools. Therefore, the iBID ND tool was also assessed against the Hoogendoorn et al. (2020) system and criteria. From Table 8.1 it can be concluded that the iBID tool also fairs well against their assessment criteria. The iBID ND tool was developed by senior burn nurses, It had good inter-rater reliability and a strong correlation with the SNCT, suggesting that the iBID ND tool is a credible tool for measuring the ND of patients with a burn injury.

However, the iBID ND tool does not have any time measurements attached to it, which does limit its ability to predict the actual number of staff required to meet the ND of patients. Nor does it take into account all nursing workload variables. Nonetheless, it can be used to identify the ND trend of a group of patients and give some evidence base to nurse staffing requests.

Table 8.1 Comparison of iBID ND tool with Hoogendoorn et al. (2020) assessment of validity and reliability of scoring systems criteria

	Hoogendoorn et al's (2020) Criteria	**iBID**
Content validity	Nurses participated in the selection of activities included in the scoring system and expert consensus was used.	IBID was developed using the knowledge and expertise of a group of senior Burn care nurses. However, these nurses were from one service so it could be argued might not be generalizable. However, from the literature and the researcher's own knowledge of practice in burn care in several burn services in the UK and abroad the content and variables are relevant.
Reliability	Inter-rater reliability. Hoogendoorn et al used kappa values of > 0.65 or a Cronbach alpha of >0.70 as an acceptable reliability.	The inter-rater reliability of the nurses scoring in phase one of this study used the Krippendorph alpha and Altman's agreement levels, which are similar to the Landis and Koch used by Hoogendoorn et al. iBID had an inter-rater reliability score of 0.74 which meets Hoogendoorn et al's acceptable reliability criteria.
Validity	The extent the scoring system measures the true outcome either by comparing the results with observed time measurements or an already existing tool.	The iBID ND tool does not have associated time criteria for the number of nurses so it could not be compared with time measurements. However, when compared to the SNCT it had a Spearman correlation coefficient of 0.87 which Hoogendoorn et al classes as a strong correlation.

Having established that the iBID ND tool does appear to measure ND, in the next section the third research objective and the related findings of this research will be critically examined.

8.4 Nurse Dependency and Burn Patient Relationships

The third objective of this research was to analyse the iBID ND data to ascertain if any relationships between ND and burn severity existed and if a predictive model for ND could be derived from the data. This section will critically examine some of the key findings from the statistical analyses presented in chapters six and seven in relation to the wider literature and clinical application.

8.4.1 ICU and ward

The statistical analysis of the iBID ND data confirmed that there was a link between the ND scores and the type of ward the patient is being cared for in (ward, HDU or ICU) (Figure 6.6). The ward, HDU and ICU are often seen as different types of areas with differing patient acuity and ND. This is demonstrated in the recommendations for ratios of 1 nurse to 1 patient in ICU (Faculty of Intensive Care Medicine, 2019) whereas the wards have a much higher ratio of patients to one nurse suggesting that ward patients have lower ND needs. Likewise, many ND tools such as the SNCT will attribute more time to patients that are likely to need ICU care. There is little argument with the fact that usually ICU patients will need 1 to 1 care and are likely to be more acutely ill requiring one or more organ support (Faculty of Intensive Care Medicine, 2019). Neither is there disagreement that ward patients will usually have a lower acuity (severity of illness) otherwise they would be in HDU or ICU. However, from a ND perspective, their nursing needs may be just as complex and require a lot of nursing time, similar to the time required for a patient in ICU even though the nursing actions required may be different.

Hoi et al. (2010) also make the argument that ND is not necessarily just correlated with the patient's acuity status. They found that less acute patients could be more nurse dependent than a patient requiring more acute medical interventions. A position that is further supported by Mark and Harless (2011) who also suggest that the lack of clarity and overlap of the terms used (such as severity of illness, patient acuity, workload intensity and dependency) lead to assumptions that the higher a patient’s acuity is, the more nursing they require. The findings of this research also suggest that there is not a clear differentiation of ND levels between the ICU, HDU and the ward. Instead, in line with Hoi et al.’s (2010) observation, it demonstrates a greater variability of nursing needs in each area, particularly in the ward (Figure 6.8 and 7.2).

It is often easier to justify the ICU and HDU staffing levels due to recommendations in policy documents but for the wards there are no such recommendations. Despite the RCN calling for safe nurse staffing levels (Borneo, 2019) and the Burn Care Review (2001), although not evidenced, suggesting that for a burn ward it should be 1:4. However, as discussed in chapter two (section 2.4) nurse-patient ratios are problematic as a nurse could have four patients with high ND or four patients with a low ND because the ND of ward patients’ can vary considerably. This variation was highlighted in sections 6.3 and 7.2 where it was identified that the average ND clearly differed between ICU, HDU and the ward (Figure 6.6 and Figure 7.1). However, the spread of the iBID ND total scores (Figure 6.8 and figure 7.2) was greater for the ward. Indicating that the wards had a greater variance of patient ND, and therefore a patient ND score-wise could be similar to one in ICU and thus may require a similar amount of nursing time although the patient acuity may be less. Therefore, the iBID ND score could be used as a guide to the daily ND trend for the area to demonstrate how ND has increased (or decreased) and how that supports the clinical professional judgement for the need to increase (or decrease) nurse staffing numbers for a shift. Nonetheless, although the iBID total score may support a change in nursing numbers it will not indicate the level of nursing experience required. Looking closer at the sub-variables of the score may give an indication of this. For example, if the ‘monitoring requirement’ or ‘procedure complexity’ is higher, then an RN is likely to be required. However, if the ‘ADL achievement’ or ‘mobility limitation’ needs are higher, then an HCA may be appropriate. However, further research would be needed to confirm this premise and quantify the iBID ND scores.

8.4.2 Procedure complexity/dressing

In the literature review discussion on ND tools for burn care in chapter three, burn wound management has specifically featured in burn ND tools as one of the aspects that makes burn nursing workload different to other areas. One of the reasons for this is the size of the wounds and the time it takes to clean and dress these large wounds. This fits with other literature measuring the actual workload of burn nurses. Forney et al. (2003) identified that wound care took up 11% of the nursing workload on a trauma burn ICU. Similarly, Abdelrahman et al. (2018) showed that wound care made up nearly a quarter of their burn score for all burn injuries and naturally increased as burn size increased. However, it is not clear from Abdelrahman et al.'s (2018) results how the burn score was affected on the days that no dressing was undertaken, although they imply that wound care was undertaken every other day.

When considering burn wound dressings this research found that the 'procedure complexity' sub-variable demonstrated a lower correlation to the iBID ND total score than the other sub-variables; apart from the 'psychosocial support' sub-variable, which had an even lower correlation as discussed earlier in this chapter. The fact that wound dressings are not performed every day is suggested as a reason that the correlation was lower than might have been expected. This is supported by the fact that the correlation did improve when the IBID ND total scores where no wound procedures were carried out were removed from the data set. Another possible reason for the lower correlation could be how the 'procedure complexity' was understood and completed by the nursing staff. It is not clear from the variable level descriptions whether the percentage group refers to the original size of the burn or the size at the time of the dressing procedure, which may have caused an imbalance and reduced the correlation with the overall total score. Both, the Linköping burn score (Abdelrahman et al., 2018) and the Cottey et al. (1992) adaptation of their hospitals commercial patient classification system, utilise the time it took to do the dressing to distinguish between groups. On the other hand, similarly to the iBID ND tool, de Jong et al. (2009)

uses TBSA to distinguish between groups but their descriptions are more in-depth. Therefore, clarifying the descriptions of the ‘procedure complexity’ categories as well as the ‘psychosocial support’ may be required for clearer understanding and more unified scoring.

8.4.3 Inhalation injury

The existence of an inhalation injury is a fundamental component of most burn mortality predictor equations (Halgas et al., 2018) because it has been shown that the presence of an inhalation injury alongside a cutaneous burn increases the severity and mortality of a burn injury (Dyamenahalli et al., 2019; Mercel et al., 2020). Subsequently, it would be reasonable to expect the ND to be increased for patients with an inhalation injury due to an increase in illness acuity and the frequent need for ventilation. This research did indeed show a relationship between the iBID ND total score and the presence of an inhalation injury, with the median ND scores being higher for the group with an inhalation injury.

However, an inhalation injury did not appear to be a strong predictor of the iBID ND total score according to the multiple regression analyses undertaken. An explanation for this may be the way the iBID ND total score is made up. A patient with an inhalation injury is more likely to be in ICU or classed as a high dependency patient requiring increased monitoring, which will be recognised in the monitoring subcategory score. This higher monitoring need and score would also be similar to patients without an inhalation injury, with a very large burn or another organ failure, that require ICU or HDU care. Thus, it is likely that the regression modelling picks up the ward type as a better explanatory indicator of the iBID ND total score than inhalation injury. Unlike other ND tools specifically designed for ICU patients, which will pick up on the nuances of different ventilatory or monitoring needs in ICU, the iBID ND tool only classifies broad types of monitoring requirements. This means that if a patient has an inhalation injury they are likely to be in ICU and by being in ICU they will have a higher iBID ND score.

But there is no evidence from this analysis that being in the ICU with an inhalation injury makes the iBID ND score any higher than other ICU burn-injured patients without an inhalation injury.

Further compounding the discussion of whether ND is increased by the presence of an inhalation injury is the difficulty of inhalation injury diagnosis (Dyamenahalli et al., 2019; Kim et al., 2017). In their study looking at the mortality predictive properties of clinical features of inhalation injury, Kim et al. (2017) found that mechanical ventilation was a significant predictive factor whereas the history and physical findings were not. A possible parallel may be drawn in ND, in that it is the need for additional monitoring or ventilation that increase ND rather than the inhalation injury itself. This may also be why the other identified burn ND tools, like the iBID ND tool, do not specifically include inhalation injury as part of their ND scoring. They either refer to ventilation needs or monitoring requirements. This argument, that other factors may mask the effect of an inhalation injury on ND, can also be related back to the earlier discussion in section 8.4.1 in that ND may not just be correlated with the patient's acuity (Hoi et al., 2010).

8.4.4 Rehabilitation therapy

From the multiple regressions, one of the stronger predictors of ND was the 'rehabilitation therapy complexity'; suggesting that when patients had a greater need for rehabilitation therapy they also had a higher ND. No explicit link to this relationship between ND and therapy needs was found in the literature. However, Mueller et al. (2010) did identify patients' functioning (a patient's ability to perform their daily living activities) as a predictor of nursing workload. Using the International Classification of Functioning, Disability and Health core sets (WHO, 2001) they showed that specific categories for groups of patients could predict up to half the variation of the nursing workload for acute inpatients with rehabilitation needs. Although not specific to burn patients, there is no reason to suspect their supposition would not be transferable. With further research, it might be possible to identify the specific

ICF core sets that are relevant to burn patients. Furthermore, two of the iBID ND tool subcategories are related to the patients' functioning – 'ADL achievement' and 'mobility limitations'. Therefore, it follows that the more input that a patient requires from the physiotherapy and occupational therapists to promote the patient's function, the more assistance the patient is going to need from nursing staff with their ADL and mobility and thus higher the workload.

8.4.5 TBSA as a ND predictor

The statistical analysis of this research has demonstrated that many variables have an impact on ND but it is not obvious if one factor has more impact than others. The regression models suggest that the rehabilitation therapy requirements and the basic care needs of the patient have a substantial impact on the ND total score. However, these will only be known once the patient is admitted and started on their treatment plan making them less suitable for predicting their individual ND scores. The TBSA on the other hand did make up nearly 50% of the regression model's variance in the change of the iBID ND total score. It is relatively quickly assessed and identified on admission that it could be used as a starting point to predict ND. Nevertheless, it is recognised that it is not just the size of the burn that will dictate the ND, other factors such as where the burn is, comorbidities, inhalation injury and pre-injury condition will all have an impact.

A clear trend in the average IBID ND total score for each TBSA group was demonstrated which could be used to help with the planning of daily nurse staffing levels and to identify whether the workload is likely to go up or down for a group of patients with a burn injury. Also, these ND trajectories might predict whether a patient will be in for a longer length of time or has an increased mortality risk if they have a higher than expected iBID ND score which does not start to reduce. However, more research would be needed to validate this prediction. Nevertheless, this finding, that for those burn patients who do not survive the ND score continues to stay high, supports Amadeu et al. (2020) findings that there was an association between a higher workload and death in patients with a burn injury. However, the fact that there is evidence that the iBID ND total score remains higher for those patients who do not survive, does not equate to ND being a predictor of mortality as there may be other reasons that a patient has a high ND score (Nassiff et al., 2018).

Although a differentiation of ND has been identified for different TBSA groups, as no staffing level weighting has been established for iBID it is not possible to quantify the change in workload with a difference in the ND scores. Further work needs to be undertaken to add a weighting to each iBID ND variable score and discover whether the workload change from one level to the next is consistent for each sub-variable or has a different workload weighting. In other words, does the change in the monitoring requirements from a B1 ward level (where the observations may be recorded four hourly) to a B2 HDU level (where the observations may be recorded hourly) equate to a change from a B2 to a B3 ICU level? Also, does the workload for one sub-variable equate to the workload of another; for example, is the workload of a moderate-sized dressing (P3) similar to the amount of time giving significant psychosocial support (S3)? In addition to the further research required to add workload weighting to these scores, the other necessity is to elaborate on what each sub-variable and category means or consists of. For example, clarifying what the difference between the 'psychological support' level 'S3 - significant support required' and 'S4 – in-depth discussion' actually is. Currently, the level descriptors are vague and open to interpretation. This existing lack of clarity may have contributed to the difference in inter-rater reliability for some of the iBID ND sub-variable scores. Nevertheless, despite the lack of workload weighting the iBID ND tool is simplistic and does not require lots of time to complete. It can be used to add evidence and support for nurse staffing level decisions in line with the NHS vision of the right staff in the right place at the right time (National Health Service, 2019; National Quality Board, 2018).

8.4.6 Professional judgement

Following the cross-validation of the multiple regression models, it was identified that the more subjective variables, which also take into consideration judgement of the value scored, had a greater predictive effect than the more objective measured variables. One reason for this could be that the scores for the subjective variables take into consideration more than just a measurement but also take into account the nuances (such as environment) and other patient and treatment factors that would affect the final score. In other words, professional judgement is used to decide on the score for these variables (for example, 'Therapy complexity', 'basic care needs'). Professional judgement can be defined as the use of professional knowledge and experience in making decisions (Law Insider, 2021; Maxwell and Leary, 2020). The literature often talks of clinical judgement in the same manner and uses the terms interchangeably (Manetti, 2019) which can be confusing. Here, the term professional judgement will be used as it also implies the professional accountability of the decision as well as the clinical decision made.

There continues to be a debate on the value of nurses' professional judgement in advocating the required staffing levels. Professional judgement, on one hand, has been criticised for its subjectivity and consequently it's potential for bias but on the other hand, it is valued for its knowledgeable contribution (Bruce et al., 2008), bringing with it expertise and experience that cannot be easily gained from a tool. Telford (1979) in an attempt to give more transparency to the professional judgement that informed the nurse staffing numbers developed the 'professional judgement' method. The Telford method was further developed by Waite and Hirsh (1986), who also tested the reliability of nurses' professional judgement on staffing. They found that the professional judgment results were similar to those obtained through other ND tools and that there was a strong correlation between the professional judgement of ward managers of similar specialities of the staffing required, supporting the view that professional judgement is reliable in assessing the nurse staffing requirements. Likewise, in the first part of this research, the reliability in the agreement between nurses who were from different burn services was demonstrated in relation to the ND scoring of the three case studies. Where the Krippendorff alpha coefficient demonstrated good agreement between scorers for both ND tools. This finding is consistent with the literature where, as part of the development and testing of various ND tools, agreement between nurses' judgement with regards to ND and staffing has been shown (Griffiths et al., 2020a; Smith et al., 2009).

Irrespective of the evidence that professional judgement can be effective in identifying the required staffing levels, a more objective measure continues to be sought by managers and those trying to justify the cost of more staff on a finite budget. The desire being to reduce nursing to a list of tasks that can be timed and quantified, similar to Taylor's scientific management concept (Taylor, 2012). In fact, this is exactly what some ND tools, such as GRASP, NAS and CNIS, have tried to do. Yet nursing is much more complex, involving more than just a task but a holistic critical assessment of physical and psychosocial issues at the same time (Manetti, 2019; Maxwell and Leary, 2020) to make judgements and actions. Pasquale (2019) also highlights holism and the ability to integrate facts and values as characteristics of professional judgement. A nurse can process a lot of factors and apply their clinical knowledge and experience in parallel to come up with a judgement in a short space of time, whereas a complex software solution would otherwise be needed.

However, it should not be a case of deciding between the objective or subjective, but instead, a combination of the two to get the best outcome. The evolution of ND tools has occurred over time to provide some evidence-base to nurse staffing decisions. Yet nursing workload is more than the activities in the vicinity of the patient (Myny et al., 2011) and so far there is no single ND tool that is able to take all variables into account, factoring in all aspects of nursing needs, different local environmental factors and individual patient nuances to build a full picture. Using Dicenso et al. (1998) model, for evidence-based clinical decisions, it is argued that true evidence-based practice needs to use professional judgement, alongside objective research evidence, to weigh up the evidence (ND tool results) in context with the patient's needs and the resources available. One on its own cannot give the best results, whereas using professional judgement to provide context and complement the more objective evidence can improve the final decision (Krishnan, 2018; Maxwell and Leary, 2020) and give more confidence to all concerned.

This research supports the view that to demonstrate good evidence-based practice the use of professional judgement alongside a ND tool is required for deciding on patient ND and nursing requirements. It has shown that the more subjective aspects of care have a greater ND predictive value and thus professional judgement is a key component and should not be ignored. Moreover, recent research, where the SNCT staffing requirements were correlated against the actual nurse staffing level, and the nurse in charge's judgement as to whether the level of staffing was sufficient to maintain quality of care, has unequivocally argued that although ND tools, such as the SNCT, can help with the prediction of nurse staffing requirements it cannot replace professional judgement (Saville and Griffiths, 2021a). As Telford argued, back in 1979, it would be a sad day if no credibility was given to the professional judgement of registered nurses (Telford, 1979).

8.5 From 'Just Data' to 'Knowledge and Wisdom'

In chapter two in the health informatics section, Nelson's (2018) Data to Wisdom Continuum Model was discussed. Nelson argues that data starts a collection of un-interpreted facts, which then get organised into information, from which knowledge then comes. The utilisation of this knowledge in practice completes the transformation of the data to wisdom. This section discusses how the results of this research have increased the understanding of ND in relation to patients with a burn injury and further develop the knowledge and wisdom aspects of the data produced by iBID.

Starting with the raw data, this research identified relationships within the data between ND and other patient and nursing variables (see section 6.2.1.3). Thus, starting to give some meaning to the data and transforming it into information that could then be interpreted (Bellinger et al., 2004; Nelson, 2018) and start a collection of knowledge that gives further insight and understanding of ND in relation to patients with a burn injury. Having established which variables demonstrated some relationship with ND, patterns in this information were explored to increase ND knowledge. From the results, particularly those discussed in this chapter, three main points of knowledge have evolved from this research. Firstly, from the predictive modelling (see sections 6.2.2 and 7.2.4), there are variables that have some predictive properties for ND in patients with a burn injury, such as TBSA and therapy needs. Secondly, there is a trend in the average iBID ND total scores over the hospital stay of a patient with a burn injury that differs for each TBSA group. This trend also demonstrates higher iBID ND total scores for patients who stay longer than the 1day/TBSA rule and for patients that do not survive the daily average iBID ND total scores remain high and do not drop over time as the scores for survivors do (see sections 6.3.2 and 7.2.3). Thirdly, of the sub-categories that make up the iBID ND total score the 'psychosocial needs' has the weakest correlation and least inter-rater agreement (see sections 5.2 and 5.3).

Moving from knowledge to wisdom involves the application of the knowledge to practice to help make decisions to help improve patient care (Nelson, 2018). The wisdom part of this research is harder to express, not least because further research is required to confirm the findings and take the ideas produced in this research forward. Nevertheless, this research has shown that the iBID ND tool could be used to measure ND and give an indication of whether the patients' ND have increased or not, providing evidence to support nurse staffing decisions. One specific clinical application that has evolved that could be useful in practice and help to support nurse staffing planning is the TBSA/ND tables that have been developed (see 7.2.3). These could be used to give an idea of what the ND might be for a given set of patients, on a given day, when their TBSA and their admission day is known and consequently the staffing requirements. However, these are only an indication as they are based on the average iBID ND score and some patients will have higher or lower scores. Consequently, it is important that this information is used to aid and support professional judgement and not replace it. This is especially true as these research findings support the need for professional judgement to be used in decision making regarding nurse staffing.

Thus, from this discussion, it is argued that the ND data in iBID can, and has in some aspects, been transformed from pure data into knowledge and has the potential to be taken forward from the knowledge stage of the Data to Wisdom Continuum Model (Nelson and Staggers, 2018) to the wisdom stage. However, for this new knowledge to be used and integrated into practice to help support decisions about nurse staffing levels, more research will be required to confirm the findings of this research and to quantify the iBID ND scores so they can be linked to actual nurse staffing needs.

8.6 Summary

This chapter has discussed the main findings from this research in relation to the wider literature and the research objectives for this study. In so doing it has demonstrated that all three of the research objectives have been met and the research questions answered. Firstly, it has shown that the iBID data is of sufficient quality to have confidence in the findings from this research. However, greater understanding and clarity of the subcategory descriptors could enhance the consistency and reliability. Secondly, the iBID ND does measure aspects of ND and is reliable and valid in relation to the Hoogendoorn et al. (2020) criteria. However, the iBID ND tool does lack a quantifiable measurement system that can be translated into exact staffing numbers. Thirdly, there is a positive relationship between ND and burn severity. Specifically, the size of the burn has been shown to have an influence on the ND trajectory over a patient's stay. The regression modelling has highlighted several variables that have some predictive properties. In particular, the variables that have some clinical judgement associated with them appear to be better predictors than pure objective variables. Giving more weight to the argument that ND tools should be used alongside professional judgement.

Finally, this chapter discussed how the findings have moved the data in iBID from being more than just ‘data’ to ‘knowledge’ about ND in patients with a burn injury. Giving the potential, with further research, for this ‘knowledge’ to be developed further into ‘wisdom’ to shape future clinical practice.

Chapter 9 **Conclusion**

9.1 Introduction

This research set out to explore the ND data in iBID. The aim was to gain an increased understanding of ND in relation to patients with a burn injury and to identify any information that could be used to predict ND of acute burn inpatients and help with the planning of nursing staff numbers. In doing so, this research has:

- Established that the iBID ND tool does measure aspects of ND of burn-injured patients.
- Demonstrated that there was good overall inter-rater reliability between nurses when scoring ND of patients. However, this was noticeably weaker when scoring the 'psychosocial support' of patients with a burn injury.
- Confirmed that many of the variables relating to burn severity (such as TBSA, and rehabilitation therapy complexity) did demonstrate evidence of a linear relationship with the iBID ND total scores. Conversely, the date and time of the injury did not affect the ND needs of the patients.
- Identified preliminary predictive models for the average, maximum and first iBID ND total scores. In doing so, this research has demonstrated that the variables using clinical judgement (such as 'therapy complexity', 'basic care needs' and 'medical intervention') gave a better predictive result than just using objective measures (such as cause of burn, mortality prediction score, inhalation injury, category of burn).
- Developed a predictive ND trajectory for different sizes of burns that can be used in the planning of nurse staffing numbers and based on these trajectories identify if a patient with a burn injury may be hospitalised for longer than 1day/TBSA.

The purpose of this chapter is to summarise the implications and contributions to knowledge that this research has generated and the recommendations for future practice and research. In addition, it discusses the strengths, limitations and challenges of this research.

9.2 Contribution to Knowledge and Implications

This research has contributed to the existing knowledge of ND in two main dimensions; the practical use of the iBID ND tool and the prediction of ND in patients with a burn injury.

The iBID ND tool has been routinely used in burns services in England and Wales to collect ND data. However, it had never been formally validated as a functional ND acuity tool nor routinely used as a ND measure in burn services. This research has demonstrated that the iBID ND tool does measure aspects of ND in patients with a burn injury. Consequently, it could be used to support managers to make decisions regarding the daily nursing staff numbers required for a burn inpatient service. Used alongside a ND tool that can calculate the average nursing establishment (such as the SNCT) the iBID ND tool can add more granularity regarding burn care nuances to staffing levels decisions. Thus, it makes up for the missing burn speciality aspects of ND in more generic ND tools.

In line with other research on the use of ND tools, this research has shown good agreement between the nurses in scoring the ND of patients with a burn injury. The only exception to this strong level of agreement relates to 'psychosocial support'. The weaker inter-rater agreement for the 'psychosocial support' was surprising as the psychosocial impact following a burn injury is well recognised. This research has postulated that one possible reason for this is the iBID ND tool descriptors could be open to different interpretations, particularly for the 'psychosocial support' variable. Therefore, to improve user conformity and increase inter-rater agreement the iBID ND tool descriptors need to be made clearer and less ambiguous. Additionally, more research is required into the role of the nurse in meeting the psychosocial needs of a patient with a burn injury, as opposed to a clinical psychologist, and the impact on nursing workload.

This research has confirmed that burn severity has an impact on the ND of patients with a burn injury. In particular, it has shown that the larger the burn size the higher the ND is. This is not restricted solely to the admission ND; the average ND trajectory reduces at a different rate for different burn sizes and length of stay. This has led to the development of a set of average daily iBID ND total scores tables that could be used to predict the likely iBID ND total score for a group of patients on a given day. Furthermore, the patient's ND trend can be compared to the average ND trajectory for their burn size to identify if they are likely to be an inpatient for longer than 1 day/TBSA, enabling an assessment of the reasons for the potential longer stay and if any actions could be taken to reduce this.

In addition to the ND trajectory for different size burns this research has found that many of the variables, identified for this research, showed signals of a relationship with the iBID ND scores. Predictive models for the average, maximum and first iBID ND total scores were developed that explained 82-84% of the variance of the iBID ND total scores. The best predictive variables identified for the maximum and first iBID ND total scores were 'TBSA groups', 'group ages', 'therapy complexity' medical intervention' and 'basic care support needs'. For the average iBID ND total score the best predictive variables identified were 'TBSA groups', 'group ages', 'therapy complexity', 'expected outcome' and 'category of injury'. Although these predictive models give an indication of which variables may be used to best predict ND, they are currently too complicated to use in everyday practice and would require significant development to be a workable tool. Additionally, there is no quantifiable scaled measurement to the iBID ND scores, nor nurse staffing multipliers, to help work out nurse staffing numbers. Therefore, reducing the iBID ND tool's ability to benchmark against and predict the nurse staffing numbers required.

The 'therapy complexity', 'medical intervention' and 'basic care support needs' variables are constructed using potentially subjective professional judgement rather than definitive objective criteria. Yet they gave better predictive results than just using objective measures. This finding combined with the complexity of identifying a simple predictive ND model supports the arguments in the literature that ND of patients is complex and that ND tools should be used alongside professional judgement as they cannot capture all the factors that affect ND that an experienced nurse can.

9.3 Strengths, Limitations and Challenges of this Research

The limitations of part one of this research, where the iBID ND tool was compared to the SNCT, are discussed in section 5.6. In this section, the limitations, strengths and challenges in relation to the whole research journey will be discussed.

9.3.1 Limitations and strengths

The limitations of this research stem from three overarching factors which will be explored in turn. First, the small sample size used in part one. Second, the use of a live data registry. Third, the narrow focus of the ND tool.

In part one of this research, where the iBID ND tool was compared to the SNCT, the sample size was small due to the small number of patients scored during the two-week snapshot and the low return rate for the simulated case studies and post data collection survey. Therefore, while the findings are useful and indicative of the iBID ND tool being able to measure ND and good agreement between nurses when scoring ND, the ability to generalise the findings of part one is compromised. Nevertheless, the findings form a basis for further research to be conducted. Despite the small sample size, the part one study population was from three of the six adult burn centres in England and represented three of the four burn networks in England and Wales. Thus, there was a good representation of the burn centres adult inpatient population. However, future research into the ND of patients with a burn injury should be expanded to include the burn units and burn facilities to gain a more complete picture across a wider spectrum.

Secondly, for part two of the research, analysis of the ND data in iBID, the data analysed was from a live data registry; meaning that due to confidentiality the accuracy of the historical data could not be confirmed. Despite this, the narrative evaluation of iBID did not raise any concerns regarding data quality and the results were in keeping with what might have been expected from a clinical perspective. It is acknowledged that the data from a live registry will be ‘messy’ compared to clinical trials, however it is real live data that is being used to make predictions so will be closer to the real-world scenarios. Using the ‘messy’ data is similar to the ‘intention to treat’ concept in randomised control trials, which includes patients that have not complied or deviated from protocol and accepts them as deviations that are likely to occur in real life (McCoy, 2017).

Thirdly, this research deliberately only focused on the iBID ND tool and its sub-categories, as the usefulness of the tool to measure and predict ND was being explored. Therefore, only the five aspects of ND (‘monitoring’, ‘procedure complexity’, ‘psychosocial needs’, ‘mobility’ and ’activities of daily living’) linked to the iBID ND tool were considered and not the other nuances of ND, particularly those related to the specifics of other specialities such as ICU. Additionally, this research did not capture the nurse staffing and skill in relation to the iBID ND scores. Therefore, future research into ND in burn care should take into consideration ward staffing as well as patients ND needs.

Despite these limitations, this research was the first in-depth analysis of the ND data in iBID. It has led to a greater understanding of the validity of the iBID ND tool and ND scores within iBID, how these ND scores relate to the presenting burn injury, the ND needs of patients with a burn injury over time, and it provides a starting point for further research into staffing requirements within burn care. All of which has led to the first published research paper on the iBID ND tool (Leaver et al., 2021). Additionally, the undertaking of this research has also led to more discussion across the burn networks about ND in burns and the inclusion of the issue on the National Burn Operational

Delivery Network Group’s work plan (National Burn Operational Delivery Network Group, 2021).

9.3.2 Challenges

The undertaking of this research did pose some challenges for the researcher, both organisational and personal. Many of which arguably could be associated with most research. There was the initial challenge of getting ethical approval and then coordinating the research in three different NHS burn centres around the country. Concentrating the research in one centre would have been simpler. The researcher may then have been able to personally supervise and develop a relationship with the participants which may have avoided the deviation from protocol and encouraged better engagement for the case studies and online survey. However, only using one burn service would have reduced the depth and generalisability of the findings of this research. Furthermore, this could then potentially have been seen as influencing the participants. Despite these challenges they have helped to develop the researcher’s networking, presentation and negotiation skills and led to a wider discussion about ND and the use of iBID.

The biggest challenge though, was a personal one, both in time and commitment (as this PhD was undertaken alongside a full-time job) and knowledge. The researcher initially had a limited knowledge of statistics and had naively expected there to be a simple established process for analysing the data from a database. It quickly emerged that this was not the case. To address this, a steep learning journey was required to understand the basics of the statistical tests and their results. Also, to develop a process to analyse what was to a novice a very large amount of data, albeit not in the realms of big data, with multiple variables and potential outcomes. Initially, this journey appeared overwhelming but with good support and advice, the journey was slowly started and eventually the research outcomes proudly achieved, as evidenced in this thesis. The personal learning that has occurred from undertaking this research does not end with the research, it will be used in future practice to enhance the researchers own knowledge and foster understanding for students and colleagues.

9.4 Recommendations

Following the analysis of the iBID ND data and the comparison of the iBID ND tool with the SNCT, the following recommendations for practice, iBID design and future research are made.

- There is a place for the ND, as collected by the iBID ND tool, to be utilised alongside professional judgement and other ND tools to aid nurse staffing decisions.
- If ND data continues to be routinely collected in iBID (UK based medical registry) it should be regularly reviewed and utilised to influence the strategic planning of nurse staffing and patient care.
- The size of the burn on admission can be used to predict the ND of patients with a burn injury.
- The iBID ND tool category level descriptors (particularly those for ‘psychosocial support’) to be reviewed and clarified to reduce ambiguity and increase consistency and confidence in the scoring.
- A review should be undertaken of the structure and content of the iBID website to provide easy access to information relating to the use of and functionality of iBID and the iBID ND tool in line with the European PARENT medical registry's quality framework and the GDPR regulations.
- Further research should be undertaken to:
    - Compare the iBID ND total scores with the actual nurse staffing levels with a view to quantifying the iBID ND tool scores and linking to the nurse staffing numbers required. There is the planned functionality of iBID to collect daily nurse staffing numbers that would make this analysis easier.

- Explore whether the initial ND total score can predict whether a patient will breech 1 day/TBSA and what factors might contribute to this.
- Confirm the generalisability of the inter-rater agreement and the predictive ND models identified in this research prospectively on a wider spectrum of burn services.
- Explore the relationship between ND and rehabilitation needs.
- Evaluate the ND scores alongside the costs of burn care to elicit if ND could be used to calculate burn care costs.
- Investigate if a relationship exists between the iBID ND scores, staffing levels and patient safety outcomes.
- Examine the nurse's role in meeting the psychosocial support needs of patients with burn injuries; both in relation to the nursing workload and the psychosocial adaptation of the patient.

9.5 Summary

This chapter has summarised the findings of this research and the implications for practice. It has also discussed the limitations and challenges of the research, concluding with recommendations for practice and future research.

In conclusion, the research presented in this thesis has given an increased insight into the ND of patients with burn injuries. It has established that the iBID ND tool can be used to measure ND and therefore can be used alongside professional judgment on a daily basis to influence nurse staffing decisions in burn services for the ultimate benefit of the patient. This research has confirmed the positive relationship between ND of burn-injured patients and burn severity supporting the clinical idea that patients with larger burns will require more nursing care throughout their inpatient stay. In particular, this research has highlighted the difference in the daily trajectory of the average iBID ND total score of patients with a burn injury with different TBSA and also between those that were discharged by 1day/TBSA and those that were not. Clinically this finding may be helpful in identifying which patients will be in for longer and whether the cause for the longer stay can be identified and prevented.

Possibly the most unexpected finding was the weaker correlation of the ‘psychosocial support’ needs with the ND total score and the weaker inter-rater agreement for this variable. This has highlighted that more attention is required in clarifying the understanding of and the nurse’s role in meeting these psychosocial needs.

Through this analysis of the iBID ND data, the raw data has been transformed into new ‘knowledge’ on burn-injured patients’ ND. This research lays the groundwork for future research to convert the ‘knowledge’ gained to established practical ‘wisdom’ to support safe nurse staffing decisions in burn care and better outcomes for patients with burn injuries.

Reference List

Abdelrahman, I., Elmasry, M., Fredrikson, M., Steinvall, I. (2018) Validation of the burn intervention score in a National Burn Centre. *Burns,* 44(5), pp. 1159-1166.

Adenike, A., Bailey, C., Hewison, A. and Wagstaff, C. (2020) Poster *106: Roles and experiences of nurses when meeting the psychological needs of patients receiving palliative care*. British Medical Journal Publishing Group [Accessed 2020-12-31T17:13:00].

Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J. and Silber, J. H. (2002) Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *JAMA,* 288(16), pp. 1987-1993.

Aiken, L. H. P., Sloane, D. M. P., Bruyneel, L. M. S., Van den Heede, K. P., Griffiths, P. P., Busse, R. P., Diomidous, M. P., Kinnunen, J. P., Kózka, M. P., Lesaffre, E. P., et al. (2014) Nurse staffing and education and hospital mortality in nine European countries: a retrospective observational study. *Lancet, The,* 383(9931), pp. 1824-1830.

Akoglu, H. (2018) User's guide to correlation coefficients. *Turk J Emerg Med,* 18(3), pp. 91-93.

Alonso-Fernández, J. M., Lorente-González, P., Pérez-Munguía, L., Cartón-Manrique, A. M., Peñas-Raigoso, M. C. and Martín-Ferreira, T. (2020) Analysis of hypothermia through the acute phase in major burns patients: Nursing care. *Enfermería Intensiva (English ed.),* 31(3), pp. 120-130.

Altman, D. G. (1991) *Practical statistics for medical research.* London: Chapman and Hall.

Amadeu, L. M., Dell'Acqua, M. C. Q., Castro, M. C. N., Palhares, V. D. C., Serafim, C. T. R. and Trettene, A. D. S. (2020) Nursing workload in burn intensive care unit. *Revista brasileira de enfermagem,* 73(suppl 1).

Anderson, L. (1997) The role and resources required for the introduction of generic ward assistants using GRASPR systems workload methodology: a quantitative study. *J Nurs Manag,* 5(1), pp. 11-17.

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

Armon, C. (2018) Ethics of clinical research in patients with ALS: is there a risk of exploitation? *Amyotrophic Lateral Sclerosis and Frontotemporal Degeneration,* 19(3-4), pp. 161-166.

Ball, J., Barker, H., Burton, C., Crouch, R., Griffith, P., Jones, J., Lawless, J. and Rycroft-Malone, J. (2019) *Implementation, Impact and Costs of Policies for Safe Staffing in Acute NHS Trusts*. University of Southampton.

Ball, J. E., Bruyneel, L., Aiken, L. H., Sermeus, W., Sloane, D. M., Rafferty, A. M., Lindqvist, R., Tishelman, C., Griffiths, P. and Consortium, R. N. C. (2018) Post-operative mortality, missed care and nurse staffing in nine countries: A cross-sectional study. *Int J Nurs Stud,* 78, pp. 10-15.

Barr, A., Moores, B. and Rhys-Hearn, C. (1973) A review of the various methods of measuring the dependency of patients on nursing staff. *Int J Nurs Stud,* 10, pp. 195-208.

Beauchamp, T. L. and Childress, J. F. (2013) *Principles of biomedical ethics.* 7th ed. edn. New York ; Oxford: Oxford University Press.

Belgian Outcome in Burn Injury Study Group (2009) Development and validation of a model for prediction of mortality in patients with acute burn injury. *Br J Surg,* 96(1), pp. 111-117.

Bellinger, G., Castro, D. and Mills, A. (2004) *Data, information, knowledge, and wisdom*. Avaiable at: http://www.systems-thinking.org/dikw/dikw.htm [Accessed 31 July 2021].

Berwick, D., Downey, A., Cornett, E., National Academies of Sciences, E. and Medicine (2016) Military and Civilian Trauma Care in the Context of a Continuously Learning Health System. In: *A National Trauma Care System: Integrating Military and Civilian Trauma Systems to Achieve Zero Preventable Deaths After Injury.* National Academies Press (US).

Bettencourt, A.P., McHugh, M.D., Sloane, D.M. and Aiken, L.H., 2020. Nurse staffing, the clinical work environment, and burn patient mortality. *Journal of Burn Care and Research*, *41*(4), pp.796-802.

Blakeney, P. E., Rosenberg, L., Rosenberg, M. and Faber, A. W. (2008) Psychosocial care of persons with severe burns. *Burns,* 34(4), pp. 433-440.

Blegen, M. A., Goode, C. J. and Reed, L. (1998) Nurse staffing and patient outcomes. *Nursing Research,* 47(1), pp. 43-50.

Blignaut, A. J., Coetzee, S. K., Klopper, H. C. and Ellis, S. M. (2017) Medication administration errors and related deviations from safe practice: an observational study. *Journal of Clinical Nursing,* 26(21-22), pp. 3610-3623.

Blumenthal, S. (2019) The NQRN Registry Maturational Framework: Evaluating the Capability and Use of Clinical Registries. *EGEMS (Wash DC),* 7(1), p. 29.

Borneo, A. C., Rachel. Fry, Oliver. Kiely, Sian. Knape, John. Maynard, Emily. Oorthuysen-Dunne, Jade. Turnbull, Lisa . (2019) *Staffing for Safe and Effective Care.* London: Royal College of Nursing.

Braunstein, M. L. a. (2015) *Practitioner's guide to health informatics.* Switzerland: Springer International Publishing.

Brennan, C. W. and Daly, B. J. (2009) Patient acuity: a concept analysis. *Journal of Advanced Nursing,* 65(5), pp. 1114-1126.

Brennan, C. W., Daly, B. J., Dawson, N. V., Higgins, P. A., Jones, K. R., Madigan, E. and Van Der Meulen, J. (2012) The Oncology Acuity Tool: A Reliable, Valid Method for Measuring Patient Acuity for Nurse Assignment Decisions. *Journal of nursing measurement,* 20(3), pp. 155-185.

Bruce, J., Langley, G. and Tjale, A. (2008) The use of experts and their judgments in nursing research: an overview. *Curationis,* 31(4), pp. 57-61.

Brusselaers, N., Monstrey, S., Vogelaers, D., Hoste, E. and Blot, S. (2010) Severe burn injury in europe: a systematic review of the incidence, etiology, morbidity, and mortality. *Critical Care,* 14(5).

Burn Standards Review Group (2018) *National Standards for Provision and* Outcomes in Adult and Paediatric Burn Care. London: British Burn Association

Cambridge Dictionary (2020) *Cambridge English Dictionary.* Available at: https://dictionary.cambridge.org/dictionary/english [Accessed 13/8/2020].

Campbell, M. J. (2020) *Statistics at Square one, correlation and regression.* Available at: https://www.bmj.com/about-bmj/resources-readers/publications/statistics-square-one/11-correlation-and-regression [Accessed 29/10/2020].

Camuci, M. B., Martins, J. T., Cardeli, A. A. M. and Robazzi, M. L. d. C. C. (2014) Nursing Activities Score: nursing work load in a burns Intensive Care Unit. *Revista latino-americana de enfermagem,* 22(2), pp. 325-331.

Carayon, P. and Hoonakker, P. (2019) Human Factors and Usability for Health Information Technology: Old and New Challenges. *Yearbook of Medical Informatics,* 28(01), pp. 071-077.

Caron, I., Gélinas, C., Boileau, J., Frunchak, V., Casey, A. and Hurst, K. (2021) Initial testing of the use of the Safer Care Nursing Tool in a Canadian acute care context. *Journal of Nursing Management*.

Caton, N. L., McGill, D. and Stewart, K. J. (2014) Is the target of 1 day length of stay per 1% total body surface area burned actually being achieved? A review of paediatric thermal injuries in South East Scotland. *International journal of burns and trauma,* 4(1), pp. 25-30.

Challis, D., Hughes, J., Xie, C. and Jolley, D. (2014) An examination of factors influencing delayed discharge of older people from hospital. *International Journal of Geriatric Psychiatry,* 29(2), pp. 160-168.

Chen, C. S., Chan, S. W.-C., Chan, M. F., Yap, S. F., Wang, W. and Kowitlawakul, Y. (2017) Nurses' perceptions of psychosocial care and barriers to its provision: A Qualitative Study. *Journal of Nursing Research,* 25(6), pp. 411-418.

Cheung, R. B., Aiken, L. H., Clarke, S. P. and Sloane, D. M. (2008) Nursing care and patient outcomes: international evidence. *Enfermeria Clinica,* 18(1), pp. 35-40.

Chiulli, K. A., Thompson, J. and Reguin-Hartman, K. L. (2014) Development and implementation of a patient acuity tool for a medical-surgical unit. *Academy of Medical-Surgical Nurses,* 23, pp. 8- 12.

Chou, S.-S., Wu, L.-F., Chang, I.-W. and Stone, P. W. (2007) The Chinese nursing interventions instrument. *Journal of Nursing Scholarship,* 39(2), p. 198.

Cleland, H., Greenwood, J. E., Wood, F. M., Read, D. J., Wong She, R., Maitz, P., Castley, A., Vandervord, J. G., Simcock, J., Adams, C. D., et al. (2016) The Burns Registry of Australia and New Zealand: progressing the evidence base for burn care. *Medical Journal of Australia,* 204(5), pp. 1951e-1957.

Cohen, J. (1992) A Power Primer. *Psychological Bulletin,* 112, pp. 155-159.

Cottey, K., Nauert, L. and Wells, S. (1992) Modifying a hospital-wide PCS for burn wound care. *Nursing Management,* 23(4), pp. 58-60, 62.

Cox, D., Kartsonaki, C. and Keogh, R. H. (2018) Big data: Some statistical issues. *Statistics & probability letters,* 136, pp. 111-115.

Creamer, D., Walsh, S. A., Dziewulski, P., Exton, L. S., Lee, H. Y., Dart, J. K., Setterfield, J., Bunker, C. B., Ardern-Jones, M. R., Watson, K. M., et al. (2016) U.K. guidelines for the management of Stevens-Johnson syndrome/toxic epidermal necrolysis in adults 2016. *British Journal of Dermatology,* 174(6), pp. 1194-1227.

Creswell, J. W. (2014) *Research design : qualitative, quantitative, and mixed method approaches.* 4th edn. London: Sage.

Creswell, J. W. and Plano Clark, V. L. (2011) *Designing and conducting mixed methods research.* 2nd edn. London: Sage.

Crotty, M. (1998) *The foundations of social research. Meaning and perspective in the research process.* London: Sage.

Cullen, D. J., Civetta, J. M., Briggs, B. A. and Ferrara, L. C. (1974) Therapeutic intervention scoring system: a method for quantitative comparison of patient care. *Critical Care Medicine,* 2(2), pp. 57-60.

Cunningham, C. T., Quan, H., Hemmelgarn, B., Noseworthy, T., Beck, C. A., Dixon, E., Samuel, S., Ghali, W. A., Sykes, L. L. and Jetté, N. (2015) Exploring physician specialist response rates to web-based surveys. *BMC Medical Research Methodology,* 15(1).

Cunningham, J. J. (2018) New System to Manage Nurses' Workloads. *Defense AT&L*, pp. 22-26.

Davies, H. T. and Crombie, I. K. (2009) What are confidence intervals and p-values. *what is …? series.* Available at: http://www.bandolier.org.uk/painres/download/whatis/What_are_Conf_Inter.pdf [Accessed 24/8/19].

de Jong, A. E. E., Leeman, J. and Middelkoop, E. (2009) Development of a nursing workload measurement instrument in burn care. *Burns,* 35(7), pp. 942-948.

de Souza Urbanetto, J., Travi Canabarro, S., Prado Lima Figueiredo, A. E., Weber, G., Pereira dos Santos, R., Stein, K., Rodrigues, N. and Ramos Garcia, P. C. (2014) Correlation between the TISS-28 and NEMS indicators in an intensive care unit. *International Journal Of Nursing Practice,* 20(4), pp. 375-381.

Dean, E. (2018) Wales adopts safe staffing laws while the rest of the UK watches. *Nursing Standard*, 32(30), pp. 12-14.

Denzin, N. K. and Lincoln, Y. S. (2011) *The Sage handbook of qualitative research*. London: Sage.

Department of Health and Social Care (2000) *Comprehensive Critical Care: A Review of Adult Critical Care Services.* London: Department of Health and Social Care.

Dicenso, A., Cullum, N. and Ciliska, D. (1998) Implementing evidence-based nursing: some misconceptions. *Evidence-Based Nursing,* 1(2), pp. 38-39.

Dolp, R., Rehou, S., McCann, M. R. and Jeschke, M. G. (2018) Contributors to the length-of-stay trajectory in burn-injured patients. *Burns,* 44(8), pp. 2011-2017.

Donoghue, J., Decker, V., Mitten-Lewis, S. and Blay, N. (2001) Critical care dependency tool: monitoring the changes. *Australian Critical Care,* 14(2), pp. 56-63.

Driscoll, D. M. (1991) Burn dressings: a critical indicator for patient care classification in burn units. *Military medicine,* 156(12), p. 654.

Duffield, C., Diers, D., O'Brien-Pallas, L., Aisbett, C., Roche, M., King, M. and Aisbett, K. (2011) Nursing staffing, nursing workload, the work environment and patient outcomes. *Applied Nursing Research,* 24(4), pp. 244-255.

Duffield, C., Roche, M. and Merrick, E. T. (2006) Methods of measuring nursing workload in Australia. *Collegian (Royal College of Nursing, Australia),* 13(1), pp. 16-22.

Dumpel, H. (2004) The California Nursing Practice Act: safe staffing standards by scope, ratio, and acuity. *California Nurse,* 100(7), pp. 18-23.

Dunn, K. (2014) Big data what we can learn from iBID. In: *British Burn Association Annual meeting*. Chelmsford. British Burn Association.

Dunn, K. (2018) *Conversation re developement of iBID with Medical Director of iBID*. [Personal verbal communication] 16th October 2018.

Dunn, K. (2020) *Personal comunication with Medical Director of iBID regarding governance and quality*. [Personal verbal communication] 9th October 2020).

Dyamenahalli, K., Garg, G., Shupp, J. W., Kuprys, P. V., Choudhry, M. A. and Kovacs, E. J. (2019) Inhalation Injury: Unmet Clinical Needs and Future Research. *Journal of Burn Care & Research,* 40(5), pp. 570-584.

Edwardson, S. R. and Giovannetti, P. B. (1994) Nursing workload measurement systems. *Annual Review of Nursing Research,* 12, pp. 95-123.

Eldh, A. C., Fredriksson, M., Halford, C., Wallin, L., Dahlström, T., Vengberg, S. and Winblad, U. (2014) Facilitators and barriers to applying a national quality registry for quality improvement in stroke care. *BMC Health Services Research,* 14(1), p. 354.

Elliott, B., Chargualaf, K. A. and Patterson, B. (2017) Military to civilian nurse: Personal and professional reconstruction. *Journal of Clinical Nursing,* 26(9-10), pp. 1375-1384.

Encyclopedia.com *'Statistical Noise'.* Available at: https://www.encyclopedia.com/social-sciences/applied-and-social-sciences-magazines/statistical-noise [Accessed 22/4/2021].

Faculty of Intensive Care Medicine (2019) *Guidelines for the provision of intensive care services version 2*. London: Faculty of Intensive Care Medicine.

Fagerström, L. (2000) Expert validation of the Oulu Patient Classification -- a phase in the development of a new system of patient classification, RAFAELA. *Nordic Journal of Nursing Research & Clinical Studies,* 20(3), pp. 15-21.

Fagerström, L., Lønning, K. and Andersen, M. H. (2014) The RAFAELA system: a workforce planning tool for nurse staffing and human resource management. *Nursing Management,* 21(2), pp. 30-36.

Fasoli, D. R. and Haddock, K. S. (2010) Results of an integrative review of patient classification systems. *Annual Review of Nursing Research,* 28, p. 295.

Feller, I., Flora, J. D., Jr and Bawol, R. (1976) Baseline results of therapy for burned patients. *The Journal of the American Medical Association,* 236(17), pp. 1943-1947.

Feller, I., Tholen, D., Herteg, G. and Cornell, R. G. (1980) The Use of a National Burn Registry to Evaluate and Improve Patient Care. *Proceedings of the Annual Symposium on Computer Application in Medical Care,* 2, pp. 1069–1077.

Fenton, K. and Casey, A. (2015) A tool to calculate safe nurse staffing levels. *Nursing Times,* 111(3), pp. 12-14.

Field, A. (2018) *Discovering statistics using IBM SPSS statistics.* 5th edn. London: Sage.

Flynn, B., Kellagher, M. and Simpson, J. (2010) Workload and workforce planning: tools, education and training. *Nursing management,* 16(10), pp. 32-35.

Fore, A., Islim, F. and Shever, L. (2019) Data collected by the electronic health record is insufficient for estimating nursing costs: An observational study on acute care inpatient nursing units. *International Journal of Nursing Studies,* 91, pp. 101-107.

Forney, A., Student, S. I., Hatcher, R., Kwiatkowski, J. and Mokienko, K. (2003) *Analysis of Nursing Workload in the Trauma Burn ICU*. University of Michigan Health System.

Foster, A. (2018) *Transfer and storage of research-generated physical personal data*. Faculty of Health, Education and Life Sciences, Birmingham City University.

Francis, R. (2013) *Report of the Mid Staffordshire NHS Foundation Trust public inquiry.*The Stationary Office Available at: www.official-documents.gov.uk/document/hc1213/hc09/0947/0947.pdf.

Frost, M. H., Brueggen, C. and Mangan, M. (1997) Intervening with the psychosocial needs of patients and families: perceived importance and skill level. *Cancer nursing,* 20(5), pp. 350-358.

Fugulin, F. M. T., Rossetti, A. C., Ricardo, C. M., Possari, J. F., Mello, M. C. and Gaidzinski, R. R. (2012) Nursing care time in the Intensive Care Unit: evaluation of the parameters proposed in COFEN Resolution N degrees 293/04. *Revista latino-americana de enfermagem,* 20(2), pp. 325-332.

Garimella, R., Koenig, H. G. and Larson, D. L. (2017) Of These, Faith, Hope, and Love: Assessing and Providing for the Psychosocial and Spiritual Needs of Burn Patients. *Clinics in plastic surgery,* 44(4), pp. 893 - 902.

Gerrish, K. and Lacey, A. (2015) Research and development in Nursing. In: Kate Gerrish and Judith Lathlean, eds. *The research process in nursing*. Chichester: Wiley Blackwell.

Gerrish, K. and Lathlean, J. (2015) *The research process in nursing.* Chichester: Wiley Blackwell.

Gillespie, R., Gillespie, R., Carroll, W., Carroll, W., Dimick, A. R., Dimick, A., Haith, L., Haith, L., Heimbach, D., Heimbach, D., et al. (1987) Diagnosis-related groupings (DRGs) and wound closure: Roundtable discussion. *Journal of Burn Care and Rehabilitation,* 8(3), pp. 199-205.

Gillon, R. (1994) Medical-Ethics – Four principles plus attention to scope. *British Medical Journal,* 309(6948), pp. 184-188.

Glen, S. (2020) Inter-rater Reliability IRR: Definition, Calculation. Available at: https://www.statisticshowto.com/inter-rater-reliability/ [Accessed 29/10/2020].

Griffiths, P. and Needleman, J. (2019) Statistical significance testing and p-values: Defending the indefensible? a discussion paper and position statement. *International Journal of Nursing Studies,* 99.

Griffiths, P., Recio-Saucedo, A., Dall'Ora, C., Briggs, J., Maruotti, A., Meredith, P., Smith, G. B., Ball, J., Missed Care Study, G., Missed Care Study, G., et al. (2018) The association between nurse staffing and omissions in nursing care: A systematic review. *Journal of Advanced Nursing,* 74(7), pp. 1474-1487.

Griffiths, P., Saville, C., Ball, J., Chable, R., Dimech, A., Jones, J., Jeffrey, Y., Pattison, N., Saucedo, A. R., Sinden, N., et al. (2020a) The Safer

Nursing Care Tool as a guide to nurse staffing requirements on hospital wards: Observational and modelling study. *Health Services and Delivery Research,* 8(16).

Griffiths, P., Saville, C., Ball, J., Jones, J., Pattison, N. and Monks, T. (2020b) Nursing workload, nurse staffing methodologies and tools: A systematic scoping review and discussion. *International Journal of Nursing Studies,* 103. p. 103487

Guest, E., Griffiths, C. and Harcourt, D. (2018) A qualitative exploration of psychosocial specialists' experiences of providing support in UK burn care services. *Scars, Burns & Healing,* 4, p. 205951311876488.

Guo, P., Chiew, Y. S., Shaw, G. M., Shao, L., Green, R., Clark, A. and Chase, J. G. (2016) Clinical Activity Monitoring System (CATS): An automatic system to quantify bedside clinical activities in the intensive care unit. *Intensive & Critical Care Nursing,* 37, pp. 52-61.

Halgas, B., Bay, C. and Foster, K. (2018) A comparison of injury scoring systems in predicting burn mortality. *Ann Burns Fire Disasters,* 31(2), pp. 89-93.

Harrison, J. (2004) Addressing increasing patient acuity and nursing workload. *Nursing management,* 11(4), p. 20.

Hauter, J. (2012) Healthcare Governance in Britain, Germany and Sweden. Available at: https://www.e-ir.info/2012/04/28/healthcare-governance-in-britain-germany-and-sweden/ [Accessed 30/12/2020].

Hayes, A. (2007) KALPHA macro for SPSS. Available at: https://www.afhayes.com/spss-sas-and-r-macros-and-code.html Accessed 17/6/19].

Hayes, A. and Krippendorff, K. (2007) Answering the call for a standard reliability measure for coding data. *Communication Methods and Measures,,* 1, pp. 77-89.

Heale, R. and Shorten, A. (2017) Ethical context of nursing research. *Evidence Based Nursing,* 20(1), pp. 7-7.

Health Research Authority (2017a) *UK policy framework for health and social care research.*Health Research Authority Available at: https://www.hra.nhs.uk/planning-and-improving-research/policies-standards-legislation/uk-policy-framework-health-social-care-research/. [Accessed 10/3/18]

Health Research Authority (2017b) *Applying a proportionate approach to the process of seeking consent.*Health Research Authority, Available at: https://www.hra.nhs.uk/documents/283/applying-proportionate-approach-process-seeking-consent_R3gbJKn.pdf [Accessed 26/8/19].

Healthcare Financial Management Association (2014) *Measuring nursing dependency: background information for costing professionals*. Bristol: HFMA.

Heath, J., Shepherd, L. and Harcourt, D. (2018) Towards improved psychological outcomes for survivors of burn injuries. *Scars, Burns and Healing,* 4.

Helmer, F. T. (1986) Patient classification systems in burn care. *The Journal of burn care & rehabilitation,* 7(6), p. 511.

Helmer, F. T., Rieg, L., Winkler, J. and Gilstrop, H. (1987) Development of a patient classification system for burn units--a case study. *The Journal of burn care & rehabilitation,* 8(2), p. 117.

Herndon, D. N., ed. (2018) *Total burn care.* 5th edn. Edinburgh: Elsevier.

Hill, A. B. (1965) The environment and disease: association or causation? *Proceedings of the Royal Society of Medicine*, 58, pp. 295-300.

Hill, H., Evans, J. M. and Forbat, L. (2015) Nurses respond to patients' psychosocial needs by dealing, ducking, diverting and deferring: an observational study of a hospice ward. *BMC Nursing,* 14(1).

Hoi, S. Y., Ismail, N., Ong, L. C. and Kang, J. (2010) Determining nurse staffing needs: the workload intensity measurement system. *Journal of Nursing Managament,* 18(1), pp. 44-53.

Holloway, I. and Galvin, K. (2015) Grounded Theory. In: Kate Gerrish and Judith Lathlean, eds. *The Research Process in Nursing*. Chichester: Wiley Blackwell.

Hoogendoorn, M. E., Margadant, C. C., Brinkman, S., Haringman, J. J., Spijkstra, J. J. and de Keizer, N. F. (2020) Workload scoring systems in the Intensive Care and their ability to quantify the need for nursing time: A systematic literature review. *International Journal of Nursing Studies,* 101, pp. 103408-103408.

Houghton, C., Hunter, A. and Meskell, P. (2012) Linking aims, paradigm and method in nursing research. *Nurse Researcher.,* 20(2), pp. 34-39.

Hughes (1999) Nursing workload: an unquantifiable entity. *Journal of Nursing Managament,* 7(6), pp. 317-322.

Human Factors and Ergonomics Society (2021) *What is Human Factors and Ergonomics?* Available at: https://www.hfes.org/About-HFES/What-is-Human-Factors-and-Ergonomics [Accessed 6/3/2021].

Hurst, K. (2003) *Selecting and applying methods for estimating the size and mix of nursing teams : a systematic review of the literature commissioned by the Department of Health.* Leeds: Nuffield Institute for Health.

Hurst, K. (2010) Evaluating the strengths and weaknesses of NHS workforce planning methods. *Nursing Times*. 106(40), pp. 10-14

Hurst, K., Smith, A., Casey, A., Fenton, K., Scholefield, H. and Smith, S. (2008) Calculating staffing requirements. *Nursing management,* 15(4), pp. 26.

IBM Corp. (2017) IBM SPSS statistics for windows, Version 25.0. Armonk, NY: IBM Corp.

Intensive Care Society (2002) *Levels of Critical Care for Adult Patients.* Intensive Care Society.

international Burn Injury Database (2019) *iBID.* Available at: ttp://www.ibidb.org/ [Accessed 7/1/19].

Junttila, J. K., Koivu, A., Haatainen, K. and Nykänen, P. (2019) Nurse-Assessed Optimality of Workload - A Valid Measure for the Adequacy of Nursing Resources? *Online Journal of Nursing Informatics,* 23(3). Available at: https://search.ebscohost.com/login.aspx?direct=true&db=ccm&AN=140435662 [Accessed 26/4/2020].

Kalakoski, V., Henelius, A., Oikarinen, E., Ukkonen, A. and Puolamäki, K. (2019) Cognitive ergonomics for data analysis. Experimental study of cognitive limitations in a data-based judgement task. *Behaviour & Information Technology,* 38(10), pp. 1038-1047.

Kane, R. L., Shamliyan, T. A., Mueller, C., Duval, S. and Wilt, T. J. (2007) The association of registered nurse staffing levels and patient outcomes - Systematic review and meta-analysis. *Medical care,* 45(12), pp. 1195-1204.

Kim, Y., Kym, D., Hur, J., Yoon, J., Yim, H., Cho, Y. S. and Chun, W. (2017) Does inhalation injury predict mortality in burns patients or require redefinition? *Plos One,* 12(9), p. e0185195.

Kirby, E. and Hurst, K. (2014) Using a complex audit tool to measure workload, staffing and quality in district nursing. *British Journal of Community Nursing,* 19(5), pp. 219-223.

Kitchen, C. M. R. (2009) Nonparametric versus parametric tests of location in biomedical research. *American Journal of Ophthalmology,* 147(4), pp. 571-572.

Klein, M.B., Goverman, J., Hayden, D.L., Fagan, S.P., Mcdonald-Smith, G.P., Alexander, A.K., Gamelli, R.L., Gibran, N.S., Finnerty, C.C., Jeschke, M.G., Arnoldo, B., Wispelwey, B., Mindrinos, M.N., Xiao, W., Honari, S.E., Mason, P.H., Schoenfeld, D.A., Herndon, D.N. & Tompkins, R.G. (2014) Benchmarking Outcomes in the Critically Injured Burn Patient. *Annals of Surgery*, 259 (5), pp.833–841

Knol, R., Kelly, E., Paul, E., Cleland, H., Wellington-Boyd, A., Lambert, C. and Harms, L. (2020) The psychosocial complexities of acute burn patients in an Australian trauma hospital. *Burns,* 46(2), pp. 447-453.

Ko, Y., Park, B., Lee, H. and Kim, D. (2021) Developing and testing a Korean patient classification system for general wards based on nursing intensity. *Nursing Open*. 8(4).

Krippendorff, K. (2004) Reliability in content analysis: Some common misconceptions and recommendations. *Human Communication Research,* 30(3), pp. 411-433.

Krippendorff, K. (2011) Computing Krippendorff 's Alpha-Reliability. Available at: http://repository.upenn.edu/asc_papers/43 [Accessed 8/9/19].

Krishnan, P. (2018) A Philosophical Analysis of Clinical Decision Making in Nursing. *Journal of Nursing Education,* 57(2), pp. 73-78.

Laerd (2019) *Spearman's rank order correlation statistical guide.* Available at: https://statistics.laerd.com/statistical-guides/spearmans-rank-order-correlation-statistical-guide.php [Accessed 15/8/19].

Law Insider (2021) *Law Insider Dictionary.* Available at: https://www.lawinsider.com/dictionary/professional-judgement [Accessed 20/3/21].

Leary, A., Cook, R., Jones, S., Smith, J., Gough, M., Maxwell, E., Punshon, G. and Radford, M. (2016) Mining routinely collected acute data to reveal non-linear relationships between nurse staffing levels and outcomes. *British Medical Journal Open,* 6(12), p. e011177.

Leary, A., Tomai, B., Swift, A., Woodward, A. and Hurst, K. (2017) Nurse staffing levels and outcomes - mining the UK national data sets for insight. *International Journal of Health Care Quality Assurance,* 30(3), pp. 235-247.

Leaver, J., Cook, R., Dunn, K., Dee, P. and Ejtehadi, H. D. (2021) Comparison of the international Burn Injury Database nurse dependency tool with the Safer Nursing Care Tool: Observational study. *International Journal of Nursing Studies Advances,* 3, p. 100018.

Leaver, J. and Thomas, C. (2012) Care of the infant or child with thermal injury. In: Michaela. Dixon and Doreen. Crawford, eds. *Paediatric Intensive Care Nursing*. Oxford: Wiley - Blackwell.

Lefering, R. (2014) Strategies for comparative analyses of registry data. *Injury,* 45 Suppl 3, pp. S83-88.

Legg, M. J. (2011) What Is Psychosocial Care and How Can Nurses Better Provide It to Adult Oncology Patients. *Australian Journal of Advanced Nursing, The,* 28(3), pp. 61-67.

Lingard, L., Albert, M. and Levinson, W. (2008) Qualitative Research: Grounded Theory, Mixed Methods, and Action Research. *British Medical Journal,* 337(7667), pp. 459-461.

Lund, C. C. and Browder, N. C. (1944) The estimation of areas of burns. *Surgery, Gynaecology, Obstetrics.,* 79, pp. 352-358.

Machin, D., Campbell, M.J., Tan, S.B. and Tan, S.H. (2009) *Sample size tables for clinical studies.* 3rd Edn. Chichester. John Wiley & Sons.

Madni, T. D., Nakonezny, P. A., Imran, J. B., Barrios, E., Rizk, P., Clark, A. T., Cunningham, H. B., Taveras, L., Arnoldo, B. D., Cripps, M. W., et al. (2019) Prospective Analysis of Operating Room and Discharge Delays in a Burn Center. *Journal of Burn Care & Research,* 40(3), pp. 281-286.

Manetti, W. (2019) Sound clinical judgment in nursing: A concept analysis. *Nursing Forum,* 54(1), pp. 102-110.

Mark, B. A. and Harless, D. W. (2011) Adjusting for patient acuity in measurement of nurse staffing: two approaches. *Nursing Research,* 60(2), pp. 107-114.

Marsden, N., Battle, C., Combellack, E., Sabra, A., Morris, K., Dickson, W., Whitaker, I. and Evans, P. A. (2016) The impact of socio-economic deprivation on burn injury: a nine-year retrospective study of 6441 patients. *Burns,* 42(2), pp. 446-452.

Maxwell, E. and Leary, A. (2020) In praise of professional judgement. *British Medical Journal*.

McCoy, E. (2017) Understanding the Intention-to-treat Principle in Randomized Controlled Trials. *Western Journal of Emergency Medicine,* 18(6), pp. 1075-1078.

McDonald, J. H. (2014) *Handbook of Biological Statistics.* 3rd edn. Baltimore, Maryland: Sparky House Publishing.

Mehta, R. and Chinthapalli, K. (2019) Glasgow coma scale explained. *British Medical Journal,* 365: l1296.

Mercel, A., Tsihlis, N. D., Maile, R. and Kibbe, M. R. (2020) Emerging therapies for smoke inhalation injury: a review. *Journal of Translational Medicine,* 18, pp. 1-16.

Merrifield, N. (2018) Nurse training aims to combat incorrect use of staffing tool. *Nursing Times,* 114(2), 8.

Mersin, S., Demiralp, M. and Öksüz, E. (2019) Addressing the psychosocial needs of patients: Challenges for nursing students. *Perspectives in Psychiatric Care,* 55(2), pp. 269-276.

Miranda, D. R., de Rijk, A. and Schaufeli, W. (1996) Simplified Therapeutic Intervention Scoring System: the TISS-28 items results from a multicenter study. *Critical Care Medicine,* 24(1), pp. 64-73.

Miranda, D. R., Moreno, R. and Iapichino, G. (1997) Nine equivalents of nursing manpower use score (NEMS). *Intensive Care Medicine,* 23(7), pp. 760-765.

Miranda, D. R., Nap, R., de Rijk, A., Schaufeli, W., Iapichino, G., Grp, T. W. and System, T. W. G. T. I. S. (2003) Nursing activities score. *Critical Care Medicine,* 31(2), pp. 374-382.

Mitchell, G., Cousins, C., Burrows, R. and Cousins, G. (2017) A review of safe-staffing models and their applicability to care homes. *Journal of Nursing Management,* 25(2), pp. 157-162.

Mittmann, N., Seung, S. J., Pisterzi, L. F., Isogai, P. K. and Michaels, D. (2008) Nursing workload associated with hospital patient care. *Disease Management & Health Outcomes,* 16(1), pp. 53-61.

Molter, N. C. (1990) Workload management system for nurses: application to the burn unit. *Journal of Burn Care & Rehabilitation,* 11(3), pp. 267-274.

Moores, B. and Barr, L. (1982) Nurse/patient dependency revisited (somewhat apologetically). *Journal of Advanced Nursing (Wiley-Blackwell),* 7(3), pp. 269-271.

Morgan, D. L. (2014) Pragmatism as a Paradigm for Social Research. *Qualitative Inquiry*.

Morris, R., MacNeela, P., Scott, A., Treacy, P. and Hyde, A. (2007) Reconsidering the conceptualization of nursing workload: literature review. *Journal of Advanced Nursing,* 57(5), pp. 463-471.

Muehler, N., Oishi, J., Specht, M., Rissner, F., Reinhart, K. and Sakr, Y. (2010) Serial measurement of Therapeutic Intervention Scoring System-28 (TISS-28) in a surgical intensive care unit. *Journal of Critical Care,* 25(4), pp. 620-627.

Mueller, M., Lohmann, S., Strobl, R., Boldt, C. and Grill, E. (2010) Patients' functioning as predictor of nursing workload in acute hospital units providing rehabilitation care: a multi-centre cohort study. *BMC Health Services Research,* 10, pp. 295-295.

Mukaka, M. M. (2012) Statistics corner: A guide to appropriate use of correlation coefficient in medical research. *Malawi Medical Journal,* 24(3), pp. 69-71.

Musy, S. N., Endrich, O., Leichtle, A. B., Griffiths, P., Nakas, C. T. and Simon, M. (2021) The association between nurse staffing and inpatient mortality: A shift-level retrospective longitudinal study. *International Journal of Nursing Studies,* 120, p. 103950.

Myers, J. (2009) *B levels dependency scoring*. [email]16/12/2009).

Myny, D., Van Goubergen, D., Gobert, M., Vanderwee, K., Van Hecke, A. and Defloor, T. (2011) Non-direct patient care factors influencing nursing workload: a review of the literature. *Journal of Advanced Nursing,* 67(10), pp. 2109-2129.

Myny, D., Van Hecke, A., De Bacquer, D., Verhaeghe, S., Gobert, M., Defloor, T. and Van Goubergen, D. (2012) Determining a set of measurable and relevant factors affecting nursing workload in the acute care hospital setting: a cross-sectional study. *International Journal of Nursing Studies,* 49(4), pp. 427-436.

Nassiff, A., de Araújo, T. R., Gonçalves Menegueti, M., Bellissimo-Rodrigues, F., Basile-Filho, A. and Laus, A. M. (2018) nursing workload and patient mortality at an intensive care unit. *Texto & Contexto Enfermagem,* 27(4), pp. 1-7.

National Burn Care Group (2004) *Burn Care Standards.* Available at: https://www.ibidb.org/download/nbcg-burn-care-standards-2004/ [Accessed 8/1/19].

National Burn Care Review Committee (2001) *Strategy and standards for burn care*. London: British Burn Association.

National Burn Operational Delivery Network Group (2021) *Item 10: Nurse staffing levels in burns*. *Notes of National Burn Operational Delivery*

Network Group meeting 21st July 2021. National Burn Operational Delivery Network Group.

National Commissioning Board (2013) *NHS standard contract for specialised burns care (all ages) schedule 2 – the services a. Service specifications.* NHS. England Available at: https://www.england.nhs.uk/commissioning/spec-services/npc-crg/group-d/d02/ [Accessed 21/12/2020].

National Coordinating Group for Paediatric Intensive Care (1997) *Paediatric Intensive Care "A framework for the future".* London: Department of Health.

National Health Service (2019) *NHS Long Term Plan.* Available at: https://www.longtermplan.nhs.uk/publication/nhs-long-term-plan/ [Accessed 2/1/2021].

National Institute for Health and Care Excellence (2014) *Safe staffing for nursing in adult inpatient wards in acute hospitals [SG1].* Available at: http://www.nice.org.uk/sg1 [Accessed16/8/2021]

National Institute for Health Research Dissemination Centre (2019) *Staffing on Wards: Making decisions about healthcare staffing, improving effectiveness and supporting staff to care well*. National Institute for Health Research. Available at: https://content.nihr.ac.uk/nihrdc/themedreview-03553-SW/FINAL-Ward-Staffing-for-WEB.pdf [Accessed 11/5/2020].

National Network for Burn Care (2012) *National Burn Care Referal Guidance*. National Network for Burn Care.

National Network for Burn Care (2013) *National Burn Care Standards.* National Network for Burn Care.

National Quality Board (2018) *Safe, sustainable and productive staffing. An improvement resource for adult inpatient wards in acute hospitals*. 1 NHS Improvements. Available at: https://www.england.nhs.uk/wp-content/uploads/2021/05/safe-staffing-adult-in-patient.pdf [Accessed16/8/2021]

Needleman, J., Buerhaus, P., Mattke, S., Stewart, M. and Zelevinsky, K. (2002) Nurse-staffing levels and the quality of care in hospitals. *New England Journal of Medicine,* 346(22), pp. 1715-1722.

Nelson, E. C., Dixon-Woods, M., Batalden, P. B., Homa, K., Van Citters, A. D., Morgan, T. S., Eftimovska, E., Fisher, E. S., Ovretveit, J., Harrison, W., et al. (2016) Patient focused registries can improve health, care, and science. *BMJ,* 354, p. i3319.

Nelson, R. (2002) Major theories supporting health care informatics. *Health care informatics: An interdisciplinary approach*, pp. 3-27.

Nelson, R. (2018) Informatics: evolution of the Nelson data, information, knowledge and wisdom model: part 1. *OJIN: The Online Journal of Issues in Nursing,* 23(3).

Nelson, R. and Staggers, N. (2018) *Health informatics : an interprofessional approach.* 2nd edn. St Louis: Elsevier.

NHS England (2019) *NHS Commissioning, specialised services quality dash board.* Available at: https://www.england.nhs.uk/commissioning/spec-services/npc-crg/spec-dashboards/ [Accessed 16/7/19].

NHS Institute for Innovation and Improvement (2012) *The NHS Institute Safer Nursing Care Tool Web Application Report*. NHS Institute for Innovation and Improvement.

Nisavic, M., Nejad, S. H. and Beach, S. R. (2017) Intentional Self-inflicted Burn Injuries: Review of the Literature. *Psychosomatics,* 58(6), pp. 581-591.

Nobre, I. E. A. M., Barros, L. M., Gomes, M. L. S., da Silva, L. A., da Silva Lima, I. C. and Caetano, J. Á. (2017) Fugulin patient classification system: medical clinic assistance profile. *Journal of Nursing UFPE / Revista de Enfermagem UFPE,* 11(4), pp. 1736-1742.

Nulty, D. D. (2008) The adequacy of response rates to online and paper surveys: what can be done? *Assessment & Evaluation in Higher Education,* 33(3), pp. 301-314.

Nursing and Midwifery Council (2018) *The Code. Professional standards of Practice and behaviour for nurses, midwives and nursing associates.* London: Nursing and Midwifery Council, Available at: https://www.nmc.org.uk/standards/code/ [Accessed 16/11/19].

Nwomeh, B. C., Lowell, W., Renae Haley, Kathy and Ameh, E. A. (2006) History and development of trauma registry: lessons from developed to developing countries. *World Journal of Emergency Surgery,* 1.

O'Reilly, G. M., Gabbe, B., Moore, L. and Cameron, P. A. (2016) Classifying, measuring and improving the quality of data in trauma registries: A review of the literature. *Injury,* 47(3), pp. 559-567.

O'Sullivan, D. and Mansour, M. (2015) The Nurse's role in managing psychological and emotional impact on women with breast cancer. *Clinical Nursing Studies,* 3(4), pp. 29-35.

Oh, H. and Seo, W. (2008) Validity for the critical patients severity classification system developed by the Korean Clinical Nurse Association. *Australian Journal of Advanced Nursing,* 25(3), pp. 49-57.

Osler, T., Glance, L. G. and Hosmer, D. W. (2010) Simplified estimates of the probability of death after burn injuries: extending and updating the baux score. *Journal of Trauma,* 68(3), pp. 690-697.

Overholser, B. R. and Sowinski, K. M. (2008) Biostatistics primer: part 2. *Nutrition in Clinical Practice,* 23(1), pp. 76-84.

Padilha, K. G., Sousa, R. M. C., Kimura, M., Miyadahira, A. M. K., da Cruz, D. A. L. M., Vattimo, M. d. F., Fusco, S. R. G., de Campos, M. E. F., Mendes, E. M. T. and Mayor, E. R. C. (2007) Nursing workload in intensive care units: A study using the Therapeutic Intervention

Scoring System-28 (TISS-28). *Intensive & Critical Care Nursing,* 23(3), pp. 162-169.

Pallant, J. (2010) *SPSS survival manual: a step by step guide to data analysis using SPSS.* 4th edn. Maidenhead: Open University Press/McGraw-Hill.

Pandis, N. (2013) Confidence intervals rather than P values. *American Journal of Orthodontics and Dentofacial Orthopedics,* 143(2), pp. 293-294.

Panunto, M. R. and Guirardello, E. B. (2009) Nursing workload at a gastroenterology unit. *Revista Latino-Americana de Enfermagem (RLAE),* 17(6), pp. 1009-1014.

Pardesi, O. and Fuzaylov, G. (2017) Pain Management in Pediatric Burn Patients. *Journal of Burn Care & Research,* 38(6), pp. 335-347.

Pasquale, F. (2019) Professional Judgment in an Era of Artificial Intelligence and Machine Learning. *boundary 2,* 46(1), pp. 73-101.

Patrician, P. A., Loan, L., McCarthy, M., Fridman, M., Donaldson, N., Bingham, M. and Brosch, L. R. (2011) The Association of Shift-Level Nurse Staffing With Adverse Patient Events. *The Journal of Nursing Administration,* 41(2), pp. 64-70.

Peck, M. D. (2012) Epidemiology of burns throughout the World. Part II: Intentional burns in adults. *Burns,* 38(5), pp. 630-637.

Peck, M., Falk, H., Meddings, D., Sugerman, D., Mehta, S. and Sage, M. (2016) The design and evaluation of a system for improved surveillance and prevention programmes in resource-limited settings using a hospital-based burn injury questionnaire. *Injury Prevention,* 22 Suppl 1, pp. i56-62.

Pehlivan, T. and Küçük, L. (2016) Skills of Oncology Nurses in Diagnosing the Psychosocial Needs of the Patients. *International Journal of Caring Sciences,* 9(2), p. 658.

Perin, G., Ching, R. C. and Anwar, M. U. (2016) Outpatient workload in the NHS: A new challenge for the burn services? *Burns,* 42(8), pp. 1699-1703.

Perroca, M. G. (2011) Development and Content Validity of the New Version of a Patient Classification Instrument. *Revista Latino-Americana de Enfermagem (RLAE),* 19(1), pp. 58-66.

Pett, M. A. a. (2016) *Nonparametric statistics for health care research : statistics for small samples and unusual distributions.* 2nd edn. California: Sage Publications, Inc.

Pipino, L. L., Lee, Y. W. and Wang, R. Y. (2002) Data quality assessment. *Communications of the Association for Computing Machinery,* 45(4), pp. 211–218.

Polit, D. F. and Beck, C. T. (2009) *Essentials of nursing research: appraising evidence for nursing practice.* London: Lippincott Williams & Wilkins.

Prescott, P. A. and Soeken, K. L. (1996) Measuring nursing intensity in ambulatory care. Part I: Approaches to and uses of patient classification systems. *Nursing economic,* 14(1), pp. 14-33.

Pruitt, B. A. and Wolf, S. E. (2009) An historical perspective on advances in burn care over the past 100 years. *Clinics in Plastic Surgery,* 36(4), pp. 527-545.

R Core Team (2017) R: A language and environment for statistical computing. Available at: https://www.R-project.org/.

Rafferty, A. M., Clarke, S. P., Coles, J., Ball, J., James, P., Mckee, M. and Aiken, L. H. (2007) Outcomes of variation in hospital nurse staffing in English hospitals: Cross-sectional analysis of survey data and discharge records. *International Journal of Nursing Studies,* 44(2), pp. 175-182.

Randall, W. S. and Mello, J. E. (2012) Grounded Theory: An Inductive Method for Supply Chain Research. *International Journal of Physical Distribution & Logistics Management,* 42(8), pp. 863 - 880.

Ranstam, J. (2012) Why the P-value is bad and confidence intervals a better alternative. *Osteoarthritis and Cartilage,* 20, pp. 805-808.

Rauhala, A. and Fagerström, L. (2004) Determining optimal nursing intensity: the RAFAELA method. *Journal of Advanced Nursing,* 45(4), pp. 351-359.

Ravat, F., Percier, L., Akkal, R., Morris, W., Fontaine, M., Payre, J. and Poupelin, J.-C. (2014) Working time and workload of nurses: The experience of a burn center in a high income country. *Burns,* 40(6), pp. 1133-1140.

Reid, B., Kane, K. and Curran, C. (2008) District nursing workforce planning: a review of the methods. *British journal of community nursing,* 13(11), pp. 525-530.

Richardson, P. and Mustard, L. (2009) The management of pain in the burns unit. *Burns,* 35(7), pp. 921-936.

Rieder, K., Vail, J., Norton, D. and Jackson, S. (1985) *Workload management system for murses educational workbook.* US department of defence medical facility.

Rivera, K. (2017) *A Comparison of a Standardized Method of Identifying Nursing Staff Needs with Measures of Nursing Staff Needs by Patient Acuity*. Doctoral Thesis. William Paterson University of New Jersey.

Robertson, R. a., Wenzel, L. a., Thompson, J. a. and Charles, A. a. (2017) *Understanding NHS financial pressures : how are they affecting patient care?* England: The Kings Fund.

Robson, C. and McCartan, K. (2016) *Real world research : a resource for users of social research methods in applied settings.* 4th edn. Wiley.

Rothen, H. U., Küng, V., Ryser, D. H., Zürcher, R. and Regli, B. (1999) Validation of "nine equivalents of nursing manpower use score" on an independent data sample. *Intensive Care Medicine,* 25(6), pp. 606-611.

Rowan, M. P., Cancio, L. C., Elster, E. A., Burmeister, D. M., Rose, L. F., Natesan, S., Chan, R. K., Christy, R. J. and Chung, K. K. (2015) Burn wound healing and treatment: review and advancements. *Critical Care,* 19(1).

Royal College of Nursing (2010) *Guidance on safe nurse staffing levels in the UK.* London: Royal College of Nursing.

Royal College of Nursing (2019) *Staffing for safe and effective care: RCN campaigning in the UK*. London: Royal College of Nursing.

Sahin, I., Ozturk, S., Alhan, D., Açikel, C. and Isik, S. (2011) Cost analysis of acute burn patients treated in a burn centre: the Gulhane experience. *Annals of Burns and Fire Disasters,* 24(1), pp. 9-13.

Salati, M., Brunelli, A., Dahan, M., Rocco, G., Van Raemdonck, D. E., Varela, G. and Committee, E. S. o. T. S. D. (2011) Task-independent metrics to assess the data quality of medical registries using the European Society of Thoracic Surgeons (ESTS) Database. *European Journal of Cardiothoracic Surgery,* 40(1), pp. 91-98.

Salkind, N. J. (2017) *Statistics for people who (think they) hate statistics.* 4th edn. Los Angeles: SAGE Publications, Inc.

Santos, D. C., Barros, F., Gomes, N., Guedes, T. and Maia, M. (2017) The effect of comorbidities and complications on the mortality of burned patients. *Annals of burns and fire disasters,* 30(2), p. 103.

Sariyar, M., Borg, A., Heidinger, O. and Pommerening, K. (2013) A practical framework for data management processes and their evaluation in population-based medical registries. *Informatics for Health and Social Care,* 38(2), pp. 104-119.

Saunders, M. N. K., Thornhill, A. and Lewis, P. (2012) *Research methods for business students*. England: Pearson Education Limited.

Saville, C. and Griffiths, P. (2021a) How effective and cost-effective is the Safer Nursing Care Tool? *Nursing Times(online),* 117(3), pp. 29-30.

Saville, C. and Griffiths, P. (2021b) Ward staffing guided by a patient classification system: A multi-criteria analysis of "fit" in three acute hospitals. *Journal of Nursing Management*. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1111/jonm.13341 [Accessed 16/8/2021]

Saville, C., Monks, T., Griffiths, P. and Ball, J. E. (2020) Costs and consequences of using average demand to plan baseline nurse staffing levels: a computer simulation study. *BMJ quality & safety*, pp. bmjqs-2019-0105.

Saville, C. E., Griffiths, P., Ball, J. E. and Monks, T. (2019) How many nurses do we need? A review and discussion of operational research techniques applied to nurse staffing. *International Journal of Nursing Studies,* 97, pp. 7-13.

Schober, P., Boer, C. and Schwarte, L. A. (2018) Correlation Coefficients: Appropriate Use and Interpretation. *Anesthesia and Analgesia,* 126(5), pp. 1763-1768.

Scott, A., Jeon, S.-H., Joyce, C. M., Humphreys, J. S., Kalb, G., Witt, J. and Leahy, A. (2011) A randomised trial and economic evaluation of the effect of response mode on response rate, response bias, and item non-response in a survey of doctors. *BMC Medical Research Methodology,* 11(1), p. 126.

Scott, C. (2003) *Setting safe nurse staffing levels. An exploration of the issues.* London: Royal College of Nursing.

Scott, P. A., Matthews, A. and Kirwan, M. (2014) What is nursing in the 21st century and what does the 21st century health system require of nursing? *Nursing Philosophy,* 15(1), pp. 23-34.

Sedgwick, P. (2013) P values or confidence intervals? *BRITISH MEDICAL JOURNAL*. Available at: 10.1136/bmj:f3212 [Accessed 24/8/19].

Sengstack, P. and Boicey, C. (2015) *Mastering Informatics: A Healthcare Handbook for Success.* Sigma Theta Tau International.

Shannon, C. E. and Weaver, W. (1949) *The Mathematical Theory of Communication.* The University of Illinois Press.

Sjöberg, F., Danielsson, P., Andersson, L., Steinwall, I., Zdolsek, J., Ostrup, L. and Monafo, W. (2000) Utility of an intervention scoring system in documenting effects of changes in burn treatment. *Burns,* 26(6), pp. 553-559.

Smith, S., Casey, A., Hurst, K., Fenton, K. and Scholefield, H. (2009) Developing, testing and applying instruments for measuring rising dependency-acuity's impact on ward staffing and quality. *International journal of health care quality assurance,* 22, pp. 30-39.

Smolle, C., Cambiaso-Daniel, J., Forbes, A. A., Wurzer, P., Hundeshagen, G., Branski, L. K., Huss, F. and Kamolz, L.-P. (2017) Recent trends in burn epidemiology worldwide: A systematic review. *Burns,* 43(2), pp. 249-257.

Snowden, A., Donnell, A. and Duffy, T. D. (2010) *Pioneering theories in nursing.* London: Quay Books.

Stafseth, S. K., Solms, D. and Bredal, I. S. (2011) The characterisation of workloads and nursing staff allocation in intensive care units: A descriptive study using the Nursing Activities Score for the first time in Norway. *Intensive & Critical Care Nursing,* 27(5), pp. 290-294.

Stafseth, S. K., Tønnessen, T. I. and Fagerström, L. (2018) Association between patient classification systems and nurse staffing costs in intensive care units: An exploratory study. *Intensive & Critical Care Nursing,* 45, pp. 78-84.

Stoltzfus, J. C. (2011) Logistic regression: a brief primer. *Academic Emergency Medicine,* 18(10), pp. 1099-1104.

Stylianou, N., Buchan, I. and Dunn, K. W. (2014) A model of British in-hospital mortality among burns patients. *Burns,* 40(7), pp. 1316-1321.

Stylianou, N., Buchan, I. and Dunn, K. W. (2015) A review of the international Burn Injury Database (iBID) for England and Wales: descriptive analysis of burn injuries 2003-2011. *British Medical Journal Open,* 5(2), p. e006184.

Sullivan, G. and Feinn, R. (2012) Using Effect Size—or Why the P Value Is Not Enough. *Journal of Graduate Medical Education,* 4, pp. 279–282.

Surmiak, A. (2019) Should we maintain or break confidentiality? The choices made by social researchers in the context of law violation and harm. *Journal of Academic Ethics*.

Swan-Mahony, A., Sadler, L. S. and Dixon, J. (2018) The Development and Validation of an Acuity Tool in a Pediatric Outpatient Burn Clinic. *The Journal of Nursing Administration,* 48(7-8), pp. 375-382.

Swiger, P. A., Vance, D. E. and Patrician, P. A. (2016) Nursing workload in the acute-care setting: A concept analysis of nursing workload. *Nursing outlook,* 64(3), pp. 244-254.

Tabachnick, B. G. and Fidell, L. S. (2014) *Using multivariate statistics.* 6th edn. Harlow: Pearson Education.

Tashakkori, A. and Teddlie, C. eds. (2010) *Sage handbook of mixed methods in social & behavioral research.* 2nd edn. Los Angeles ; London: SAGE.

Taylor, F. W. (2012) *The Principles of Scientific Management.* Auckland: The Floating Press.

Taylor, P. C. and Medina, M. N. D. (2013) Educational Research Paradigms: From Positivism to multiparadigmatic. *The Journal of Meaning-Centered Education.,* 1(2).

Taylor, S. L., Sen, S., Greenhalgh, D. G., Lawless, M., Curri, T. and Palmieri, T. L. (2017) Not all patients meet the 1day per percent burn rule: A simple method for predicting hospital length of stay in patients with burn. *Burns,* 43(2), pp. 282-289.

Telford, W. (1979) Determining nursing establishments. *Health services manpower review,* 5(4), pp. 11-17.

The Education Committee of the Australian and New Zealand Burn Association (2012) Emergency Management of Severe Burns Course Manual - UK Edition. 15th ed. London: British Burn Association.

The Joint Commission (2020) *The Joint Commission: over a century of quality and safety.* Available at: https://www.jointcommission.org/-/media/tjc/documents/about-us/tjc-history-timeline-through-2019-pdf.pdf [Accessed 25/4/2020].

The Shelford Group (2014) *Safer Nursing Care Tool. Implementation Resource Pack*. The Shelford Group

The Shelford Group (2019) *the Safer Nursing Care Tool specification document - Adult inpatient wards in acute hospitals.* Available at:

http://quicktech.imperialinnovations.co.uk/i/Surveys_Questionnaires/SNCT_adult_inpatient_wards.html [Accessed 5/6/19].

Tobiasen, J., Hiebert, J. M. and Edlich, R. F. (1982) The abbreviated burn severity index. *Ann Emerg Med,* 11(5), pp. 260-262.

Tubbs-Cooley, H. L., Mara, C. A., Carle, A. C. and Gurses, A. P. (2018) The NASA Task Load Index as a measure of overall workload among neonatal, paediatric and adult intensive care nurses. *Intensive & Critical Care Nursing,* 46, pp. 64-69.

Turner, K. M., Winder, R., Campbell, J. L., Richards, D. A., Gandhi, M., Dickens, C. M. and Richards, S. (2017) Patients' and nurses' views on providing psychological support within cardiac rehabilitation programmes: a qualitative study. *British Medical Journal Open,* 7(9), p. e017510.

Twigg, D. and Duffield, C. (2009) A review of workload measures: a context for a new staffing methodology in Western Australia. *International Journal of Nursing Studies,* 46(1), pp. 131-139.

UK Government (2018) *The Government response to the Health and Social Care Select Committee Second Report of Session 2017-19, 'The Nursing Workforce'.* London: Her Majesty's Stationary Office.

Vafaee-Najar, A., Amiresmaili, M. R., Nekoie-Moghadam, M. and Tabatabaee, S. S. (2018) The design of an estimation norm to assess nurses required for educational and non-educational hospitals using workload indicators of staffing need in Iran. *Human resources for health,* 16.

Van Stralen, K. J., Dekker, F. W., Zoccali, C. and Jager, K. J. (2012) Measuring Agreement, More Complicated Than It Seems. *Nephron Clinical Practice,* 120(3), pp. c162-c167.

Viney, C., Poxon, I., Jordan, C. and Winter, B. (1997) Does the APACHE II scoring system equate with the Nottingham Patient Dependency System? Can these systems be used to determine nursing workload and skill mix? *Nursing in critical care,* 2(2), p. 59.

Waite, R. and Hirsh, W. (1986) Not another dependency study. *Senior Nurse,* 4(1), pp. 29-32.

Wang, Z.-W., Zheng, J., You, L.-M., Wang, Y.-X., Gao, M.-R. and Guan, X.-D. (2018) Evaluation of the simplified therapeutic intervention scoring system: Chinese version. *Intensive & critical care nursing,* 45, pp. 85-90.

Ward, J., Phillips, G., Radotra, I., Smailes, S., Dziewulski, P., Zhang, J. and Martin, N. (2018) Frailty: an independent predictor of burns mortality following in-patient admission. *Burns,* 44(8), pp. 1895-1902.

Ward, V. (2016) Why, whose, what and how? A framework for knowledge mobilisers. *Evidence and Policy,* 13(3), pp. 477 - 497.

Warren, L. R., Clarke, J., Arora, S. and Darzi, A. (2019) Improving data sharing between acute hospitals in England: an overview of health record system distribution and retrospective observational analysis of inter-hospital transitions of care. *British Medical Journal Open,* 9(12), p. e031637.

Watson, P. M., Lower, M. S., Wells, S.A., Farrah, S.J. and Jarrell, c.(1991) Discovering what nurses do and what it costs. *Nursing Management,* 22(5), pp. 38-40, 42-45.

Weaver, K. and Olson, J. k. (2006) Understanding paradigms used for nursing research. *Journal of Advanced Nursing,* 53((4)), pp. 459–469.

West, E., Barron, D. N., Harrison, D., Rafferty, A. M., Rowan, K. and Sanderson, C. (2014) Nurse staffing, medical staffing and mortality in Intensive Care: An observational study. *International Journal of Nursing Studies,* 51(5), pp. 781-794.

Whitaker, I. S., Shokrollahi, K. and Dickson, W. A. (2019) *Burns (Oxford Specialist Handbooks in Surgery).* Oxford: Oxford University Press.

Williams, Z. R. and Karpelowsky, J. (2019) A narrative systematic review of medical registries. *Journal of Child and Adolescent Health,* 3(1), pp. 1-6.

Wisely, J. (2013) The impact of psychological distress on the healing of burns. *Wounds UK,* 9(3), pp. 14-17.

Wisely, J. A., Hoyle, E., Tarrier, N. and Edwards, J. (2007) Where to start?. Attempting to meet the psychological needs of burned patients. *Burns,* 33(6), pp. 736-746.

World Health Organisation (2001) *International Classification of Functioning, Disability and Health.* Geneva: World Health Organisation.

World Health Organisation (2018) *Global burn registry released to the public.* Available at: https://www.who.int/news/item/19-01-2018-global-burn-registry [Accessed 2/8/21].

Yamase, H. (2003) Development of a comprehensive scoring system to measure multifaceted nursing workloads in ICU. *Nursing & health sciences*, 5(4), pp. 299-308.

Zaletel, M. and Kralj, M. eds.(2015) *Methodological guidelines and recommendations for efficient and rational governance of patient registries.* Ljubljana, Slovenia: National Institute of Public Health,. Available through: https://ec.europa.eu/health/sites/health/files/ehealth/docs/patient_registries_guidelines_en.pdf [Accessed 13/7/20].

Appendices

Appendix A – Adult Burn Services Referral Threshold Criteria (National Network for Burn Care, 2012: 6)

Criteria		Burn Facility Threshold	Burn Unit Threshold	Burn Centre Threshold	Note
TBSA	Refer	≥3%<10% (includingthose with inhalation injury)	≥10%<40% ≥10%<25 % with inhalation injury	≥40% ≥25% with inhalation injury	*The minimum indication for Inhalation Injury is defined as* *- Visual evidence of suspected upper airway smoke inhalation, laryngoscopic and/or bronchscopic evidence of tracheal or more distal contamination/injury or unconsciousat scene with suspicion of inhalationor raised COHb.* *If there are any concerns regarding inhalation injury with a patient with any size burn then it should be discussed with a Burn Care Centre*
	Discuss			≥25%	*Special Consideration should be given to referring patients >65 yrswith ≥25% TBSA (especially wherethere are co-morbidities) to the Burn Care Centre*
Depth	Refer	Any full thickness burns	≥5%<40% if non-blanching		*All burns that are not blanching should be referred to a specialised burn service*
Site	Refer		Any significant burn tospecial areas (hands, feet, face, perineum, genitalia) Any non-blanching circumferential burn		*"Significant" can mean any injurieswhere the referrer feels that greater MDT expertise is required*
	Discuss	Any burnto special areas (hands, feet, face, perineum, genitalia)			
Mechanism	Discuss	Any chemical, electrical, friction burn. Any cold injury			

Criteria		Burn Facility Threshold	Burn Unit Threshold	Burn Centre Threshold	Note
Other Factors	Refer	Any burn not healed in 2 weeks.	Any predicted or actual need for HDU or ITU level care		
			Any burn with suspicionof non-accidental injury should be referred to a Burn Unit / Centre for expert assessmen twithin 24 hours		
			Any burn with suspicionof non-accidental injury should be referred to a Burn Unit / Centre for expert assessment within 24 hours	All patients with MajorTrauma + Burn Injury (post treatment within Major Trauma Centre) where the burn injury meets centre level thresholds. Patients assessed as requiring end of life care shouldbe discussed with a Consultant Burn Specialist at a Burn Centre (to discuss theappropriateness of local palliative care versus transfer to a centre).	*The treatment of patients with Major Trauma + Burn Injury should be agreed between the Trauma service and the appropriate specialisedburn service (in accordance with the TBSA,Depth, Site and Mechanism criteria listed above)*

Appendix B – Ethics Approval Letters

HRA approval letter for part one of the research and the BCU letters of approval and sponsorship agreement.

Ymchwil Iechyd a Gofal Cymru
Health and Care Research Wales

NHS
Health Research Authority

Email: hra.approval@nhs.net
Research-permissions@wales.nhs.uk

Mrs Jane Leaver
Senior Lecturer
Birmingham City University
BCU City south campus
Westbourne Road
Birmingham
B15 3TN

26 June 2018

Dear Mrs Leaver

HRA and Health and Care Research Wales (HCRW) Approval Letter

Study title:	**Validation of the international Burn Injury Database (iBID) nurse dependency variables**
IRAS project ID:	**240626**
Sponsor	**Birmingham City University**

I am pleased to confirm that HRA and Health and Care Research Wales (HCRW) Approval has been given for the above referenced study, on the basis described in the application form, protocol, supporting documentation and any clarifications received. You should not expect to receive anything further relating to this application.

How should I continue to work with participating NHS organisations in England and Wales?
You should now provide a copy of this letter to all participating NHS organisations in England and Wales, as well as any documentation that has been updated as a result of the assessment.

Following the arranging of capacity and capability, participating NHS organisations should **formally confirm** their capacity and capability to undertake the study. How this will be confirmed is detailed in the "*summary of assessment*" section towards the end of this letter.

You should provide, if you have not already done so, detailed instructions to each organisation as to how you will notify them that research activities may commence at site following their confirmation of capacity and capability (e.g. provision by you of a 'green light' email, formal notification following a site initiation visit, activities may commence immediately following confirmation by participating organisation, etc.).

It is important that you involve both the research management function (e.g. R&D office) supporting each organisation and the local research team (where there is one) in setting up your study. Contact details of the research management function for each organisation can be accessed here.

How should I work with participating NHS/HSC organisations in Northern Ireland and Scotland?
HRA and HCRW Approval does not apply to NHS/HSC organisations within the devolved administrations of Northern Ireland and Scotland.

If you indicated in your IRAS form that you do have participating organisations in either of these devolved administrations, the final document set and the study wide governance report (including this letter) has been sent to the coordinating centre of each participating nation. You should work with the relevant national coordinating functions to ensure any nation specific checks are complete, and with each site so that they are able to give management permission for the study to begin.

Please see IRAS Help for information on working with NHS/HSC organisations in Northern Ireland and Scotland.

How should I work with participating non-NHS organisations?
HRA and HCRW Approval does not apply to non-NHS organisations. You should work with your non-NHS organisations to obtain local agreement in accordance with their procedures.

What are my notification responsibilities during the study?
The attached document *"After HRA Approval – guidance for sponsors and investigators"* gives detailed guidance on reporting expectations for studies with HRA and HCRW Approval, including:

- Registration of Research
- Notifying amendments
- Notifying the end of the study

The HRA website also provides guidance on these topics and is updated in the light of changes in reporting expectations or procedures.

I am a participating NHS organisation in England or Wales. What should I do once I receive this letter?
You should work with the applicant and sponsor to complete any outstanding arrangements so you are able to confirm capacity and capability in line with the information provided in this letter.

The sponsor contact for this application is as follows:

Name: Mrs Julie Quick
Tel: 01213317080
Email: julie.quick@bcu.ac.uk

Who should I contact for further information?
Please do not hesitate to contact me for assistance with this application. My contact details are below.

Your IRAS project ID is **240626**. Please quote this on all correspondence.

IRAS project ID	240626

Yours sincerely

Simon Connolly
Senior Assessor

Email: hra.approval@nhs.net

Copy to: *Sponsor Representative: Mrs Julie Quick Birmingham City University*
Lead NHS R&D Office Representative: Mr Bradley Tallon, University Hospital of South Manchester NHS Foundation Trust

IRAS project ID	240626

List of Documents

The final document set assessed and approved by HRA and HCRW Approval is listed below.

Document	*Version*	*Date*
Evidence of Sponsor insurance or indemnity (non NHS Sponsors only)		24 July 2017
HRA Schedule of Events	1.0	21 June 2018
HRA Statement of Activities	1.0	21 June 2018
IRAS Application Form [IRAS_Form_08062018]		08 June 2018
Letter from sponsor [BCU sponsor letter]	1.0	19 March 2018
Non-validated questionnaire [Post data collection survey]	1.0	16 May 2018
Participant consent form [participant consent form 16/5/18]	1.1	07 June 2018
Participant consent form [Validation of the iBID nurse dependency variables participant consent]	1.2	15 June 2018
Participant information sheet (PIS) [Validation of iBID nurse dependency variables participants information sheet]	1.3	15 June 2018
Participant information sheet (PIS)	1.4	22 June 2018
Participant information sheet (PIS) [iBID nurse dependency validation participant information sheet]	1.2	13 May 2018
Research protocol or project proposal [Validation of the iBID nurse dependency variables research protocol]	1.0	16 May 2018
Summary CV for Chief Investigator (CI) [J Leaver CV]	1.0	01 April 2018
Summary CV for supervisor (student research) [H Ejtehadi CV]	1.0	06 June 2018

IRAS project ID	240626

Summary of assessment

The following information provides assurance to you, the sponsor and the NHS in England and Wales that the study, as assessed for HRA and HCRW Approval, is compliant with relevant standards. It also provides information and clarification, where appropriate, to participating NHS organisations in England and Wales to assist in assessing, arranging and confirming capacity and capability.

Assessment criteria

Section	Assessment Criteria	Compliant with Standards	Comments
1.1	IRAS application completed correctly	Yes	No comments
2.1	Participant information/consent documents and consent process	Yes	No comments
3.1	Protocol assessment	Yes	No comments
4.1	Allocation of responsibilities and rights are agreed and documented	Yes	The Statement of Activities will form the agreement between the sponsor and the participating NHS organisations. The Schedule of Events was submitted.
4.2	Insurance/indemnity arrangements assessed	Yes	No comments
4.3	Financial arrangements assessed	Yes	No application for external funding made.
5.1	Compliance with the Data Protection Act and data security issues assessed	Yes	No comments
5.2	CTIMPS – Arrangements for compliance with the Clinical Trials Regulations assessed	Not Applicable	No comments
5.3	Compliance with any applicable laws or regulations	Yes	No comments
6.1	NHS Research Ethics Committee favourable opinion received for applicable studies	Not Applicable	NHS Research Ethics Committee favourable opinion is not required.

Section	Assessment Criteria	Compliant with Standards	Comments
6.2	CTIMPS – Clinical Trials Authorisation (CTA) letter received	Not Applicable	No comments
6.3	Devices – MHRA notice of no objection received	Not Applicable	No comments
6.4	Other regulatory approvals and authorisations received	Not Applicable	No comments

Participating NHS Organisations in England and Wales

This provides detail on the types of participating NHS organisations in the study and a statement as to whether the activities at all organisations are the same or different.

This is a multi-site study undertaking the same research activities; there is therefore one site type.

The Chief Investigator or sponsor should share relevant study documents with participating NHS organisations in England and Wales in order to put arrangements in place to deliver the study. The documents should be sent to both the local study team, where applicable, and the office providing the research management function at the participating organisation. Where applicable, the local LCRN contact should also be copied into this correspondence.

If chief investigators, sponsors or principal investigators are asked to complete site level forms for participating NHS organisations in England and Wales which are not provided in IRAS, the HRA or HCRW websites, the chief investigator, sponsor or principal investigator should notify the HRA immediately at hra.approval@nhs.net or HCRW at Research-permissions@wales.nhs.uk. We will work with these organisations to achieve a consistent approach to information provision.

Principal Investigator Suitability

This confirms whether the sponsor position on whether a PI, LC or neither should be in place is correct for each type of participating NHS organisation in England and Wales, and the minimum expectations for education, training and experience that PIs should meet (where applicable).

As per the Statement of Activities, a Local Collaborator will be in place at each participating NHS organisation; no assistance to identify potential Local Collaborators are required from the participating NHS organisations.

GCP training is not a generic training expectation, in line with the HRA/HCRW/MHRA statement on training expectations.

HR Good Practice Resource Pack Expectations

This confirms the HR Good Practice Resource Pack expectations for the study and the pre-engagement checks that should and should not be undertaken
The following is revised from information previously given: If existing arrangements are not in place and the researcher requires access to an NHS care facility, then a letter of access would be appropriate. There is no requirement for specific DBS or occupational health checks if only working with staff.

Other Information to Aid Study Set-up

This details any other information that may be helpful to sponsors and participating NHS organisations in England and Wales to aid study set-up.
The applicant has indicated that they do not intend to apply for inclusion on the NIHR CRN Portfolio.

BIRMINGHAM CITY University

Faculty of Health, Education & Life Sciences Research Office
Seacole Building, 8 Westbourne Road
Birmingham
B15 3TN

HELS_Ethics@bcu.ac.uk

19/Mar/2018

Mrs. Jane Leaver

jane.leaver@bcu.ac.uk

Dear Jane .

Re: Leaver /1358 /R(C) /2018 /Mar /HELS FAEC - Validation of the international Burn Injury Database (iBID) nurse dependency variables.

Thank you for your application and documentation regarding the above study. I am pleased to confirm that Birmingham City University has agreed to take on the role of Sponsor.

I can also confirm that the legal liability for death or injury to any person participating in the project is covered under the University's insurance arrangements.

A copy of BCU's insurance details is available at:
https://icity.bcu.ac.uk/Finance/Procurement-and-Insurance/Insurance

If you wish to make any changes to your proposed study (by request or otherwise), then you must submit an Amendment application to us. Examples of changes include (but are not limited to) adding a new study site, a new method of participant recruitment, adding a new method of data collection and/or change of Project Lead.

Please also note that the Committee should be notified of any serious adverse effects arising as a result of this activity.

Keep a copy of this letter along with the corresponding application for your records as evidence of approval.

If you have any queries, please contact HELS_Ethics@bcu.ac.uk

I wish you every success with your study.

Yours Sincerely,

Ms Julie Quick

On behalf of the Health, Education & Life Sciences Faculty Academic Ethics Committee

Ref: AW/jb211/2015

Address for Correspondence

Faculty of Health, Education and Life Science Research Office

Faculty of Health, Education and Life Sciences

Birmingham City University

Westbourne Road

Birmingham B15 3TN

Tel: 0121 331 6172

Email: HELS_Ethics@bcu.ac.uk

07/12/2015

Jane Leaver

Nursing Midwifery and Social Work

Faculty of Health, Education and Life Sciences

Seacole Room 460

Birmingham City University

Dear Jane,

Re: Development and validation of a burn patient dependency tool to predict the correct/safe nurse staffing level in burn units.

Thank you for your application which has been reviewed by members of the Ethics Committee. I am happy to issue a favourable opinion which means that you may begin your research.

The Committee's opinion is based on the information supplied in your application. If you wish to make any substantial changes to the research please contact the Committee and provide details of what you propose to alter. A substantial change is one that is likely to affect the:

i) safety and well-being of the participants;

ii) scientific value of the study;

iii) conduct or management of the study.

The Committee should also be notified of any serious adverse effects arising as a result of this research. The Committee is required to keep a favourable opinion under review in the light of progress reports.

I hope the project goes well and wish you every success.

Yours sincerely,

Dr Alex Wade

Moderator, Faculty of Health, Education and Life Sciences Academic Ethics Committee

Appendix C – Participant Information Sheet and Consent Form

Participant information Sheet

My name is Jane Leaver and I am a Lecturer Practitioner in Burns and plastic surgery. I am currently a post-graduate student at Birmingham City University undertaking a research study as part of my PhD.

The research study title is:
“Validation of the international Burn Injury Database (iBID) nurse dependency variables”

I would like to invite you to take part in this research study. However before you decide I would like you to understand why the research study is being done and what it would involve for you.

This information sheet explains the purpose of the research study and what will be involved if you take part. Section 1 covers the essential information you need to know, and if you are interested in participating having read this, section 2 gives some additional relevant information. Please ask me if there is anything that is not clear or if you would like more information. You can discuss the study with others if you wish. Participation in this study is voluntary and entirely your choice.

SECTION 1

What is the purpose of the study?
Inadequate staffing levels has been a concern raised by patients and nurses (Royal College of Nursing, 2017; Francis, 2013) alike over the years. The British Burn Association in their burn care standards also recognised the importance of adequate staffing levels related to patient dependency for quality care. Thus one of the standards states “The nursing establishment should be based on the capacity and dependency of the patients managed in the service” (National Network for Burn Care, 2013:16) . Yet this is difficult to demonstrate with very few validated nurse dependency tools available to predict or support such staffing levels and particularly when there are none specifically related to burn care.

Nurse dependency data has been collected in iBID over the last 5 years from all the burn units and burn centres across England and Wales as part of an ongoing record of burn injuries. The first part of this PhD has been to analyse this data in order to establish what relationships exist between burn severity and workload. During this analysis and review of the literature it was noted that the dependency variables measured different aspects of care than the tools in the literature and in particular the National Institute for Health and Care Excellence (NICE) endorsed the Safer Nursing Care Tool (SNCT). Therefore in order to take the model forward it needs to be validated against a recognised and commonly used model.

The aim of this part of the study is to compare the iBID dependency scores with the SNCT scores in order to validate the use of the iBID dependency scores and ascertain if they are more sensitive than the SNCT for burn patients.

The study will involve 3 burn services, including your burn service, scoring patients' dependency using the two dependency tools over a 2 week period, along with the staffing numbers per shift. You will also be asked to score three case studies, to enable us to create a baseline and assess reliability of the tools, and to complete a questionnaire at the end about your experience in using the scoring tools.

The collected data will be anonymised and all names removed before being passed onto the researcher. It will then be used alongside the results of the first part of the research to ascertain the validity of the iBID dependency variables and to evolve a burns workload acuity tool.

Why is this research important?
In order to provide effective care for patients in a clinical setting, it is imperative that the numbers and skill mix of nursing staff are correct to meet the needs of patients. However there are very few validated nurse dependency tools available to predict or support staffing levels. Those that are in common use in the UK either do not address the specific challenges of patients with a burn or have not been validated.

Why have I been invited to take part in the study?
Your burn service has agreed to take part in collecting dependency scores on the burn patients admitted. As a registered nurse caring for these patients you will have the knowledge of these patients' needs and condition. You are therefore ideally placed to make a professional judgement about your patients' dependency and to score your patients on each shift using the iBID and SNCT dependency scoring systems.

Do I have to take part?
Your participation in this study is voluntary and entirely your choice. If you agree to participate I will ask you to complete a consent form. If you do not want to take part at any time then you are free to withdraw and not complete the scoring sheets for your patients on your shift. Additionally with the written case studies and the end of study survey it is your choice whether you decide to take part and complete them or not. You may choose to take part in one aspect and not the other.
If you do choose to complete the dependency scoring sheet this data will be used in the study. Once the scoring has been completed it will not be possible to identify and remove your scores as no staff names are recorded on the score sheets.

What will taking part involve?
Prior to you deciding whether you want to participate in this study there will be the opportunity to attend a meeting in your work area to find out more about the project and what will be required. There will be additional information available about the study and how to use the scoring tools. You will have the opportunity to ask questions either in person of the researcher at the meeting or via email or phone.
If you agree to participate you will be asked to

- Sign a consent form.
- Read and score three written case studies using the same dependency scoring tools to help create a baseline and assess reliability of the tools.
- Score your patients' dependency a maximum of once per shift using the scoring systems of both iBID and SNCT. It is anticipated that this should not take up more than a couple of minutes of your time each shift. This will be for a two week period. Prior to the start of this period a couple of practice days

will be undertaken so that you can get used to the scoring and any difficulties highlighted and resolved.

- Complete a short post study questionnaire.
- If you are the nurse in charge of a shift (or nominated member of the nursing team) you will also be asked to record the number of staff on each shift, if in their opinion the number of staff was sufficient and if there were any events that may have affected this.

What are the potential benefits of taking part?
It is widely recognised that if staffing levels are not sufficient there is a risk to patients. However there are few validated appropriate dependency scoring tool available and none specifically in burns. By participating in this study you will be able to help us identify if the iBID dependency tool can help to identify staffing numbers required and act as evidence to meet the burn care standards. The collated dependency data collected over the two week period will also be returned to the individual services to use for their own audit purposes.

What are the possible disadvantages/risks of taking part?
Participation will require a few minutes of your time per shift during the 2 weeks of the study. Additionally the case studies and post study questionnaire are likely to take approximately 10 minutes each. In the unlikely event that any unsafe standards of care are identified these will be notified to the ward manager to action as appropriate

SECTION 2 - If you are still interested in this research please continue to read the rest of this Participant information sheet

How will confidentiality be maintained?
Information about who has consented to take part will be kept strictly confidential in a specific locked filing cabinet in a locked room. The Consent forms will be kept separate from the scoring sheets. The consent forms and information on them will be destroyed at the end of the research and PhD study time which is expected to be 2021. Only in the unlikely event, that it is considered that there is as serious risk of harm to you or others from the research will the details on the consent form be shared with those that need to know.
The scoring sheets and questionnaires do not require you to put your name on them, so will be anonymous. You will be asked to record which grade grouping you are in but these are wide enough to maintain anonymity (i.e. band 5/ band 6 and above). All patient identifiers will be removed and the data anonymised prior to the data reaching me to maintain patient confidentiality.
This anonymised data will be stored in a password protected file, on a university ID and password protected computer which only the researcher will have access to.

What if there is a problem?
If you have a concern about any aspect of this research study, you should contact me and I will do my best to answer your questions. My Contact details are below. If you are not satisfied and/or wish to make a formal complaint, you can do this by contacting the Insurance Lead for the, Faculty of Health, Education and Life Sciences at Birmingham City University (Julie Quick).

What will happen to the results of the research study?
The results of this study will form part of a research thesis. I hope to publish the results in relevant nursing journals, and present the findings at national or international burn care and nursing conferences. Participants will not be identified individually in any publication or presentation.

Who is organising and funding the research study?
This is part of Higher Education study which is funded by Birmingham City University. I have organised the research study under supervision of my PhD supervisors at Birmingham City University.

Who has reviewed the study?
All research in the NHS is looked at by an independent group of people, called a Research Ethics Committee, to protect your interests. This study has been reviewed and given a favourable opinion by Birmingham City University Research Governance Committee and has Health Research Authority approval.

Contact details

For further information - If you require more information, please do not hesitate to contact me: - Jane Leaver jane.leaver@bcu.ac.uk 0121 331 7164

If you have a complaint – Please contact Julie Quick Julie.quick@bcu.ac.uk

How will your data be used?
Birmingham City University ('BCU') is the sponsor for this study based in the United Kingdom. We will be using information from you in order to undertake this study and will act as the data controller for this study. This means that we are responsible for looking after your information and using it properly. BCU will keep identifiable information about you 5 years after the study has finished. BCU will securely destroy information held about you 5 years after the study has finished, unless there is a legal requirement to retain information for a longer period.

Your rights to access, change or move your information are limited, as we need to manage your information in specific ways in order for the research to be reliable and accurate. If you withdraw from the study, we will keep the information about you that we have already obtained. To safeguard your rights, we will use the minimum personally-identifiable information possible.

BCU will use your name, and contact details to contact you about the research study, and make sure that relevant information about the study is recorded to oversee the quality of the study. Individuals from BCU and regulatory organisations may look at your research records to check the accuracy of the research study. The only people in BCU who will have access to information that identifies you will be people who need to contact you to to disseminate findings or audit the data collection process.

You can find out more about how we use your information by contacting [Jane Leaver jane.leaver@bcu.ac.uk 0121 331 7164.

If you have any concerns about how we use or handle your personal data please contact the University's Data Protection Officer using the following contact details:

By Email to: informationmanagement@bcu.ac.uk

By Telephone on: +44 (0)121 331 5288

By Post to: Data Protection Officer , Information Management Team, Birmingham City University, University House, 15 Bartholomew Row, Birmingham, B5 5JU

If you are not content with how we handle your information we would ask you to contact our Data Protection Officer to help you who will investigate the matter. However, you do also have the right to complain directly to the Information Commissioner at: Information Commissioner's Office, Wycliffe House, Water Lane, Wilmslow, Cheshire, SK9 5AF. Information about the Information Commissioner is available at: http://ico.org.uk

Participant Consent form

Project Title: Validation of the international Burn Injury Database (iBID) nurse dependency variables.

Researchers Name: Jane Leaver

Participant study Number:

Please initial each right hand box if you agree with the statement:

a) I confirm that I have read and understood the information sheet dated.16.5.18 (version 1) for the above study.	
b) I have had the opportunity to ask questions and these have been answered fully.	
c) I understand that my participation is voluntary and that I am free to withdraw at any stage of the study without giving a reason or prejudice.	
d) I understand that I will not be identified on the scoring sheets nor the questionnaire responses.	
e) I understand that confidentiality will be maintained accept in the unlikely event that there is a serious risk to me or others that requires reporting.	
f) In case of my withdrawal, I understand that because the scoring sheets and questionnaires are anonymous, once they are submitted it will not be possible to isolate them and remove them from the data.	
g) I agree to take part in the above study.	

-- *Participants Name*	-- *Signature*	----------------- *Date*

-- *Consent received by*	-- *Signature*	----------------- *Date*

If you require any further details please contact
Jane Leaver
jane.leaver@bcu.ac.uk 0121 331 7164

Appendix D – Comparison of iBID and SNCT Data Collection Form and Tool Descriptors

Patient name/number……………………………………………………………

-------------------Please remove the above section before returning to researcher ---------------------

Patient iBID number ………………………………………….....

Date	Shift			Nursing grade		SNCT score					iBID score					
	am	pm	night	Band 5	above band 5	0	1a	1b	2	3	Monitoring requirement	Procedure complexity	Psychological support	ADL achievement	Mobility Limitation	Basic care needs

Dependency Tool descriptors

Safer Nursing Care Tool (SNCT). (Shelford, 2014)	
Levels of Care	**Care requirements may include the following**
Level 0 Patient requires hospitalisation Needs met by provision of normal ward cares.	Elective medical or surgical admission, May have underlying medical condition requiring on-going treatment Patients awaiting discharge Post-operative / post-procedure care - observations recorded half hourly initially then 4-hourly Regular observations 2 - 4 hourly Early Warning Score is within normal threshold. ECG monitoring. Fluid management Oxygen therapy less than 35% Single chest drain Patient controlled analgesia, Nerve block Confused patients not at risk Patients requiring assistance with some activities of daily living, require the assistance of one person to mobilise, or experiences occasional incontinence
Level 1a Acutely ill patients requiring intervention or those who are UNSTABLE with a GREATER POTENTIAL to deteriorate.	Increased level of observations and therapeutic interventions Early Warning Score - trigger point reached and requiring escalation. Post-operative care following complex surgery Emergency admissions requiring immediate therapeutic intervention. Instability requiring continual observation / invasive monitoring, Arterial blood gas analysis - intermittent Oxygen therapy greater than 35% + / - chest physiotherapy 2 - 6 hourly Post 24 hours following insertion of tracheostomy, central lines, epidural or multiple chest or extra ventricular drains Severe infection or sepsis

Dependency Tool descriptors

Safer Nursing Care Tool (SNCT). (Shelford, 2014)	
Levels of Care	**Care requirements may include the following**
Level 0 Patient requires hospitalisation Needs met by provision of normal ward cares.	Elective medical or surgical admission, May have underlying medical condition requiring on-going treatment Patients awaiting discharge Post-operative / post-procedure care - observations recorded half hourly initially then 4-hourly Regular observations 2 - 4 hourly Early Warning Score is within normal threshold. ECG monitoring. Fluid management Oxygen therapy less than 35% Single chest drain Patient controlled analgesia, Nerve block Confused patients not at risk Patients requiring assistance with some activities of daily living, require the assistance of one person to mobilise, or experiences occasional incontinence
Level 1a Acutely ill patients requiring intervention or those who are UNSTABLE with a GREATER POTENTIAL to deteriorate.	Increased level of observations and therapeutic interventions Early Warning Score - trigger point reached and requiring escalation. Post-operative care following complex surgery Emergency admissions requiring immediate therapeutic intervention. Instability requiring continual observation / invasive monitoring, Arterial blood gas analysis - intermittent Oxygen therapy greater than 35% + / - chest physiotherapy 2 - 6 hourly Post 24 hours following insertion of tracheostomy, central lines, epidural or multiple chest or extra ventricular drains Severe infection or sepsis
Level 1b Patients who are in a STABLE condition but are dependent on nursing care to meet most or all of the activities of daily living.	Complex wound management requiring more than one nurse or takes more than one hour to complete. VAC therapy where ward-based nurses undertake the treatment Patients with Spinal Instability / Spinal Cord Injury Mobility or repositioning difficulties requiring the assistance of two people Complex Intravenous Drug Regimes - (including those requiring prolonged preparatory / administration / post-administration care) Patient and / or carers requiring enhanced psychological support owing to poor disease prognosis or clinical outcome Patients on End-of-Life Care Pathway Confused patients who are at risk or requiring constant supervision Requires assistance with most or all activities of daily living Potential for self-harm and requires constant observation Facilitating a complex discharge where this is the responsibility of the ward-based nurse

Level 2 May be managed within clearly identified, designated beds, resources with the required expertise and staffing level OR may require transfer to a dedicated Level 2 facility / unit	Deteriorating / compromised single organ system Post-operative optimisation (pre-op invasive monitoring) / extended post-op care. Patients requiring non-invasive ventilation / respiratory support; CPAP / BiPAP in acute respiratory failure First 24 hours following tracheostomy insertion Requires a range of therapeutic interventions including: Greater than 50% oxygen continuously Continuous cardiac monitoring and invasive pressure monitoring Drug Infusions requiring more intensive monitoring e.g. vasoactive drugs (amiodarone, inotropes, gtn) or potassium, magnesium Pain management - intrathecal analgesia CNS depression of airway and protective reflexes Invasive neurological monitoring
Level 3 Patients needing advanced respiratory support and / or therapeutic support of multiple organs.	Monitoring and supportive therapy for compromised / collapse of two or more organ / systems Respiratory or CNS depression / compromise requires mechanical / invasive ventilation Invasive monitoring, vasoactive drugs, treatment of hypovolaemia / haemorrhage / sepsis or neuro protection

iBID nurse dependency variables

Monitoring requirement B1 - Surgical Ward Level B2 - High dependency B3 - Intensive care B4 - Additional Intensive care B5 - complex intensive care	Procedure complexity P0 - no dressing or procedure P1 - simple small dressing <5% or ROS P2 - single body segment dressing 5-10% P3 - moderate dressing 10-20% / small op P4 - multi segment dressing >20% / significant op P5 - near full dressing / major op	Psychological support S1 - ward round contact/social S2 - explanatory chat S3 - significant support needed S4 - in depth discussion or NOK support S5 - intense observation or NOK in crisis
Activities of daily living (ADL) achievement D1 - self caring/minimal input D2 - minimally dep assistance few tasks D3 - limited function assistance with some tasks D4 - severely limited assistance with most tasks D5 - fully dependant assistance with all tasks	Mobility Limitation L1 - fully mobile L2 - some limitation supervision/assistance needed L3 - significant limitation needing 1-2 assistants and walking aid L4 - severe limitation hoist / tilting table / standing frame L5 - totally immobile high pressure sore risk hoist only	Basic care support needs C0 - Largely independent in basic care activities, C1 - Requires help from 1 person for most basic care needs, C2 - Requires help from 2 people for most basic care needs, C3 - Requires help from > 2 people or 1:1 supervision

Appendix E – Staffing Levels Daily Record

Staffing levels research sheet

Date	shift			Number of staff on shift				In your opinion was this enough staff			were there any events that affected staffing / Other comments
	am	pm	night	band 6 & above	band 5	band 4 & below	Students	Too many	Correct number	Not enough	

Appendix F – Case Studies

Name:	Mr Peter Norris	**Case study 1**	
D.O.B.	07.11.1971 Age 46		
Address:	127 Burns Street, Lincoln		
Hospital ID:	K123456	Weight:	89kg
Time:	16.00hr		
Ward:	Burns Unit	Allergies:	NKDA
Prior Location:	ED Lincoln County		
Prior Doctor:	Mr Jones	Family History:	Lives with wife and teenage son
Consultant:	Mr Batt		

Past Medical History	
Medical	Surgical
• Hypertension • Smoker – 10 a day Drinks occasionally	• None

Medication
• Medication for BP - Propranolol 200mg daily • Analgesia - I.V. Morphine

Background Brief
46 year old gentleman presented to ED, with a 28% mixed depth burn injury to arms, legs and face. Time of Burn was 14.00hr yesterday. He was burning rubbish in garden and used accelerant, resulting in flame flash back and clothing caught fire. Shouted for help, wife called 999 and gave some first aid. Ambulance road transfer to Burns Unit from Lincoln County ED. Arrived Burns Unit 17.00hr

Nursing Assessment/Daily living activities	
Airway and breathing	Patent airway. Resps between 18-26. No wheezing or difficulty breathing. 02 sats on admission were 98% on Oxygen. Now 96- 97% on air
Cardiovascular	Heart rate between 80-110 BP 155/70 Cannula in right arm Temperature 38.0c
Neurological	Alert and pupils equal and reacting. GCS 15. No neurological conditions

Pain	At rest current morphine dose keeping him comfortable but on movement requiring additional analgesia. Dressings done using Entonox
Elimination/hygiene	Urinary catheter in situ with hourly urine measurements. Able to sit out on commode with help. Needs assistance to wash. Has a shower when dressings changed
Eating and drinking	Normally self-caring. Currently able to feed himself using right arm if food is cut up and placed within reach. Has an NG tube in situ with continuous feed as prescribed by dietician. Able to take tablets
mobility	Normally fully mobile and active. Able to move from bed to chair with assistance
Skin integrity	Burns to face, arms and legs as per diagram. Dressing urgotul silver and gauze. Face cleaned 2-3 times a day and white paraffin applied. All other areas intact
psychological	No mental health conditions
sleep	Normally sleeps well - approximately 8hrs
Communication and language needs	Speaks English and does not require any aids. No hearing or sight problems difficulties.
Social circumstances	Lives with wife and one teenage son in their own two story house Employed as a teacher No living will or power of attorney
spiritual	Church of England. Goes to church on a regular basis

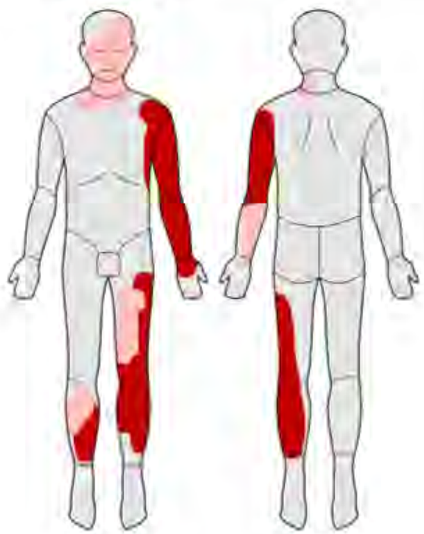
Nusing care given in last 24 hours
1 day post injury - 17.00hr Slept in between observations but did wake once from a nightmare but settled back to sleep following reassurance. Observations were hourly till 14.00hr then reduced to 2 hourly as stable. Managing on room air with O2 sats above 96%, early warning scores between 0- 3

Eating and drinking small amounts. NG feed running well as prescribed by dietician. Urine output measured hourly and is between 50-100mls per hour. Resuscitation fluid calculated using the parkland formula finished at 14.00hr but IV fluids continue with revised IV prescription

Sat out in the chair for a couple of hours in the afternoon. Seen by physio who commenced passive exercises. Pain appears controlled when at rest but requiring additional boluses on movement.
Had a shower and change of dressing today which took 2 nurses 1 ¾ hours. Although he managed on entonox the dressing change was painful so ketamine will be used next time if not going to theatre. Face cleaned twice today as a lot of exudate. He was also given a shave during the shower.

TBSA Body chart – mapping of burn injury

28%



Full thickness

Partial thickness

Name:	Mrs Madhini Patel	**Case study 2**	
D.O.B.	17.08.1941 Age 77		
Address:	5, Brook Close, Coventry	Weight:	65kg
Hospital ID:	K369258		
Ward:	Burns Unit	Allergies:	Penicillin
Prior Location:	ED	Family History:	Lives in a care home and has a married daughter
Consultant:	Mr Batt		

***Past Medical* History**

Medical	Surgical
• Diabetes • Used to smoke, Drinks occasionally • Mild dementia	• Hysterectomy 12 years ago • Appendectomy 50 years ago

Medication

- Medication for Diabetes - Tolbutamide
- Analgesia - Paracetamol and morphine

Background Brief

72 year old woman who sustained partial thickness 11% scald to abdomen and tops of legs when she spilt a fresh cup of tea 2 week ago. Now mostly healed except for approx. 1 % on top of right thigh. Awaiting for care home and district nurse to assess ready for discharge

Nursing Assessment/Daily living activities

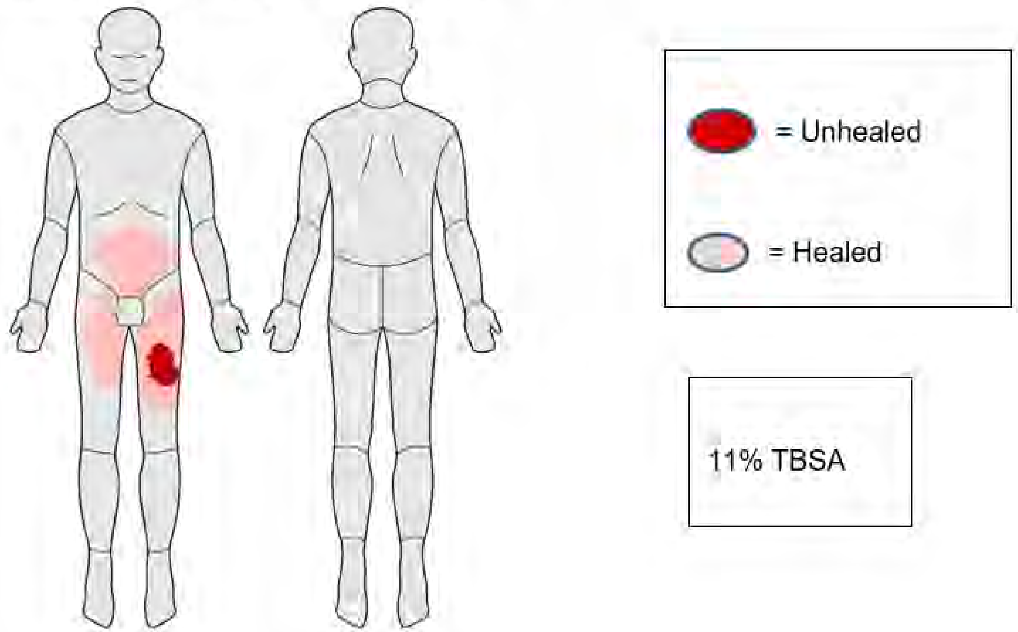
Airway and breathing	Patent airway. Resps between 14- 18. No breathing difficulty. 02 sats are 98% on air
Cardiovascular	Heart rate between 70-90 BP 150/65 Temperature 36.7c
Neurological	Alert and pupils equal and reacting. GCS 15. Forgets recent activities and is confused as to where she is.

Pain	At rest pain is controlled with paracetamol but requires morphine for dressing changes.
Elimination/hygiene	Needs assistance to wash and to mobilise to the toilet. Bowels usually opened daily after breakfast
Eating and drinking	Needs assistance with daily living activities as often forgets what she has done. Needs assistance at meal times and regular reminding to drink. Able to take tablets but needs assistance
mobility	Unstable on mobilising. Uses a frame and needs 1 person to assist her to the toilet. Occasionally will try to mobilise on own but at risk of falls. Able to get out of bed with assistance
Skin integrity	Burns to abdomen and thighs mostly healed now. Sacral area red.
psychological	Suffers from mild dementia. No other mental health conditions
sleep	Normally sleeps well at night but wakes early. Has frequent naps during the day.
Communication and language needs	Originally from India but can speak English Wears a hearing aid and glasses
Social circumstances	Lives in a care home. Has one daughter who visits every few days Retired Daughter has power of attorney
spiritual	Sikhism

Nursing care given in last 24 hours
Day 14 post injury - 17.00hr Woke at usual time of 05.00hr. Remains forgetful as to where she is and recent activities. Slept in between observations but did wake once from a nightmare but settled back to sleep following reassurance. Observation undertaken 4hrly and remain stable. Early warning scores between 0- 1 Eating and drinking small amounts with encouragement and assistance.

Assistance given with a shower after which her dressing was renewed which took about 20 minutes. Still has about 1% to heal but looks clean. Redness on sacral area but skin not broken. She has the correct pressure relieving mattress on her bed and cushion on her chair. Needs to be encouraged to move every hour. Went to physiotherapy department today.
This afternoon her daughter visited and was very distressed about her mother and her return to the care home. I spent over ½ an hour with her talking through her concerns and worries. She feels the care home is the right place for her mum but is concerned that she needs more assistance at mealtimes. We agreed that at the discharge planning meeting this would be discussed.

TBSA Body chart – mapping of burn injury



Name:	Mr Charles Howard	**Case study 3**	
D.O.B.	30.01.1996 Age 22		
Address:	22, Narnhull Road, Reading	Weight:	98kg
Hospital ID:	K184567		
Ward:	Burns ICU	Allergies:	NKDA
Prior Location:	ED	Family History:	Lives in a first floor flat
Consultant:	Mr Wand		

Past Medical History

Medical	Surgical
• Smokes 20 a day, Drinks a couple of pints with mates down the pub about 4 nights a week	• Repair of fractured tibia 6 years ago which occurred while playing football

Medication

- Analgesia – morphine via continuous infusion and bolus morphine PRN
- Sedation – midazolam infusion

Background Brief

22 year old mechanic who sustained 48% mixed depth burns to face, chest, arms and legs when flat caught fire after he had come home drunk and fell asleep in the chair while smoking. Occurred 3 days ago.

Nursing Assessment/Daily living activities

Airway and breathing	Inhalation injury. On a ventilator receiving lung protective ventilation via an endotracheal tube
Cardiovascular	Heart rate between 90-100. Continuously monitored and documented hourly BP 100/50 monitored via an arterial line Temperature 38.9c
Neurological	Pupils equal and reacting. Sedated to stipulated sedation score
Pain	On repositioning and movement heart rate goes up and facial grimaces noted

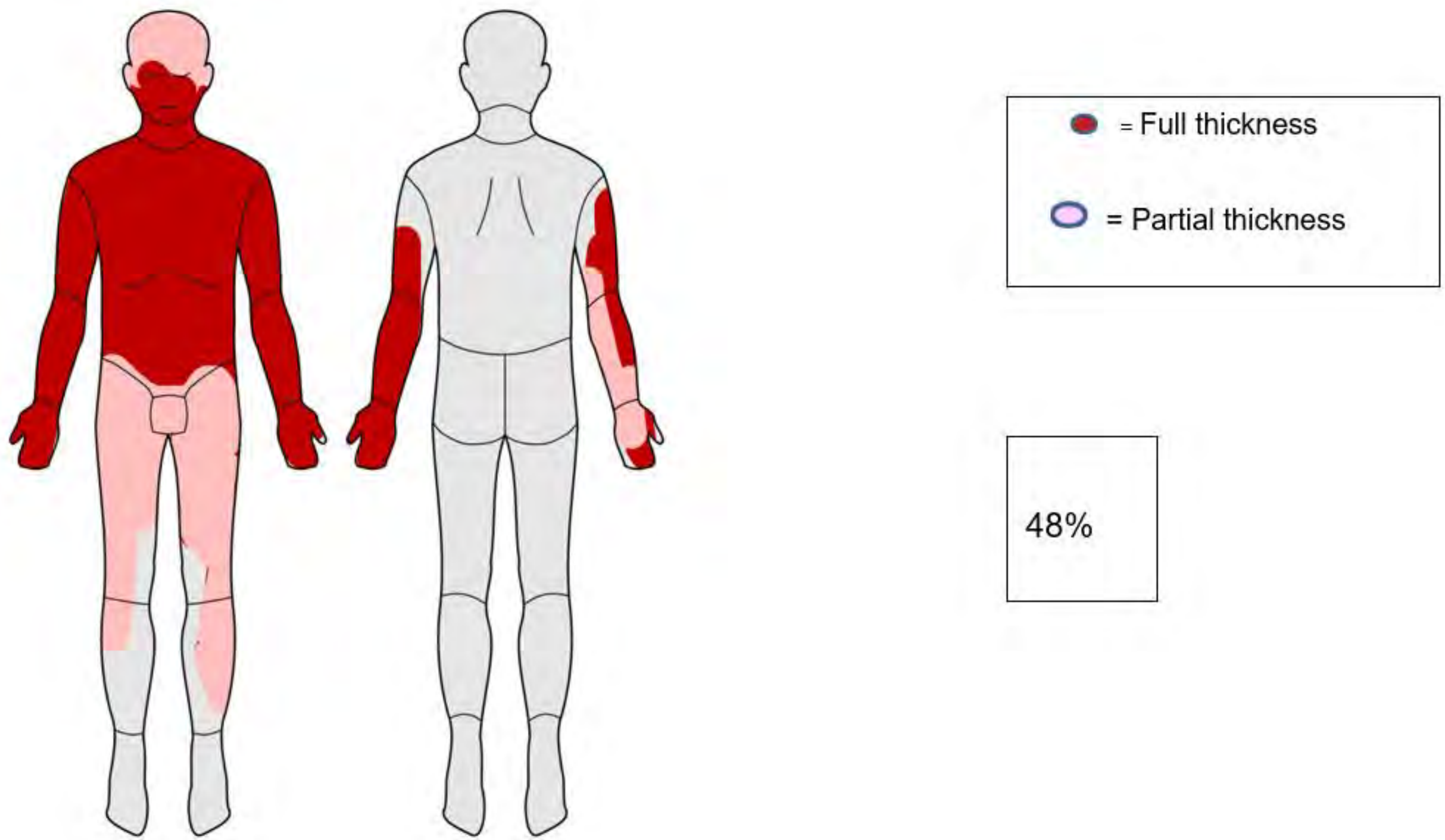
Elimination/hygiene	Sedated so requires all hygiene needs to be met. Has a urinary catheter insitu
Eating and drinking	NJ feed IV fluids
mobility	Prior to injury was fully mobile. Now requires regular repositioning in bed due to sedation-induced immobility. Receiving regular physio for chest and passive limb movements
Skin integrity	Burns to face, chest, arms and legs. Pressure areas intact
psychological	No mental health conditions. Parents distraught
sleep	Prior to accident normally sleeps well.
Communication and language needs	English
Social circumstances	Lives on own in a first floor flat
spiritual	Atheist

Nursing care given in last 24 hours

Third day post injury - 17.00hr

Regular ABG's – gas exchange remains acceptable, so ventilation settings continue as before. Turned side to side 2-3 hourly. Chest physio – minimal secretions but soot-streaked in nature.
CVS – remains in ST, regular. BP stable.
Continues with midazolam and morphine infusions to maintain comfort and tolerance of interventions.
Hygiene – full care given including oral and eye care. Visual infusion phlebitis (VIP) scores normal.
Elimination – urine output remains at around 1ml/kg/hr.
E&D – He is tolerating NJ feeding. Blood glucose levels 5-7
Mobility – passive limb / joint exercises given.
Skin – PA's intact.
Psych / social – all care explained. Consultant and bedside nurse updating parents throughout the day.
Theatre – went to theatre for debridement and grafting this morning.

TBSA Body chart – mapping of burn injury



Appendix G – Post Data Collection Survey

Online Post data collection survey (will use the Bristol online survey platform)

Thank you for taking part in the 'validation of the iBID dependency variables research. You participation is greatly appreciated. Finally to complete your involvement in this research please could I ask you to undertake this 5 – 10 minute survey? The aim of the survey is to find out about your experience of using the two dependency tools. Your answers will be anonymous and participation is voluntary.

Demographics

Which burn service are you working in? QEHB/ St Andrews/ Wythenshawe

How long have you been qualified - free text box

What nursing band are you? – band 5/ band 6 and above

1 – How often have you been involved in assessing patient dependency prior to being involved in this research study

never/occasionally (less than once a month)/ frequently (once a month or more)

1a – If you answered occasionally or frequently to the previous question what dependency scoring tools had you used *(please tick all that apply)*

iBID/SCNT/other/do not know (free text box for other)

2 – During this research study on how many days did you complete the two dependency scores?

Drop down box of 0 – 16

3 – Do you think it is important to assess patient dependency on a daily basis?

Yes/ No/ Do not have a strong opinion on this/ yes but not daily

3a – Please explain the reason for your answer to the previous question?

free text box

4- Please rank how important you think it is to have a scoring tool to help assess patient dependency?

1-5 with 1 being not important and 5 is essential

5- Please rank how easy you found the iBID dependency scoring tool to use?

1-5 with 1 being very difficult to 5 is very easy

6 - Please rank how easy you found the SNCT dependency scoring tool to use?

1-5 with 1 being very difficult to 5 is very easy

7 -Which tool did you prefer using?

iBID/SCNT/no preference

7a - Please explain the reason for your answer to the previous question?

free text box

8 - Which tool did you think represented your patients dependency needs best?

iBID/SCNT/neither

8a - Please explain the reason for your answer to the previous question?

free text box

9 - Please rank how easy you found the descriptions of the iBID dependency variables to understand and score

1-5 with 1 being very difficult to 5 is very easy

10 - Please rank how easy you found the descriptions of the SNCT dependency levels to understand and score

1-5 with 1 being very difficult to 5 is very easy

11 – Is there any specific aspect that you think is missing from the iBID tool?

free text box

12 - Are there any comments you would like to make about the use of dependency scoring tools and/or the research process that you have been involved in?

free text box

Appendix H – Variables from iBID

List of variables obtained from iBID (= burn mortality scores, =

List of variables obtained from iBID (= burn mortality scores, = event that caused the burn, = type of burn, = address area, = where accident occurred, = age, = size of burn, = variables that make up the total ND score)

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Absi	Absi_Mp	American Burn Severity Index score - a mortality predictor score	Score 99 = null = missing	Continuous	Independent
Activity	Activity	The activity the patient was undertaking when the burn occurred	1= 01 Transport 2= 02 Employment 3= 03 Housework 4= 04 Washing / Bathing 5= 05 Food preparation 6= 06 Sleep / rest 7= 07 Child Play / Exploration 8= 08 Household DIY 9= 09 Vehicle DIY 10= 10 Hobby 11= 11 Sport 12= 12 Amusement / Entertainment 13= 13 Socialising / Eating / Drinking 14= 14 Argument / Fight 15= 15 Civil unrest 16= 97 No Specific Activity 17= 98 Other 18= 99 Unknown 19 = null = missing	Nominal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
ADL	ADL	Activities of daily living achievement category that makes up part of the nurse dependency total score	1= D1 self caring - minimal input 2= D2 minimally dep assistance few tasks 3= D3 limited function assistance with some tasks 4= D4 severely limited assistance with most tasks 5= D5 fully dependant assistance with all tasks	Ordinal	Independent / Dependant
Age	Age	Actual Age at time of data input	age in years 9999 = null = missing	Continuous	Independent
Group Age(1)	Group_Age1	Group into 3 age groups	1= _Child 2= Adult 3=Elderly 4= null = missing	Ordinal	Independent
Group Age(2)	Group_Age2	Group into 2 age groups	1= _Child 2= Adult 3=null = missing	Ordinal	Independent
Group Age(3)	Group_Age3	Group into 6 age groups	1= 1_Neonate 2= 2_Infant 3= 3_Child 4= 4_Adult 5= 5_MiddleAged 6= 6_Elderly 7= null = missing	Ordinal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Average Nurse Dependency Total Score	Average of Nurse Dependency Total	Average of all the patients nurse dependency total scores	Average score	Continuous	Dependant
Basic Care Support Need	Basic Care Supp Need	Basic care Support needs	1= C0 Largely independent in basic care activities 2= C1 Requires help from 1 person for most basic care needs 3= C2 Requires help from 2 people for most basic care needs 4= C3 Requires help from > 2 people or 1:1 supervision 5= null = unknown = missing	Ordinal	Independent
Baux Index	Bauxindex	The Baux mortality predictor score	score 0 = missing	Continuous	Independent
BCUF Status	BCUF_Status	Burn service status - Centre, Unit, Facility, sub facility, minor	1= B C = Burn centre 2= B U = Burn Unit 3= BF= Burn Facility 4= minor= minor burn e.g. ED 5= sBF= sub facility (services doing work below facility status 6= DnK= Do not know	Nominal	Independent
BMI	Body Mass Index	Body Mass index	BMI 99 = null = missing	Continuous	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
BMI Group	BMI Group	Body Mass Index group	1=BMI_N 2= BMI_u18.5 3=BMI_o25 4= BMI_o30 5= BMI_o40 6= OoRL 7= null = missing	Ordinal	Independent
Bobi	Bobi_Mp	The Belgian Outcome in Burn Injury mortality predictor score	score 99 = missing score	Continuous	Independent
Burn Areas Body	Burnareas Body	number of burned areas on body	number of burned areas on body	Continuous	Independent
Burn Areas HH	Burnareas HH	number of burned areas on head and hands	number of burned areas on head and hands	Continuous	Independent
Burn Areas Legs	Burnareas Legs	number of burned areas on legs	number of burned areas on legs	Continuous	Independent
Burn Areas Total	Burnareas Total	total number of burned areas	total number of burned areas	Continuous	Independent

Friendly Name	**IBID Variable Name**	**meaning**	**Categorical values and coding instructions**	**Type of data**	**Type of variable**
Burn Network	Network	Burn operational delivery network patient is treated in	1= Midlands 2= North 3= S.East 4= S.West	Nominal	Independent
Case Identifier	ID	Identifies the case but not the patient	iBID anonymous coded number	Nominal	Independent
Category of Activity	CATEGORY	Category of activity	1= 01 Accidental: Recreation 2= 02 Accidental: Work Related 3= 03 Accidental: Not Work Related 4= 04 Accidental: Unspecified 5= 05 Assault 6= 06 Self Inflicted 7= 07 Suicidal 8= 08 NAI of Child / 08.1 Suspected neglect of child or adult / 08.2 Suspected NAI of child or adult 9= 09 Arson 10= 10 Suspected Criminal activity 11= 11 Irresponsible act by other 12= 98 Other 13= 99 Unknown 14 = null = missing	Nominal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Charlson Comorbidity Index	Charlson Index	A scoring system that weights the comorbidities to predict mortality	score	Continuous	Independent
Comfort Care Only	Comfort Care Only	Comfort care only given. No aggressive treatment	0= No 1 = Yes 2 = null = missing	Nominal	Independent
Complications	Complications	Number of complications arising	number	Continuous	Independent
Core Temperature	Core Temperature	Temperature on admission	Degrees Celsius 99 = missing	Continuous	Independent
Core Temperature Group	Core Temp Grp	Temperature on admission in to 5 groups	1 = under 31 2 = 31-35 3= 35-37 4 = normal 5 = over 39 6 = null = missing	Ordinal	Independent
Count of Dependency ID	Count of Dependency ID	The count of how many dependency entries for that patient	number	Continuous	Independent

Friendly Name	**IBID Variable Name**	**meaning**	**Categorical values and coding instructions**	**Type of data**	**Type of variable**
Dep Days Post Acute Injury	Dep_Days_Post _Acute_Inj				
Discharge Destination	Dischargedest	Where the patient was discharged to	1= Foster care 2= Home 3= Home of Friend 4= Home of Relative 5= Hostel 6= Mortuary 7= Nursing home 8= Other Burn Ward 9= Other Hospital 10= Other ward in hospital 11= Prison 12= Rehab. Hospital 13= Self-Discharge 14= Unknown 15 = null = missing	Nominal	Independent

Friendly Name	**IBID Variable Name**	**meaning**	**Categorical values and coding instructions**	**Type of data**	**Type of variable**
Ethnic Category	Ethnic Category	Ethnic Category	1=African 2= Any other Asian background 3= Any other Black background 4= Any other ethnic Group 5= Any other mixed background 6= Any other White background 7= Bangladeshi 8= British 9= Caribbean 10= Chinese 11= Indian 12= Irish 13= Pakistani 14= White and Asian 15= White and Black African 16= White and Black Caribbean 17= Not stated 18= null = unknown	Nominal	Independent
Expected Outcome	Expected Outcome	Expected survival outcome probability	1= 1_>75% Survivor 2= 2_50-75% Survivor 3= 3_Expected Survivor 4= 4_>75% Death 5= 5_50-75% Death 6= 6_25-50% Death 7= 7_<25% Death	Nominal	Independent

Friendly Name	**IBID Variable Name**	**meaning**	**Categorical values and coding instructions**	**Type of data**	**Type of variable**
First Aid Type	Firstaid type	Type of first aid given	1= Antiseptic 2= Burn Shield 3= Butter 4= Chemical antedote 5= Cling Film 6= Cream 7= Dressing 8= Toothpaste 9= Towel/sheet 10= Water (Clean) 11= Water (Contaminated) 12= Waterjel 13=Wet Fabric Wrap 14= Wet Gel Dressing 15= other 16= None 17= Unknown 18= null = missing	Nominal	Independent
First Nurse Dependency Total Score	First Nurse Dependency Total	The patients first nurse dependency total score recorded	score	Continuous	Dependant
Expected Fluid Resuscitation	Kpi Resus	According to size of burn and national guidelines fluid resuscitation should occur	0= No 1 = Yes 2 = null = missing	Nominal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Fluid Resuscitation	Formal Resusc	Fluid resuscitation was actually given	0= No 1 = Yes 2 = null = missing	Nominal	Independent
Full Thickness/ Deep Dermal BSA	PSU_FTDD BSA	Area of burn that had a deep dermal or full thickness depth	% full thickness/deep dermal TBSA 9999 = null = missing	Ordinal	Independent
GCS	GCscore	Glasgow coma scale score - the level of consciousness on admission	0-15 (0? Missing data) 99 = missing	Continuous	Independent
Gender	Gender	Gender	1= Female 2= male 3= unknown	Nominal	Independent
Inhalation Injury	Inhalation	Inhalation injury present	0= No 1= Yes 2 = null = missing	Nominal	Independent
Inhalation Severity	Inhaleseverity	Severity of inhalation injury	1= None 2= Mild 3= Moderate 4= Severe 5= null = missing	Ordinal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Inhalation Symptoms	Inhalsymptoms	number of inhalation symptoms	number of inhalation symptoms	Continuous	Independent
Injury Cause Group	Injury Group	Cause of injury divided into 6 groups	1= Spill 2= HWSystem 3= Accelerant 4= Contact 5= Fire 6= Other 7= missing	Nominal	Independent
Injury Day	Injury Day	The day of the week that the injury occurred	1= Sun 2= Mon 3= Tues 4= Wed 5= Thurs 6= Fri 7= Sat 8= missing data	Nominal	Independent
Injury Post Code District	Injury_Pc District	First part of post code where injury occurred	first part of post code where injury occurred See SPSS recoded output	Nominal	Independent
Injury to Healed Days	Injtohealdays	Number of days from injury to burn healed	number 9999 = null = missing	Continuous	Independent
Injury Week	Injury Week	The week of the year that the injury occurred	week of the year 99= null = missing	Nominal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Intentional Injury Suspected	Intentional Injury Suspected	Suspected that injury was cause deliberately by individual or another	0= No 1 = Yes 2 = null = missing	Nominal	Independent
Living Space	Livingspace	Where the burn occurred classed in relation to living spaces	1= 01 Kitchen 2= 02 Bathroom 3= 03 Bedroom 4=04 Living Room 5= 05 Hall 6= 06 Garage / Carport 7= 07 Outhouse 8= 08 Garden / Yard 9= 10 Drive 10= 11 Shed or outhouse 11= 12 Tent 12= 97 Not applicable 13= 98 Other 14= 99 Unknown 15= null = missing	Nominal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Locality of Accident	Locality	Where the burn occurred	1= 01 Own Home 2= 02 Other Private Dwelling 3= 03 Office Place Of Work 4= 04 Industrial Place Of Work 5= 05 School / College 6= 06 RTA 7= 07 Motor Vehicle - Not RTA 8= 08 Other Transport 9= 09 Camping / caravan / Boat 10= 10 Hotel / Restaurant / Disco 11= 11 Nursing Home 12= 12 Residential Home 13= 13 Hospital / Hospice 14= 14 Open Space 15= 15 Farm 16= 16 Mine Or Quarry 17= 17 Prison 18= 18 Beach 19= 19 Sports area 20= 20 Street or Roadway 21= 21 Trade or Service area 22= 22 Industrial or Construction Area 23= 98 Other 24= 99 Unknown 25 = null = missing	Nominal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Ward Type	Location	Type of ward that care is being given in	1= BHDU 2= BICU 3= burn ward 4= burns rehab unit 5= general HDU 6= general ICU 7= other hospital site ward 8= other ward on site 9= general rehab unit 10= null = unknown/missing	Nominal	Independent
LOS Group	LOS Group	Length of stay grouped	1= 0 days 2= _1 days 3= _2 days 4= _3-6 days 5= _7-13 days 6= _14-30 days 7= _31-89 days 8= 90+ days 9= 0	Ordinal	Independent
LOS Ventilated	LOSventilated	Number of days ventilated	number of days ventilated 9999 = null missing	Continuous	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
LOS Ventilated Group	LOSvent Grp	Number of days ventilated grouped	1= _1 day 2= _2 days 3= _3-6 days 4= _7-13 days 5= 14-30 days 6= 31-89 days 7= 90+ days 8= Null = missing	Ordinal	Independent
LOS TBSA	Los_Tbsa	Length of stay per percentage TBSA	number 9999 = null = missing	Continuous	Independent
Maximum Nurse Dependency Total Score	Max Nurse Dependency Total	The patients highest nurse dependency total score recorded	score	Continuous	Dependent
Medical Intervention	Medical Intervention	Level of Medical intervention required	1= M0 No active medical intervention 2= M1 Basic investigation/monitoring/treatment 3= M2 Specialist medical intervention 4= M3 Acutely sick or potentially unstable medical condition 5= null = unknown = missing	Ordinal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Minimum Nurse Dependency Total Score	Min Nurse Dependency Total	The patients lowest nurse dependency total score recorded	score	Continuous	Dependent
Mobility Limitation	Mobility Limitation	Mobility limitation category that makes up part of the nurse dependency total score	1= L1 fully mobile 2= L2 some limitation supervision/assistance needed 3= L3 significant limitation needing 1-2 assistants and walking aid 4= L4 severe limitation hoist / tilting table / standing frame 5= L5 totally immobile high pressure sore risk hoist only	Ordinal	Independent / Dependent
Monitoring Requirement	Monitoring Requirement	Monitoring requirement category that makes up part of the nurse dependency total score	1= B1 Surgical Ward Level 2= B2 High dependency 3= B3 Intensive care 4= B4 Additional Intensive care 5= B5 complex intensive care	Ordinal	Independent / Dependant
Month	Month	Month injury occurred	1= January 2= February 3= March 4= April 5= May 6= June 7= July 8= August 9= September 10= October 11= November 12= December	Nominal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Neglect Suspected	Neglect Suspected	Suspected that injury was caused by neglect	0= No 1 = Yes 2 = null = missing	Nominal	Independent
Number of Dependency Days Post Admission	DEP_DAYS POST_ADM	Number of dependency days post admission	number	Continuous	Independent
Nurse Dependency Total	Nurse Dep Total	iBID ND total score	number	Continuous	Dependant
Outcome	Outcome	Survival outcome	1= Died 2= Survived	Nominal	Independent
Partial Thickness TBSA	PSU SFSD BSA	Area of burn that had a superficial depth	% partial thickness TBSA 9999 = null = missing	Continuous	Independent
Patient Status	Pt.Status	Whether patient is an inpatient or outpatient	1= inpatient ward attender 2= ward inpatient	Nominal	Independent
PC Area	PC_Area	Similar to PC district but letters only	similar to PC district but letters only See SPSS recoded output	Nominal	Independent
PC District	PC_District	First part of post code of where live	first part of post code of where live (1365 values) See SPSS recoded output	Nominal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
PC Network District	PC_D_PC_A_ Network	The network district the patient lives in	1= Midlands 2= NIreland 3= North_NWales 4= Scotland 5= SEast 6= SWest 7= null	Nominal	Independent
Pc_D_Pc_D_ Imd2004	Pc_D_Pc_D_Im d2004		9999 = null = missing	Nominal	Independent
Pc_F2.3m_I md2004	Pc_F2.3m_Imd2 004		9999 = null = missing	Nominal	Independent
Procedure Complexity	Procedure Complexity	Procedure complexity category that makes up the nurse dependency total score	1= P0 no dressing or procedure 2= P1 simple small dressing <5% or ROS 3= P2 single body segment dressing 5-11% 4= P3 mod dressing 11-21% / small op 5= P4 mult seg dressing >21% / signif op 6= P5 near full dressing / major op	Ordinal	Independent / Dependent
Psychosocial Support	Psychosocial Support	Psychosocial support category that makes up the nurse dependency total score	1= S1 ward round contact - social 2= S2 explanatory chat 3= S3 significant support needed 4= S4 in depth discussion or NOK support 5= S5 intense observation or NOK in crisis	Ordinal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Race	RACE	Race	1= African: Arabic 2= African: Negran 3= Asian 4= Caucasian: Celtic 5 = Caucasian: Saxon 6= Caucasian: Med. 7= Caucasian: Nordic 8= Caucasian: Slavic 9= Mixed Origin 10= Oriental 11= Unknown	Nominal	Independent
RC Score Total	RC_Score Total	Northwick park therapy needs score	score 99 = missing score	Continuous	Independent
Referral to Social Services	Referral_To Social_Services	A referral to social services was made	0= No 1 = Yes 2 = null = missing	Nominal	Independent
Revbaux	Revbaux_MP	The Revised Baux mortality predictor score	score 99 = null = missing	Continuous	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Sc Hub	Sc_Schub	Wider specialist commissioning areas	1 = EEng 2= EMid 3= Lond 4= NEast 5= NWest 6= Scottish DH 7= SECoast 8= SWest 9= TVWessex 10= Wales 11= WMid 12= YHum 13 = null = missing	Nominal	Independent
Skilled Nursing Needs	Skilled Nursing Needs	Level of nurse required	1= N0 No needs for skilled nursing 2= N1 Requires intervention from a RGN 3= N2 Requires intervention from trained rehabilitation nursing staff 4= N3 Requires highly specialist nursing care 5= null = unknown = missing	Ordinal	Independent
Source of Burn Injury	Sourceofinjury	Where the source of heat came from that caused the injury	see SPSS recode output	Nominal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Specialist Commissioning LAT	SC_LAT	Specialist commissioning local area teams (LAT)	specialist commissioning LAT (no 1s, 2=0) 1 = Arden, Herefordshire and Worcestershire 2 = Bath, Gloucestershire, Swindon and Wiltshire 3 = Birmingham and the Black Country 4 = Bristol, North Somerset, Somerset and South Gloucestershire 5 = Cheshire, Warrington and Wirral 6 = Cumbria, Northumberland, Tyne and Wear 7 = Derbyshire and Nottinghamshire 8 = Devon, Cornwall and Isles of Scilly 9 = Durham, Darlington and Tees 10 = East Anglia 11 = Essex 12 = Greater Manchester 13 = Hertfordshire and the South Midlands 14 = Kent and Medway 15 = Lancashire 16 = Leicestershire and Lincolnshire 17 = London 18 = Merseyside 19 = North Yorkshire and Humber 20 = Scottish DH 21 = Shropshire and Staffordshire 22 = South Yorkshire and Bassetlaw 23 = Surrey and Sussex 24 = Thames Valley 25 = Wales 26 = Wessex 27 = West Yorkshire 28 = null = missing	Nominal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Specialist Commissioning Region	Sc_Region	specialist commissioning region	1= London 2= M_E Eng 3= N Eng 4= S Eng 5= Scottish DH 6= Wales 7= Unknown	Nominal	Independent
Sum of Nurse Dependency Total Score	Sum of nurse dep total	Sum of the patients' nurse dependency total score	number	Continuous	Independent
Supervision Lapse	Supervision Lapse	Suspected that injury was caused lack of supervision at the time	0= No 1 = Yes 2 = null = missing	Nominal	Independent
Therapy Complexity	Therapy Complexity	Levels of Therapy complexity that make up the Therapy complexity total score	1= Y0 no input required 2= Y1 splint check single joint Rx 3= Y2 single limb Rx (exc hands) uncomplicated respiratory Rx 4= Y3 multiple limb / single hand Rx mod complicated respiratory 5= Y4 single or multiple limb Rx inc hand(s) full respiratory Rx 6= Y5 near full body Rx complicated respiratory Rx 7= null = unknown = missing	Ordinal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Therapy Complexity	Therapy Complexity	Levels of Therapy complexity that make up the Therapy complexity total score	1= Y0 no input required 2= Y1 splint check single joint Rx 3= Y2 single limb Rx (exc hands) uncomplicated respiratory Rx	Ordinal	Independent
Therapy Complexity Total Score	Therapy Complexity Total	total therapy complexity score	score 99 = missing score	Continuous	Independent
Therapy Intervention	Therapy Intervention	Therapy intervention category that makes up the Therapy complexity total score	1= T0 No therapy intervention (e.g. awaiting discharge) 2= T1 Total therapy intervention ? 4 hours per week (or > 1 hr/day) 3= T2 Total therapy intervention 4-9 hours per week (or approx. 1-2 hrs/day 4= T3 Total therapy intervention 10-15 hours per week (or approx. 2-3 hrs/day) 5= T4 Total therapy intervention 16-20 hours per week (or approx. 3-4 hrs/day) 6= T5 Total therapy intervention 21-25 hours per week (or approx. 4-5 hrs/day) 7= T6 Total therapy intervention > 25 hours per week (or > 5hrs/day) 8= null = unknown = missing	Ordinal	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Therapy Support	Therapy Support	Therapy support category that makes up the Therapy complexity total score	1= R0 No input 2= R1 Minimal review 3= R2 Daily visit 4= R3 Regular visits per day 5= R4 Intensive support 6= R5 Constant attendance 7= null = unknown = missing	Ordinal	Independent
Injury Time	Injtm_Hr	Time of injury	Time of injury in hours 99 = null = missing	Continuous	Independent
Injury Time Group	Injtm_Cir	Time of injury grouped	1= a_1-5am 2= b_5-9am 3= c_9-1pm 4= d_1-5pm 5= e_5-9pm 6= f_9-1am 7= null = missing	Ordinal	Independent
Total Burn Surface Area (TBSA)	PSU Total BSA	The total area of body burnt regardless of depth	% total TBSA 9999 = null = missing	Continuous	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Total Burn Surface Area (TBSA) Group	BSA Group	Total area burned grouped	1= _0 % 2= _0-0.9% 3= _1-4% 4= _5-9% 5= 10-14% 6= 15-19% 7= 20-29% 8= 30-39% 9= 40-49% 10= 50-59% 11= 60-69% 12= 70-100%" 13= null = missing	Ordinal	Independent
Total Length of Stay	TOTALLOS	total length of stay in days as an inpatient	days as an inpatient (total length of stay) 9999 = null = missing	Continuous	Independent
Total Theatre Visits	Total Theatre Visits	Number of visits to theatre	number of visits to theatre 99 = null = missing	Continuous	Independent

Friendly Name	IBID Variable Name	meaning	Categorical values and coding instructions	Type of data	Type of variable
Type of Burn Injury	Type Of Injury	Type of burn injury	1= 01 Flame 2= 02 Flash 3= 03 Contact 4= 04 Scald 5= 05 Chemical 6= 06 Electrical 7= 07 Radiation 8= 08 Cold 9= 09 Friction 10= 10 Non Burn 11= null = missing	Nominal	Independent

Appendix I – Published Article

The link to the published article
[Leaver, J., Cook, R., Dunn, K., Dee, P. and Ejtehadi, H. D. (2021) Comparison of the international Burn Injury Database nurse dependency tool with the Safer Nursing Care Tool: Observational study. *International Journal of Nursing Studies Advances*, 3, p. 100018.]

International Journal of Nursing Studies Advances 3 (2021) 100018

Contents lists available at ScienceDirect

International Journal of Nursing Studies Advances

journal homepage: www.elsevier.com/locate/ijnsa

ELSEVIER

Comparison of the international Burn Injury Database nurse dependency tool with the Safer Nursing Care Tool: Observational study

Jane Leaver[a,*], Robert Cook[a], Ken Dunn[b], Philip Dee[a], Hora Davari Ejtehadi[a]

[a] Birmingham City University, Westbourne Road, Birmingham B15 3TN, UK
[b] Manchester University Hospital NHS Foundation Trust, Wythenshawe Hospital, Southmoor Road, Manchester M23 9LT, UK

A R T I C L E I N F O

Keywords:
Burns
International Burn Injury Database
iBID
Nurse dependency
Psychosocial support
Safer Nursing Care Tool

A B S T R A C T

Background: Safe and effective nurse staffing is widely recognised as an important issue to ensure quality patient care and reduce mortality. There are many nurse dependency tools described in the literature but no gold standard tool that can be used in all specialities. In burn care there are even fewer burn specific tools and none reported for use in the UK to date. The international Burn Injury Database contains routinely collected information about burn injuries, including nurse dependency data which so far has not been reported in the literature.

Objective: This study aimed to confirm whether the international Burn Injury Database nurse dependency tool can be used to measure nurse dependency in burn services.

Methods: Over a two week period, nurses in three burn services scored the nurse dependency of their burn injured patients daily using the international Burn Injury Database Nurse Dependency Tool and the Safer Nursing Care Tool. Additionally all the participating nurses were asked to score three fictional case studies using the same two tools to assess inter-rater reliability.

Results: There was a statistically significant positive correlation between the international Burn Injury Database Nurse Dependency Tool and the Safer Nursing Care Tool scores (ρ = 0.87, 95% CI = 0.82–0.90). The case study scores showed a similar correlation pattern as the daily comparison recordings. The inter-rater reliability between the participants was comparable for both the international Burn Injury Database Nurse Dependency Tool (α =0.74, CI = 0.71–0.77) and the Safer Nursing Care Tool (α =0.79, CI = 0.76–0.81). Psychological support variable had the weakest correlation with the nurse dependency tools and the lowest agreement between nurses.

Conclusion: This is the first report in the literature of the international Burn Injury Database Nurse Dependency Tool, the results of which suggest that it does measure aspects of nurse dependency and thus could be a valuable tool in the battle to ensure safe staffing. The good inter-rater reliability between the nurses, regardless of the nurse dependency tool used, should give confidence to nurses and managers using the dependency data to influence staffing.

What is known about the topic?

- There is a growing body of evidence that suggests there is a link between registered nurse staffing numbers with mortality and quality of care.
- Currently there is no consensus about what nurse staffing numbers should be, particularly in burn care.

* Corresponding author.
E-mail address: jane.leaver@bcu.ac.uk (J. Leaver).

https://doi.org/10.1016/j.ijnsa.2020.100018
Received 17 September 2020; Received in revised form 24 November 2020; Accepted 30 December 2020
Available online 5 January 2021

Appendix J – Multiple Regression Results

The IBID sample Average ND total score hierarchical stepwise model

Model Summary[t]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.687[a]	.471	.469	2.03971	
2	.713[b]	.508	.506	1.96857	
6	.909[f]	.826	.825	1.17003	
19	.916[s]	.839	.837	1.12899	1.993

a. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=50-59%, BSA_GRP=40-49%, BSA_GRP=_0 %, BSA_GRP=30-39%, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%

b. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=50-59%, BSA_GRP=40-49%, BSA_GRP=_0 %, BSA_GRP=30-39%, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=Elderly, GROUP_AGE1=Adult

f. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=50-59%, BSA_GRP=40-49%, BSA_GRP=_0 %, BSA_GRP=30-39%, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=Elderly, GROUP_AGE1=Adult, Avg Ther Complx, Expected outcome=3_Expected Survivor, Expected outcome=1_>75% Survivor, CATEGORY=01 Accidental: Recreation

s. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=50-59%, BSA_GRP=40-49%, BSA_GRP=_0 %, BSA_GRP=30-39%, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=Elderly, GROUP_AGE1=Adult, Avg Ther Complx, Expected outcome=3_Expected Survivor, Expected_outcome=1_>75% Survivor, CATEGORY=01 Accidental: Recreation, network=S.West, network=North, ABSI_MP, Expected_outcome=2_50-75% Survivor, Expected_outcome=7_<25% Death, CATEGORY=06 Self Inflicted, LOCALITY=14 Open Space, BURNAREAS_HH, CATEGORY=04 Accidental: Unspecified, BURNAREAS_BODY, CATEGORY=Suspected neglect or NAI of child or adult, Expected_outcome=4_>75% Death, LOCALITY=18 Beach

t. Dependent Variable: Avg Dep

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9708.103	11	882.555	212.132	.000[b]
	Residual	10887.781	2617	4.160		
	Total	20595.884	2628			
2	Regression	10462.012	13	804.770	207.667	.000[c]
	Residual	10133.873	2615	3.875		
	Total	20595.884	2628			
6	Regression	17021.478	17	1001.263	731.394	.000[g]
	Residual	3574.407	2611	1.369		
	Total	20595.884	2628			
19	Regression	17284.449	30	576.148	452.020	.000[t]
	Residual	3311.435	2598	1.275		
	Total	20595.884	2628			

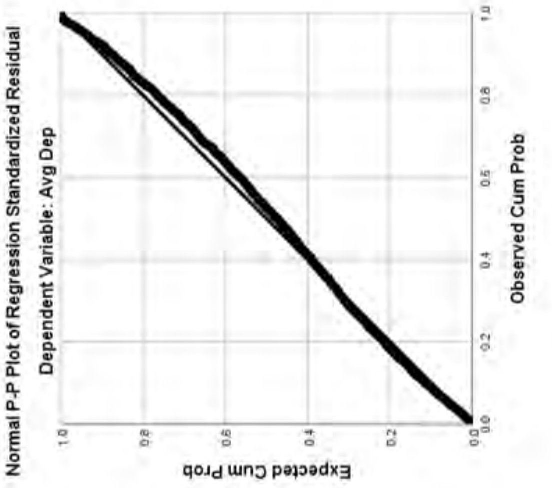
Coefficients[a]

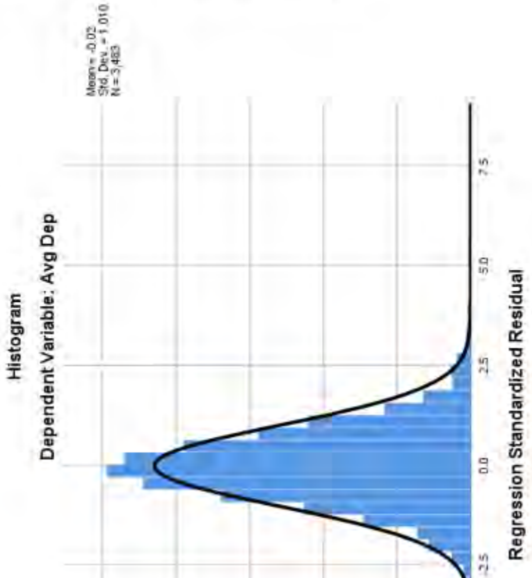
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	6.563	.055		118.698	.000		
	BSA GRP= 0 %	-1.481	.568	-.037	-2.605	.009	.995	1.005
	BSA GRP= 0-0.9%	.080	.108	.011	.737	.461	.904	1.106
	BSA GRP= 5-9%	.755	.108	.104	6.990	.000	.904	1.106
	BSA GRP=10-14%	2.281	.188	.176	12.137	.000	.961	1.041
	BSA GRP=15-19%	4.113	.271	.218	15.164	.000	.980	1.020
	BSA GRP=20-29%	5.947	.331	.257	17.953	.000	.987	1.013
	BSA GRP=30-39%	7.020	.459	.218	15.281	.000	.993	1.007
	BSA GRP=40-49%	10.748	.617	.248	17.406	.000	.996	1.004
	BSA GRP=50-59%	11.493	.617	.265	18.613	.000	.996	1.004
	BSA GRP=60-69%	11.152	.914	.174	12.203	.000	.998	1.002
	BSA_GRP=70-100%	15.269	.548	.397	27.866	.000	.995	1.005
2	(Constant)	6.986	.068		102.250	.000		
	BSA GRP= 0 %	-.935	.550	-.023	-1.699	.089	.990	1.010
	BSA GRP= 0-0.9%	.045	.105	.006	.430	.667	.897	1.115
	BSA GRP= 5-9%	.737	.104	.102	7.071	.000	.904	1.106
	BSA GRP=10-14%	2.390	.182	.184	13.147	.000	.956	1.046
	BSA GRP=15-19%	4.305	.262	.228	16.408	.000	.976	1.024
	BSA GRP=20-29%	6.033	.321	.261	18.778	.000	.977	1.023
	BSA GRP=30-39%	7.027	.444	.218	15.836	.000	.992	1.009
	BSA GRP=40-49%	11.153	.597	.257	18.681	.000	.992	1.008
	BSA GRP=50-59%	11.707	.596	.270	19.632	.000	.995	1.005
	BSA GRP=60-69%	11.325	.882	.176	12.837	.000	.998	1.002
	BSA_GRP=70-100%	15.559	.530	.405	29.374	.000	.992	1.008

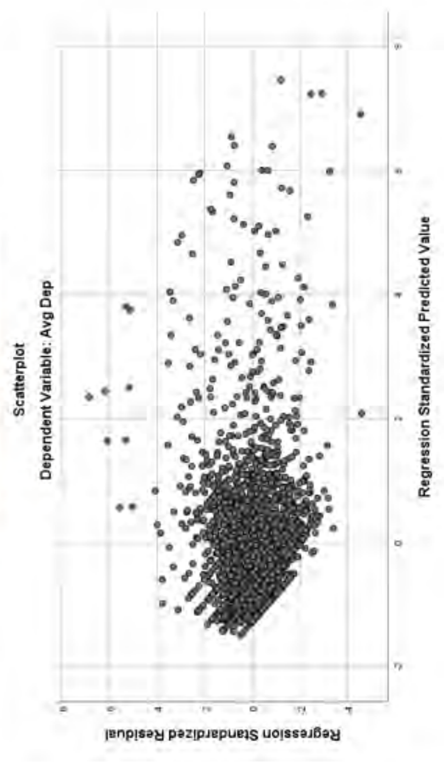
	GROUP_AGE1=Adult	-1.050	.083	-.186	-12.656	.000	.874	1.145
	GROUP_AGE1=Elderly	.170	.127	.020	1.333	.183	.875	1.143
6	(Constant)	5.556	.234		23.727	.000		
	BSA_GRP= 0 %	-.608	.327	-.015	-1.858	.063	.990	1.010
	BSA_GRP= 0-0.9%	.151	.062	.021	2.422	.015	.890	1.123
	BSA_GRP= 5-9%	.399	.062	.055	6.419	.000	.897	1.115
	BSA_GRP=10-14%	.873	.110	.067	7.906	.000	.916	1.091
	BSA_GRP=15-19%	1.351	.162	.071	8.344	.000	.906	1.104
	BSA_GRP=20-29%	1.806	.202	.078	8.925	.000	.870	1.150
	BSA_GRP=30-39%	2.090	.276	.065	7.562	.000	.903	1.107
	BSA_GRP=40-49%	3.242	.376	.075	8.631	.000	.886	1.129
	BSA_GRP=50-59%	3.542	.379	.082	9.347	.000	.870	1.149
	BSA_GRP=60-69%	4.255	.537	.066	7.923	.000	.951	1.051
	BSA_GRP=70-100%	7.415	.397	.193	18.672	.000	.623	1.604
	GROUP_AGE1=Adult	-.793	.053	-.140	-15.027	.000	.763	1.311
	GROUP_AGE1=Elderly	-.636	.079	-.073	-8.016	.000	.795	1.257
	Avg Ther Complx	.649	.010	.675	64.472	.000	.606	1.649
	Expected_outcome=3 Expected Survivor	-2.537	.212	-.129	-11.941	.000	.573	1.744
	Expected_outcome=1 >75% Survivor	-7.846	.894	-.077	-8.774	.000	.857	1.167
	CATEGORY=01 Accidental: Recreation	.286	.050	.051	5.777	.000	.848	1.179
19	(Constant)	6.193	.314		19.748	.000		
	BSA_GRP= 0 %	-.419	.317	-.010	-1.320	.187	.980	1.021
	BSA_GRP= 0-0.9%	.221	.061	.031	3.600	.000	.854	1.171
	BSA_GRP= 5-9%	.323	.064	.045	5.039	.000	.786	1.272
	BSA_GRP=10-14%	.688	.114	.053	6.041	.000	.802	1.247
	BSA_GRP=15-19%	1.115	.167	.059	6.688	.000	.795	1.257
	BSA_GRP=20-29%	1.320	.213	.057	6.184	.000	.728	1.373

	BSA_GRP=30-39%	1.593	.288	.049	5.536	.000	.775	1.290
	BSA_GRP=40-49%	2.347	.402	.054	5.836	.000	.720	1.390
	BSA_GRP=50-59%	1.588	.437	.037	3.634	.000	.610	1.640
	BSA_GRP=60-69%	2.357	.622	.037	3.789	.000	.660	1.515
	BSA_GRP=70-100%	3.686	.645	.096	5.713	.000	.220	4.548
	GROUP_AGE1=Adult	-.815	.053	-.144	-15.342	.000	.700	1.428
	GROUP_AGE1=Elderly	-.924	.097	-.107	-9.504	.000	.493	2.029
	Avg Ther Complx	.656	.010	.683	64.894	.000	.559	1.788
	Expected_outcome=3 Expected Survivor	-2.953	.297	-.150	-9.933	.000	.273	3.667
	Expected_outcome=1 >75% Survivor	-6.879	.982	-.068	-7.006	.000	.662	1.512
	CATEGORY=01 Accidental: Recreation	.308	.055	.055	5.630	.000	.648	1.542
	network=S.West	-.488	.075	-.056	-6.480	.000	.829	1.207
	network=North	-.355	.052	-.063	-6.867	.000	.725	1.380
	ABSI_MP	2.379	.490	.091	4.858	.000	.176	5.679
	Expected_outcome=2 50-75% Survivor	-3.196	.545	-.054	-5.867	.000	.717	1.394
	Expected_outcome=7 <25% Death	-1.474	.409	-.038	-3.601	.000	.546	1.832
	CATEGORY=06 Self Inflicted	.523	.171	.025	3.055	.002	.905	1.105
	LOCALITY=14 Open Space	-.444	.122	-.029	-3.630	.000	.968	1.033
	BURNAREAS_HH	-.072	.020	-.033	-3.663	.000	.781	1.281
	CATEGORY=04 Accidental: Unspecified	-.205	.071	-.026	-2.884	.004	.740	1.352
	BURNAREAS_BODY	.058	.020	.032	2.901	.004	.518	1.930
	CATEGORY=Suspected neglect or NAI of child or adult	1.026	.355	.024	2.892	.004	.924	1.082
	Expected_outcome=4 >75% Death	1.534	.596	.035	2.575	.010	.328	3.049
	LOCALITY=18 Beach	-.694	.305	-.018	-2.277	.023	.985	1.015

a. Dependent Variable: Avg Dep


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Avg Dep
Expected Cum Prob
Observed Cum Prob


Histogram
Dependent Variable: Avg Dep
Frequency
Regression Standardized Residual
Mean = -0.02
Std. Dev. = 1.010
N = 3,483


Scatterplot
Dependent Variable: Avg Dep
Regression Standardized Residual
Regression Standardized Predicted Value

The IBID sample Maximum ND total score hierarchical stepwise model

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.704[a]	.495	.493	2.636	
2	.723[b]	.523	.519	2.566	
6	.918[f]	.843	.842	1.472	
21	.927[u]	.860	.858	1.396	1.923

a. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=_0 %, BSA_GRP=30-39%, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%

b. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=_0 %, BSA_GRP=30-39%, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=Elderly, GROUP_AGE1=Adult

f. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=_0 %, BSA_GRP=30-39%, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=Elderly, GROUP_AGE1=Adult, THERAPY COMPLEXITY TOTAL, MEDICAL_INTERVENTION=M3 Acutely sick or potentially unstable medical condition, BASIC_CARE_SUPP_NEEDS=C0 Largely independent in basic care activities, BASIC CARE SUPP NEEDS=C1 Requires help from 1 person for most basic care needs

u. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA GRP=50-59%, BSA_GRP=_0 %, BSA_GRP=30-39%, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=Elderly, GROUP AGE1=Adult, THERAPY_COMPLEXITY_TOTAL, MEDICAL_INTERVENTION=M3 Acutely sick or potentially unstable medical condition, BASIC_CARE_SUPP_NEEDS=C0 Largely independent in basic care activities, BASIC CARE SUPP NEEDS=C1 Requires help from 1 person for most basic care needs, network=S.West, BCUF status=minor, CATEGORY=01 Accidental: Recreation, MEDICAL INTERVENTION=M2 Specialist medical intervention, SKILLED NURSING_NEEDS=N0 No needs for skilled nursing, ABSI MP, LOCALITY=14 Open Space, BURNAREAS LEGS, BCUF status=BF, Expected outcome=7 <25% Death, InjTm_Circ=a_1-5am, SKILLED NURSING NEEDS=N1 Requires intervention from RGN, KPI Resus=Yes, LOCALITY=18 Beach, CATEGORY=03 Accidental: Not Work Related

v. Dependent Variable: MAX_NURSE_DEPENDENCY_TOTAL

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	13716.500	11	1246.955	179.399	.000[b]
	Residual	13971.001	2010	6.951		
	Total	27687.501	2021			
2	Regression	14467.912	13	1112.916	169.047	.000[c]
	Residual	13219.590	2008	6.583		
	Total	27687.501	2021			
6	Regression	23345.808	17	1373.283	633.868	.000[g]
	Residual	4341.693	2004	2.167		
	Total	27687.501	2021			
21	Regression	23809.284	32	744.040	381.592	.000[v]
	Residual	3878.217	1989	1.950		
	Total	27687.501	2021			

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	7.725	.080		96.699	.000		
	BSA_GRP= 0 %	-2.325	.838	-.044	-2.777	.006	.996	1.004
	BSA_GRP= 0-0.9%	-.199	.155	-.021	-1.287	.198	.912	1.097
	BSA_GRP= 5-9%	1.797	.164	.181	10.957	.000	.916	1.091
	BSA_GRP=10-14%	4.589	.295	.250	15.538	.000	.968	1.033
	BSA_GRP=15-19%	7.375	.424	.278	17.375	.000	.984	1.016
	BSA_GRP=20-29%	10.184	.568	.285	17.937	.000	.991	1.009
	BSA_GRP=30-39%	12.184	.799	.242	15.250	.000	.995	1.005
	BSA_GRP=40-49%	15.108	1.079	.222	13.998	.000	.997	1.003
	BSA_GRP=50-59%	15.163	.882	.273	17.184	.000	.996	1.004
	BSA_GRP=60-69%	12.608	1.524	.131	8.272	.000	.999	1.001
	BSA_GRP=70-100%	16.375	.838	.310	19.551	.000	.996	1.004
2	(Constant)	8.100	.099		81.994	.000		
	BSA_GRP= 0 %	-1.716	.817	-.033	-2.099	.036	.991	1.009
	BSA_GRP= 0-0.9%	-.245	.151	-.026	-1.618	.106	.899	1.112
	BSA_GRP= 5-9%	1.801	.160	.182	11.285	.000	.916	1.092
	BSA_GRP=10-14%	4.759	.289	.260	16.490	.000	.960	1.042
	BSA_GRP=15-19%	7.545	.414	.284	18.235	.000	.981	1.020
	BSA_GRP=20-29%	10.303	.554	.289	18.590	.000	.985	1.015
	BSA_GRP=30-39%	12.154	.778	.242	15.618	.000	.994	1.006
	BSA_GRP=40-49%	15.276	1.052	.225	14.520	.000	.994	1.006
	BSA_GRP=50-59%	15.456	.859	.278	17.984	.000	.995	1.005
	BSA_GRP=60-69%	12.411	1.484	.129	8.364	.000	.998	1.002
	BSA_GRP=70-100%	16.819	.817	.319	20.598	.000	.992	1.008

	GROUP_AGE1=Adult	-1.094	.124	-.145	-8.839	.000	.879	1.137
	GROUP_AGE1=Elderly	.560	.192	.048	2.924	.003	.887	1.127
3	(Constant)	3.974	.107		37.053	.000		
	BSA_GRP= 0 %	-1.414	.551	-.027	-2.566	.010	.991	1.009
	BSA_GRP= 0-0.9%	-.016	.102	-.002	-.152	.879	.897	1.114
	BSA_GRP= 5-9%	.910	.109	.092	8.340	.000	.891	1.123
	BSA_GRP=10-14%	2.287	.201	.125	11.378	.000	.900	1.111
	BSA_GRP=15-19%	3.837	.289	.144	13.274	.000	.914	1.094
	BSA_GRP=20-29%	5.192	.388	.146	13.384	.000	.914	1.094
	BSA_GRP=30-39%	6.394	.538	.127	11.890	.000	.946	1.057
	BSA_GRP=40-49%	6.581	.731	.097	9.000	.000	.936	1.069
	BSA_GRP=50-59%	7.639	.601	.137	12.710	.000	.925	1.081
	BSA_GRP=60-69%	7.409	1.006	.077	7.366	.000	.988	1.012
	BSA_GRP=70-100%	10.262	.567	.195	18.111	.000	.937	1.067
	GROUP_AGE1=Adult	-.787	.084	-.105	-9.409	.000	.874	1.144
	GROUP_AGE1=Elderly	-.242	.130	-.021	-1.861	.063	.873	1.145
	THERAPY_COMPLEXITY_TOTAL	.634	.013	.625	49.077	.000	.666	1.501
4	(Constant)	4.461	.106		42.042	.000		
	BSA_GRP= 0 %	-1.372	.521	-.026	-2.634	.008	.991	1.010
	BSA_GRP= 0-0.9%	-.030	.097	-.003	-.314	.754	.897	1.115
	BSA_GRP= 5-9%	.937	.103	.095	9.085	.000	.890	1.123
	BSA_GRP=10-14%	2.130	.190	.116	11.198	.000	.897	1.114
	BSA_GRP=15-19%	3.437	.274	.129	12.524	.000	.906	1.104
	BSA_GRP=20-29%	4.606	.369	.129	12.495	.000	.904	1.106
	BSA_GRP=30-39%	4.621	.521	.092	8.870	.000	.901	1.110
	BSA_GRP=40-49%	4.400	.705	.065	6.239	.000	.899	1.113
	BSA_GRP=50-59%	5.541	.584	.100	9.491	.000	.875	1.142

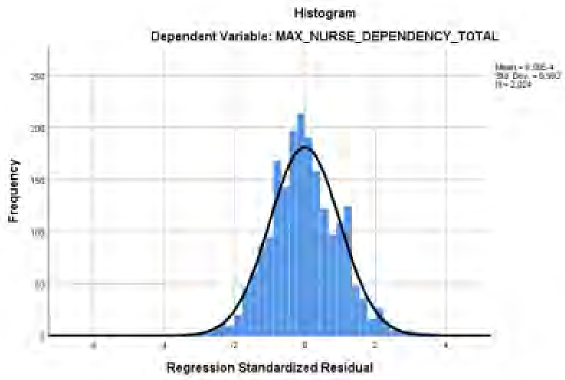
	BSA_GRP=60-69%	5.429	.959	.056	5.660	.000	.970	1.031
	BSA_GRP=70-100%	7.167	.571	.136	12.542	.000	.823	1.215
	GROUP_AGE1=Adult	-.932	.080	-.124	-11.703	.000	.862	1.159
	GROUP_AGE1=Elderly	-.309	.123	-.026	-2.514	.012	.872	1.147
	THERAPY COMPLEXITY_TOTAL	.562	.013	.555	43.159	.000	.584	1.713
	MEDICAL_INTERVENTION=M3 Acutely sick or potentially unstable medical condition	3.912	.252	.206	15.523	.000	.548	1.824
5	(Constant)	5.329	.115		46.382	.000		
	BSA_GRP= 0 %	-1.262	.492	-.024	-2.564	.010	.990	1.010
	BSA_GRP= 0-0.9%	-.071	.091	-.008	-.775	.438	.896	1.115
	BSA_GRP= 5-9%	.930	.098	.094	9.534	.000	.890	1.123
	BSA_GRP=10-14%	1.962	.180	.107	10.889	.000	.894	1.119
	BSA_GRP=15-19%	3.145	.260	.118	12.091	.000	.901	1.110
	BSA_GRP=20-29%	4.304	.349	.121	12.334	.000	.902	1.109
	BSA_GRP=30-39%	4.494	.492	.089	9.127	.000	.901	1.110
	BSA_GRP=40-49%	4.431	.667	.065	6.647	.000	.899	1.113
	BSA_GRP=50-59%	5.567	.552	.100	10.087	.000	.875	1.142
	BSA_GRP=60-69%	5.295	.907	.055	5.840	.000	.970	1.031
	BSA_GRP=70-100%	6.934	.540	.131	12.833	.000	.822	1.216
	GROUP_AGE1=Adult	-.018	.096	-.002	-.185	.853	.534	1.872
	GROUP_AGE1=Elderly	.289	.123	.025	2.359	.018	.785	1.273
	THERAPY_COMPLEXITY_TOTAL	.483	.013	.476	36.130	.000	.497	2.013
	MEDICAL_INTERVENTION=M3 Acutely sick or potentially unstable medical condition	3.811	.238	.201	15.995	.000	.548	1.826

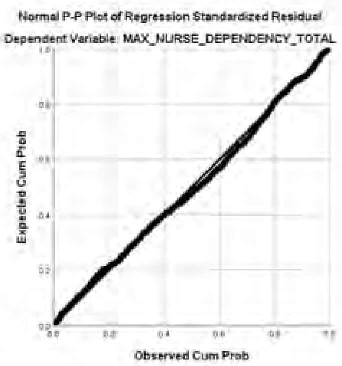
	BASIC_CARE_SUPP_NEEDS=C0 Largely independent in basic care activities	-1.503	.097	-.203	-15.489	.000	.504	1.984
6	(Constant)	8.310	.234		35.490	.000		
	BSA_GRP= 0 %	-1.271	.469	-.024	-2.711	.007	.990	1.010
	BSA_GRP= 0-0.9%	-.075	.087	-.008	-.866	.386	.896	1.115
	BSA_GRP= 5-9%	.908	.093	.092	9.781	.000	.890	1.123
	BSA_GRP=10-14%	1.758	.172	.096	10.216	.000	.888	1.126
	BSA_GRP=15-19%	2.529	.251	.095	10.065	.000	.875	1.143
	BSA_GRP=20-29%	3.487	.337	.098	10.345	.000	.876	1.141
	BSA_GRP=30-39%	3.986	.470	.079	8.476	.000	.896	1.117
	BSA_GRP=40-49%	4.165	.635	.061	6.559	.000	.898	1.114
	BSA_GRP=50-59%	4.932	.527	.089	9.351	.000	.869	1.150
	BSA_GRP=60-69%	4.932	.864	.051	5.710	.000	.969	1.032
	BSA_GRP=70-100%	6.174	.517	.117	11.937	.000	.814	1.229
	GROUP_AGE1=Adult	-.152	.092	-.020	-1.657	.098	.529	1.892
	GROUP_AGE1=Elderly	-.004	.119	.000	-.030	.976	.762	1.312
	THERAPY_COMPLEXITY_TOTAL	.430	.013	.424	32.471	.000	.459	2.180
	MEDICAL_INTERVENTION=M3 Acutely sick or potentially unstable medical condition	2.603	.242	.137	10.759	.000	.482	2.075
	BASIC_CARE_SUPP_NEEDS=C0 Largely independent in basic care activities	-4.045	.199	-.545	-20.302	.000	.108	9.226
	BASIC_CARE_SUPP_NEEDS=C1 Requires help from 1 person for most basic care needs	-2.686	.187	-.362	-14.401	.000	.124	8.061
21	(Constant)	8.531	.277		30.839	.000		

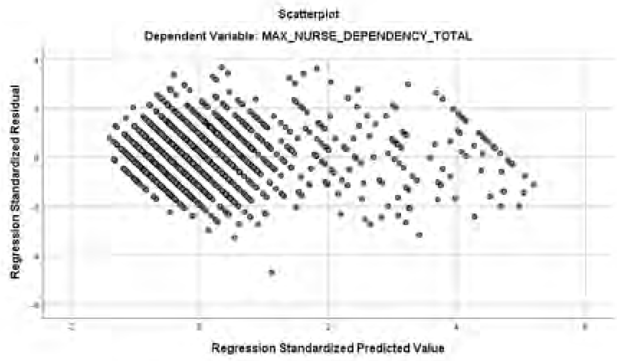
	BSA GRP= 0 %	-1.377	.449	-.026	-3.069	.002	.974	1.027
	BSA GRP= 0-0.9%	.091	.088	.010	1.031	.303	.783	1.277
	BSA GRP= 5-9%	.550	.120	.055	4.586	.000	.481	2.079
	BSA GRP=10-14%	.888	.248	.048	3.574	.000	.384	2.608
	BSA GRP=15-19%	1.097	.469	.041	2.340	.019	.226	4.420
	BSA GRP=20-29%	1.870	.530	.052	3.528	.000	.319	3.135
	BSA GRP=30-39%	1.950	.634	.039	3.078	.002	.444	2.252
	BSA GRP=40-49%	2.370	.784	.035	3.025	.003	.531	1.884
	BSA GRP=50-59%	2.335	.738	.042	3.166	.002	.400	2.500
	BSA GRP=60-69%	1.963	1.009	.020	1.945	.052	.639	1.565
	BSA GRP=70-100%	2.855	.824	.054	3.465	.001	.289	3.465
	GROUP AGE1=Adult	-.012	.103	-.002	-.118	.906	.376	2.658
	GROUP AGE1=Elderly	-.138	.152	-.012	-.913	.362	.420	2.381
	THERAPY COMPLEXITY TOTAL	.430	.013	.424	33.873	.000	.450	2.223
	MEDICAL_INTERVENTION=M3 Acutely sick or potentially unstable medical condition	2.665	.245	.140	10.855	.000	.421	2.375
	BASIC_CARE_SUPP_NEEDS=C0 Largely independent in basic care activities	-3.718	.193	-.501	-19.231	.000	.104	9.654
	BASIC_CARE_SUPP_NEEDS=C1 Requires help from 1 person for most basic care needs	-2.467	.182	-.332	-13.543	.000	.117	8.543
	network=S.West	-.614	.098	-.059	-6.269	.000	.795	1.257
	BCUF_status=minor	-.782	.166	-.099	-4.717	.000	.160	6.241
	CATEGORY=01 Accidental: Recreation	.287	.081	.038	3.529	.000	.593	1.687
	MEDICAL_INTERVENTION=M2 Specialist medical intervention	.247	.074	.033	3.359	.001	.732	1.367

	SKILLED_NURSING_NEEDS=N0 No needs for skilled nursing	-.946	.234	-.040	-4.051	.000	.718	1.392
	ABSI_MP	2.160	.675	.059	3.201	.001	.207	4.829
	LOCALITY=14 Open Space	-.562	.172	-.028	-3.271	.001	.963	1.038
	BURNAREAS_LEGS	.089	.028	.031	3.192	.001	.727	1.376
	BCUF_status=BF	-.395	.149	-.053	-2.654	.008	.174	5.742
	Expected_outcome=7 <25% Death	-1.346	.507	-.024	-2.656	.008	.847	1.180
	InjTm_Circ=a 1-5am	-.381	.162	-.020	-2.352	.019	.958	1.044
	SKILLED_NURSING_NEEDS=N1 Requires intervention from a RGN	-.232	.112	-.023	-2.081	.038	.575	1.739
	KPI_Resus=Yes	.776	.358	.050	2.168	.030	.132	7.582
	LOCALITY=18 Beach	-.764	.378	-.017	-2.022	.043	.982	1.018
	CATEGORY=03 Accidental: Not Work Related	-.207	.102	-.021	-2.019	.044	.675	1.481

a. Dependent Variable: MAX_NURSE_DEPENDENCY_TOTAL







The IBID sample First ND total score hierarchical stepwise model

Model Summary[ab]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.695[a]	.483	.480	2.515	
2	.714[b]	.509	.506	2.452	
6	.910[f]	.828	.827	1.452	
27	.922[aa]	.851	.848	1.359	1.882

a. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=_0 %, BSA_GRP=30-39%, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%

b. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=_0 %, BSA_GRP=30-39%, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=3.0, GROUP_AGE1=2.0

f. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=_0 %, BSA_GRP=30-39%, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=3.0, GROUP_AGE1=2.0, THERAPY_COMPLEXITY_TOTAL, BASIC_CARE_SUPP_NEEDS=C3 Requires help from > 2 people or 1:1 supervision, BASIC_CARE_SUPP_NEEDS=C0 Largely independent in basic care activities, BASIC_CARE_SUPP_NEEDS=C2 Requires help from 2 people for most basic care needs

aa. Predictors: (Constant), BSA GRP=70-100%, BSA GRP=60-69%, BSA GRP=40-49%, BSA GRP=50-59%, BSA GRP=0 %, BSA GRP=30-39%, BSA GRP=20-29%, BSA GRP=15-19%, BSA GRP=10-14%, BSA GRP=_5-9%, BSA GRP=_0-0.9%, GROUP AGE1=3.0, GROUP AGE1=2.0, THERAPY COMPLEXITY TOTAL, BASIC CARE_SUPP NEEDS=C3 Requires help from > 2 people or 1:1 supervision, BASIC CARE_SUPP NEEDS=C0 Largely independent in basic care activities, BASIC CARE SUPP NEEDS=C2 Requires help from 2 people for most basic care needs, network=S.West, MEDICAL INTERVENTION=M3 Acutely sick or potentially unstable medical condition, CATEGORY=01 Accidental: Recreation, Expected outcome=2.0, LOCALITY=18 Beach, InjTm Circ=c_9-1pm, InjTm Circ=b_5-9am, InjTm_Circ=d 1-5pm, MEDICAL INTERVENTION=M0 No active medical intervention, BCUF status=minor, LOCALITY=14 Open Space, ABSI_MP, CATEGORY=Suspected neglect or NAI of child or adult, network=North, SKILLED NURSING NEEDS=N0 No needs for skilled nursing, SKILLED NURSING NEEDS=N1 Requires intervention from a RGN, BURNAREAS LEGS, LOCALITY=08 Other Transport, InjTm_Circ=a 1-5am

ab. Dependent Variable: FIRST_NURSE_DEPENDENCY_TOTAL

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11949.694	11	1086.336	171.710	.000[b]
	Residual	12792.344	2022	6.327		
	Total	24742.038	2033			
2	Regression	12601.330	13	969.333	161.280	.000[c]
	Residual	12140.708	2020	6.010		
	Total	24742.038	2033			
6	Regression	20489.868	17	1205.286	571.439	.000[g]
	Residual	4252.169	2016	2.109		
	Total	24742.038	2033			
27	Regression	21052.681	36	584.797	316.543	.000[ab]
	Residual	3689.357	1997	1.847		
	Total	24742.038	2033			

Coefficients[a]

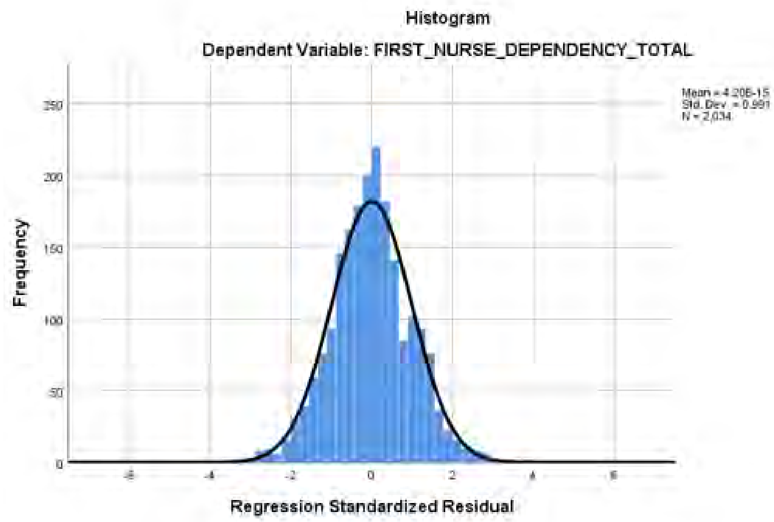
Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	7.149	.076		94.091	.000	7.000	7.298		
	BSA GRP= 0 %	-1.849	.799	-.037	-2.314	.021	-3.416	-.282	.996	1.004
	BSA GRP= 0-0.9%	.012	.147	.001	.085	.932	-.276	.301	.912	1.096
	BSA GRP= 5-9%	1.430	.155	.154	9.198	.000	1.125	1.735	.916	1.092
	BSA GRP=10-14%	4.223	.282	.244	14.994	.000	3.671	4.776	.968	1.033
	BSA GRP=15-19%	6.926	.405	.276	17.107	.000	6.132	7.720	.984	1.016
	BSA GRP=20-29%	8.260	.542	.245	15.251	.000	7.198	9.323	.991	1.009
	BSA GRP=30-39%	11.033	.762	.232	14.476	.000	9.538	12.528	.995	1.005
	BSA GRP=40-49%	15.518	1.030	.241	15.071	.000	13.499	17.537	.997	1.003
	BSA GRP=50-59%	14.518	.842	.276	17.245	.000	12.867	16.169	.996	1.004
	BSA GRP=60-69%	13.185	1.454	.145	9.067	.000	10.333	16.036	.999	1.001
	BSA_GRP=70-100%	16.551	.799	.332	20.715	.000	14.984	18.118	.996	1.004
2	(Constant)	7.672	.094		81.352	.000	7.487	7.857		
	BSA GRP= 0 %	-1.283	.781	-.026	-1.643	.101	-2.814	.248	.991	1.009
	BSA GRP= 0-0.9%	-.100	.145	-.011	-.689	.491	-.383	.184	.899	1.112
	BSA GRP= 5-9%	1.444	.152	.155	9.529	.000	1.147	1.741	.916	1.092
	BSA GRP=10-14%	4.450	.276	.257	16.145	.000	3.909	4.991	.961	1.041
	BSA GRP=15-19%	7.141	.395	.284	18.067	.000	6.366	7.917	.981	1.019
	BSA GRP=20-29%	8.530	.529	.253	16.111	.000	7.492	9.568	.985	1.015
	BSA GRP=30-39%	11.138	.743	.234	14.980	.000	9.679	12.596	.994	1.006
	BSA GRP=40-49%	15.896	1.005	.247	15.814	.000	13.925	17.868	.994	1.006
	BSA GRP=50-59%	14.833	.821	.282	18.065	.000	13.223	16.443	.995	1.005
	BSA GRP=60-69%	13.160	1.418	.145	9.281	.000	10.379	15.940	.998	1.002
	BSA_GRP=70-100%	17.025	.780	.341	21.823	.000	15.495	18.555	.992	1.008

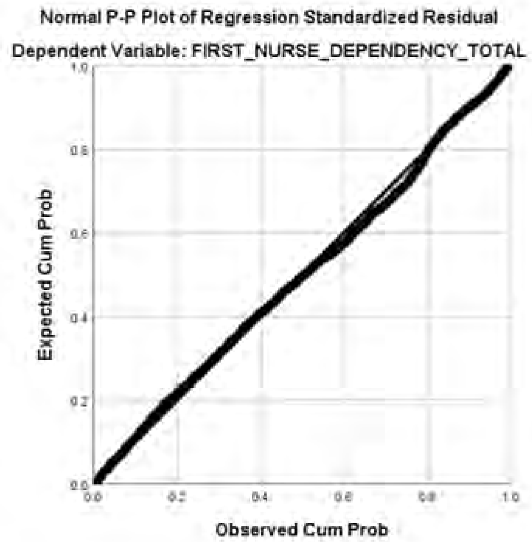
	GROUP_AGE1=2.0	-1.211	.118	-.171	-10.262	.000	-1.442	-.979	.878	1.139
	GROUP_AGE1=3.0	-.286	.181	-.026	-1.575	.115	-.641	.070	.885	1.130
6	(Constant)	5.079	.113		44.981	.000	4.857	5.300		
	BSA_GRP= 0 %	-1.104	.463	-.022	-2.386	.017	-2.011	-.196	.991	1.010
	BSA_GRP= 0-0.9%	.034	.086	.004	.398	.691	-.134	.202	.896	1.116
	BSA_GRP= 5-9%	.818	.090	.088	9.047	.000	.641	.995	.903	1.108
	BSA_GRP=10-14%	1.792	.169	.103	10.583	.000	1.460	2.125	.893	1.120
	BSA_GRP=15-19%	2.403	.247	.096	9.720	.000	1.918	2.888	.880	1.136
	BSA_GRP=20-29%	3.283	.325	.097	10.087	.000	2.645	3.921	.915	1.093
	BSA_GRP=30-39%	3.820	.458	.080	8.339	.000	2.921	4.718	.919	1.088
	BSA_GRP=40-49%	4.632	.629	.072	7.367	.000	3.399	5.865	.892	1.121
	BSA_GRP=50-59%	5.056	.521	.096	9.705	.000	4.035	6.078	.867	1.153
	BSA_GRP=60-69%	5.618	.852	.062	6.596	.000	3.948	7.288	.971	1.030
	BSA_GRP=70-100%	6.832	.505	.137	13.536	.000	5.842	7.822	.832	1.202
	GROUP_AGE1=2.0	-.116	.090	-.016	-1.280	.201	-.293	.062	.525	1.903
	GROUP_AGE1=3.0	-.143	.116	-.013	-1.236	.216	-.370	.084	.764	1.309
	THERAPY_COMPLEXITY_TOTAL	.464	.014	.438	32.670	.000	.436	.491	.474	2.109
	BASIC_CARE_SUPP_NEEDS=C3 Requires help from > 2 people or 1:1 supervision	4.386	.221	.254	19.831	.000	3.953	4.820	.518	1.932
	BASIC_CARE_SUPP_NEEDS=C0 Largely independent in basic care activities	-1.245	.092	-.178	-13.513	.000	-1.426	-1.064	.489	2.047
	BASIC_CARE_SUPP_NEEDS=C2 Requires help from 2 people for most basic care needs	2.639	.263	.098	10.046	.000	2.124	3.154	.888	1.126
27	(Constant)	5.204	.178		29.203	.000	4.854	5.553		
	BSA_GRP=_0 %	-1.018	.437	-.020	-2.330	.020	-1.875	-.161	.972	1.029

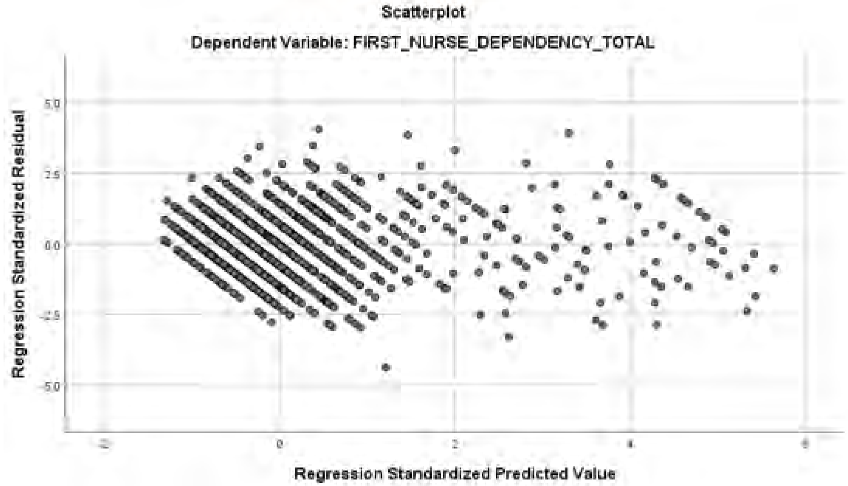
	BSA_GRP= 0-0.9%	.091	.086	.010	1.064	.288	-.077	.260	.784	1.276
	BSA_GRP= 5-9%	.774	.089	.083	8.691	.000	.599	.948	.815	1.226
	BSA_GRP=10-14%	1.576	.164	.091	9.609	.000	1.254	1.898	.834	1.199
	BSA_GRP=15-19%	2.185	.236	.087	9.242	.000	1.721	2.649	.843	1.186
	BSA_GRP=20-29%	2.672	.323	.079	8.262	.000	2.038	3.307	.811	1.232
	BSA_GRP=30-39%	2.524	.474	.053	5.323	.000	1.594	3.453	.751	1.331
	BSA_GRP=40-49%	2.799	.659	.044	4.250	.000	1.508	4.091	.712	1.405
	BSA_GRP=50-59%	3.410	.596	.065	5.721	.000	2.241	4.579	.580	1.723
	BSA_GRP=60-69%	3.528	.912	.039	3.869	.000	1.739	5.316	.742	1.348
	BSA_GRP=70-100%	4.393	.699	.088	6.284	.000	3.022	5.764	.380	2.633
	GROUP_AGE1=2.0	-.028	.092	-.004	-.303	.762	-.209	.153	.440	2.275
	GROUP_AGE1=3.0	-.273	.143	-.025	-1.912	.056	-.552	.007	.440	2.271
	THERAPY_COMPLEXITY_TOTAL	.457	.014	.432	33.564	.000	.430	.483	.452	2.214
	BASIC_CARE_SUPP_NEEDS=C3 Requires help from > 2 people or 1:1 supervision	3.171	.255	.184	12.445	.000	2.672	3.671	.342	2.927
	BASIC_CARE_SUPP_NEEDS=C0 Largely independent in basic care activities	-1.084	.089	-.155	-12.152	.000	-1.258	-.909	.457	2.188
	BASIC_CARE_SUPP_NEEDS=C2 Requires help from 2 people for most basic care needs	2.136	.253	.080	8.427	.000	1.639	2.633	.836	1.196
	network=S.West	-.897	.106	-.091	-8.441	.000	-1.106	-.689	.639	1.564
	MEDICAL_INTERVENTION=M3 Acutely sick or potentially unstable medical condition	2.167	.272	.114	7.961	.000	1.633	2.701	.364	2.748
	CATEGORY=01 Accidental: Recreation	.399	.070	.057	5.737	.000	.262	.535	.763	1.311

	Expected_outcome=2.0	2.999	1.054	.027	2.846	.004	.932	5.066	.833	1.201
	LOCALITY=18 Beach	-1.209	.369	-.029	-3.276	.001	-1.933	-.485	.975	1.026
	InjTm_Circ=c 9-1pm	.324	.081	.038	3.983	.000	.165	.484	.838	1.193
	InjTm_Circ=b 5-9am	.458	.124	.034	3.696	.000	.215	.700	.895	1.118
	InjTm_Circ=d 1-5pm	.203	.077	.025	2.629	.009	.052	.355	.833	1.200
	MEDICAL_INTERVENTION=M0 No active medical intervention	-.494	.196	-.023	-2.523	.012	-.878	-.110	.934	1.071
	BCUF_status=minor	-.138	.077	-.018	-1.795	.073	-.288	.013	.707	1.415
	LOCALITY=14 Open Space	-.428	.167	-.023	-2.558	.011	-.756	-.100	.962	1.039
	ABSI_MP	1.407	.656	.041	2.145	.032	.121	2.693	.207	4.820
	CATEGORY=Suspected neglect or NAI of child or adult	.996	.427	.021	2.331	.020	.158	1.834	.925	1.081
	network=North	-.254	.083	-.035	-3.078	.002	-.416	-.092	.592	1.690
	SKILLED_NURSING_NEEDS=N0 No needs for skilled nursing	-.690	.227	-.031	-3.041	.002	-1.134	-.245	.709	1.410
	SKILLED_NURSING_NEEDS=N1 Requires intervention from a RGN	-.257	.114	-.026	-2.263	.024	-.480	-.034	.560	1.784
	BURNAREAS_LEGS	.061	.027	.023	2.263	.024	.008	.113	.734	1.362
	LOCALITY=08 Other Transport	-1.324	.622	-.019	-2.131	.033	-2.543	-.105	.959	1.043
	InjTm_Circ=a 1-5am	-.334	.160	-.019	-2.088	.037	-.649	-.020	.915	1.093

a. Dependent Variable: FIRST_NURSE_DEPENDENCY_TOTAL


Histogram
Dependent Variable: FIRST_NURSE_DEPENDENCY_TOTAL
Std. Dev. = 0.991
N = 2,034
Frequency
Regression Standardized Residual


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: FIRST_NURSE_DEPENDENCY_TOTAL
Expected Cum Prob
Observed Cum Prob


Scatterplot
Dependent Variable: FIRST_NURSE_DEPENDENCY_TOTAL
Regression Standardized Residual
Regression Standardized Predicted Value

The IBID sample Minimum ND total score hierarchical stepwise model

Model Summary[x]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.537[a]	.288	.284	2.093	
2	.598[b]	.357	.353	1.990	
6	.833[f]	.693	.691	1.376	
23	.856[w]	.732	.728	1.291	1.926

a. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=30-39%, BSA_GRP=_0 %, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%

b. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=30-39%, BSA_GRP=_0 %, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=Elderly, GROUP_AGE1=Adult

f. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=30-39%, BSA_GRP=_0 %, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=Elderly, GROUP_AGE1=Adult, THERAPY_COMPLEXITY_TOTAL, MEDICAL_INTERVENTION=M3 Acutely sick or potentially unstable medical condition, BASIC_CARE_SUPP_NEEDS=C0 Largely independent in basic care activities, BASIC_CARE_SUPP_NEEDS=C1 Requires help from 1 person for most basic care needs

w. Predictors: (Constant), BSA GRP=70-100%, BSA GRP=60-69%, BSA GRP=40-49%, BSA GRP=50-59%, BSA GRP=30-39%, BSA GRP=_0 %, BSA GRP=20-29%, BSA GRP=15-19%, BSA GRP=10-14%, BSA GRP=_5-9%, BSA GRP=_0-0.9%, GROUP AGE1=Elderly, GROUP AGE1=Adult, THERAPY COMPLEXITY_TOTAL, MEDICAL INTERVENTION=M3 Acutely sick or potentially unstable medical condition, BASIC CARE SUPP NEEDS=C0 Largely independent in basic care activities, BASIC CARE SUPP NEEDS=C1 Requires help from 1 person for most basic care needs, Expected outcome=1 >75% Survivor, Expected outcome=3 Expected Survivor, LOCATION=BICU, LOCATION=general ICU, Expected outcome=4_>75% Death, BURNAREAS_HH, network=North, SKILLED NURSING NEEDS=N2 Requires intervention from trained rehabilitation nursing staff, BURNAREAS LEGS, BCUF status=B C, LOCATION=BHDU, CATEGORY=09 Arson, KPI Resus=Yes, LOCALITY=14 Open Space, GENDER=Female, BCUF status=minor, SKILLED NURSING NEEDS=N3 Requires highly specialist nursing care

x. Dependent Variable: MIN_NURSE_DEPENDENCY_TOTAL

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3566.176	11	324.198	74.023	.000[b]
	Residual	8807.525	2011	4.380		
	Total	12373.701	2022			
2	Regression	4421.223	13	340.094	85.916	.000[c]
	Residual	7952.478	2009	3.958		
	Total	12373.701	2022			
6	Regression	8579.871	17	504.698	266.728	.000[g]
	Residual	3793.830	2005	1.892		
	Total	12373.701	2022			
23	Regression	9060.346	34	266.481	159.887	.000[x]
	Residual	3313.356	1988	1.667		
	Total	12373.701	2022			

Coefficients[a]

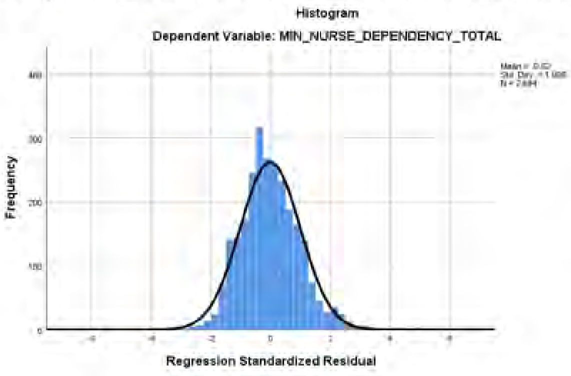
Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	5.801	.063		91.679	.000	5.677	5.925		
	BSA GRP= 0 %	-1.101	.665	-.031	-1.656	.098	-2.405	.203	.996	1.004
	BSA GRP= 0-0.9%	.348	.123	.056	2.837	.005	.107	.588	.913	1.095
	BSA GRP= 5-9%	.075	.130	.011	.576	.565	-.180	.330	.917	1.090
	BSA GRP=10-14%	.858	.236	.070	3.641	.000	.396	1.320	.969	1.032
	BSA GRP=15-19%	1.071	.341	.060	3.141	.002	.402	1.740	.985	1.016
	BSA GRP=20-29%	1.654	.451	.069	3.670	.000	.770	2.538	.991	1.009
	BSA GRP=30-39%	2.899	.665	.082	4.361	.000	1.595	4.203	.996	1.004
	BSA GRP=40-49%	11.033	.857	.243	12.878	.000	9.352	12.713	.998	1.003
	BSA GRP=50-59%	8.199	.700	.221	11.706	.000	6.826	9.573	.996	1.004
	BSA GRP=60-69%	11.199	1.210	.174	9.256	.000	8.826	13.572	.999	1.001
	BSA_GRP=70-100%	13.199	.665	.374	19.854	.000	11.895	14.503	.996	1.004
2	(Constant)	6.447	.077		84.116	.000	6.297	6.598		
	BSA GRP= 0 %	-.479	.634	-.014	-.756	.450	-1.721	.764	.991	1.009
	BSA GRP= 0-0.9%	.196	.117	.032	1.672	.095	-.034	.427	.900	1.112
	BSA GRP= 5-9%	.092	.124	.014	.746	.456	-.150	.335	.917	1.091
	BSA GRP=10-14%	1.128	.225	.092	5.018	.000	.687	1.569	.961	1.040
	BSA GRP=15-19%	1.317	.325	.073	4.056	.000	.680	1.954	.982	1.019
	BSA GRP=20-29%	2.013	.430	.084	4.684	.000	1.170	2.856	.985	1.015
	BSA GRP=30-39%	3.084	.632	.087	4.878	.000	1.844	4.324	.995	1.005
	BSA GRP=40-49%	11.537	.816	.254	14.142	.000	9.937	13.137	.994	1.006
	BSA GRP=50-59%	8.563	.666	.230	12.850	.000	7.256	9.870	.995	1.005
	BSA GRP=60-69%	11.234	1.151	.175	9.763	.000	8.977	13.490	.998	1.002
	BSA_GRP=70-100%	13.744	.633	.390	21.708	.000	12.502	14.985	.992	1.008

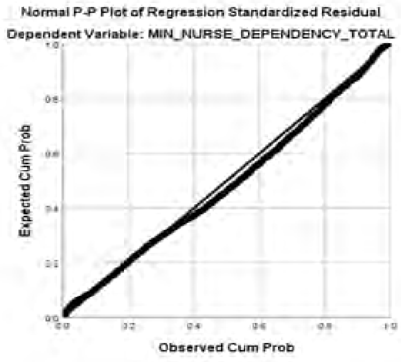
	GROUP_AGE1=Adult	-1.409	.096	-.280	-14.693	.000	-1.598	-1.221	.879	1.138
	GROUP_AGE1=Elderly	-.634	.148	-.081	-4.282	.000	-.924	-.343	.887	1.127
6	(Constant)	7.218	.307		23.497	.000	6.616	7.820		
	BSA_GRP= 0 %	-.645	.438	-.018	-1.471	.141	-1.504	.215	.990	1.010
	BSA_GRP= 0-0.9%	.170	.081	.027	2.091	.037	.011	.330	.897	1.115
	BSA_GRP= 5-9%	-.124	.086	-.019	-1.441	.150	-.292	.045	.912	1.097
	BSA_GRP=10-14%	.220	.157	.018	1.402	.161	-.088	.528	.943	1.060
	BSA_GRP=15-19%	.039	.228	.002	.172	.863	-.408	.486	.952	1.050
	BSA_GRP=20-29%	-.074	.301	-.003	-.247	.805	-.664	.515	.961	1.040
	BSA_GRP=30-39%	.449	.441	.013	1.018	.309	-.416	1.313	.978	1.022
	BSA_GRP=40-49%	2.868	.601	.063	4.773	.000	1.690	4.047	.876	1.142
	BSA_GRP=50-59%	-.159	.510	-.004	-.311	.755	-1.158	.841	.813	1.230
	BSA_GRP=60-69%	2.805	.831	.044	3.374	.001	1.175	4.436	.914	1.094
	BSA_GRP=70-100%	3.659	.512	.104	7.146	.000	2.655	4.664	.725	1.379
	GROUP_AGE1=Adult	-.541	.087	-.108	-6.211	.000	-.712	-.370	.509	1.964
	GROUP_AGE1=Elderly	-.370	.112	-.048	-3.306	.001	-.590	-.151	.741	1.350
	THERAPY_COMPLEXITY_TOTAL	.338	.013	.380	25.319	.000	.312	.364	.680	1.471
	MEDICAL_INTERVENTION=M3 Acutely sick or potentially unstable medical condition	5.820	.402	.265	14.490	.000	5.032	6.607	.457	2.188
	BASIC_CARE_SUPP_NEEDS=C0 Largely independent in basic care activities	-3.538	.281	-.709	-12.604	.000	-4.088	-2.987	.048	20.689
	BASIC_CARE_SUPP_NEEDS=C1 Requires help from 1 person for most basic care needs	-2.301	.281	-.458	-8.192	.000	-2.852	-1.750	.049	20.398
23	(Constant)	8.748	.434		20.142	.000	7.896	9.600		
	BSA_GRP=_0 %	-.829	.414	-.023	-2.001	.045	-1.641	-.017	.977	1.024

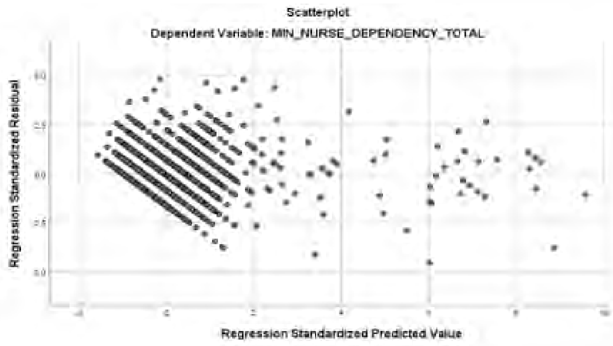
	BSA_GRP= 0-0.9%	.126	.081	.020	1.555	.120	-.033	.286	.791	1.265
	BSA_GRP= 5-9%	.057	.086	.009	.659	.510	-.112	.226	.796	1.257
	BSA_GRP=10-14%	.208	.178	.017	1.169	.242	-.141	.557	.646	1.549
	BSA_GRP=15-19%	-.992	.400	-.055	-2.480	.013	-1.776	-.208	.272	3.671
	BSA_GRP=20-29%	-1.065	.448	-.045	-2.374	.018	-1.944	-.185	.381	2.625
	BSA_GRP=30-39%	-1.407	.586	-.040	-2.400	.016	-2.556	-.257	.488	2.051
	BSA_GRP=40-49%	-1.560	.975	-.034	-1.601	.110	-3.472	.351	.293	3.411
	BSA_GRP=50-59%	-3.760	.910	-.101	-4.131	.000	-5.544	-1.975	.225	4.453
	BSA_GRP=60-69%	-1.038	1.114	-.016	-.932	.352	-3.222	1.146	.449	2.229
	BSA_GRP=70-100%	-1.131	1.064	-.032	-1.063	.288	-3.218	.956	.148	6.763
	GROUP_AGE1=Adult	-.564	.087	-.112	-6.520	.000	-.734	-.394	.455	2.197
	GROUP_AGE1=Elderly	-.505	.110	-.065	-4.615	.000	-.720	-.291	.682	1.467
	THERAPY_COMPLEXITY_TOTAL	.348	.013	.391	27.244	.000	.323	.373	.654	1.529
	MEDICAL_INTERVENTION=M3 Acutely sick or potentially unstable medical condition	3.164	.453	.144	6.991	.000	2.277	4.052	.317	3.155
	BASIC_CARE_SUPP_NEEDS=C0 Largely independent in basic care activities	-2.563	.281	-.514	-9.117	.000	-3.114	-2.011	.042	23.558
	BASIC_CARE_SUPP_NEEDS=C1 Requires help from 1 person for most basic care needs	-1.353	.281	-.269	-4.817	.000	-1.903	-.802	.043	23.151
	Expected_outcome=1_>75% Survivor	-4.687	1.220	-.060	-3.841	.000	-7.081	-2.294	.560	1.786
	Expected_outcome=3_Expected Survivor	-2.153	.370	-.109	-5.822	.000	-2.878	-1.428	.387	2.585
	LOCATION=BICU	3.122	.515	.119	6.060	.000	2.112	4.133	.352	2.841
	LOCATION=general ICU	3.099	.578	.079	5.359	.000	1.965	4.233	.626	1.599

	Expected_outcome=4 >75% Death	3.698	.864	.081	4.282	.000	2.004	5.392	.373	2.678
	BURNAREAS_HH	-.161	.029	-.080	-5.648	.000	-.217	-.105	.673	1.485
	network=North	-.354	.066	-.068	-5.352	.000	-.484	-.224	.837	1.195
	SKILLED_NURSING_NEEDS=N2 Requires intervention from trained rehabilitation nursing staff	.742	.131	.070	5.675	.000	.486	.999	.884	1.132
	BURNAREAS_LEGS	-.095	.028	-.050	-3.432	.001	-.150	-.041	.628	1.591
	BCUF_status=B C	2.440	.662	.125	3.685	.000	1.141	3.739	.117	8.541
	LOCATION=BHDU	.649	.266	.029	2.438	.015	.127	1.171	.953	1.049
	CATEGORY=09 Arson	-1.451	.511	-.034	-2.839	.005	-2.454	-.449	.914	1.094
	KPI_Resus=Yes	.877	.327	.084	2.684	.007	.236	1.518	.137	7.289
	LOCALITY=14 Open Space	-.404	.160	-.030	-2.521	.012	-.719	-.090	.958	1.044
	GENDER=Female	-.153	.061	-.030	-2.519	.012	-.272	-.034	.938	1.066
	BCUF_status=minor	.175	.072	.033	2.421	.016	.033	.318	.716	1.397
	SKILLED_NURSING_NEEDS=N3 Requires highly specialist nursing care	.450	.210	.031	2.147	.032	.039	.862	.640	1.562

a. Dependent Variable: MIN_NURSE_DEPENDENCY_TOTAL







Known on admission First ND total score hierarchical stepwise model

Model Summary[n]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.699[a]	.489	.487	2.591	
2	.711[b]	.505	.503	2.550	
6	.739[f]	.545	.543	2.445	
13	.750[m]	.563	.560	2.400	1.888

a. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=30-39%, BSA_GRP=_0 %, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%

b. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=30-39%, BSA_GRP=_0 %, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=3.0, GROUP_AGE1=2.0

f. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=30-39%, BSA_GRP=_0 %, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=3.0, GROUP_AGE1=2.0, inhalation_adjusted=1.0, CATEGORY=01 Accidental: Recreation, BURNAREAS_TOTAL, network=North

m. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=30-39%, BSA_GRP=_0 %, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=3.0, GROUP_AGE1=2.0, inhalation_adjusted=1.0, CATEGORY=01 Accidental: Recreation, BURNAREAS_TOTAL, network=North, network=Midlands, CATEGORY=06 Self Inflicted, IBID_MP, CATEGORY=09 Arson, Injury_Grp=Contact, LOCALITY=14 Open Space, CATEGORY=Suspected neglect or NAI of child or adult

n. Dependent Variable: FIRST_NURSE_DEPENDENCY_TOTAL

ANOVA[a]

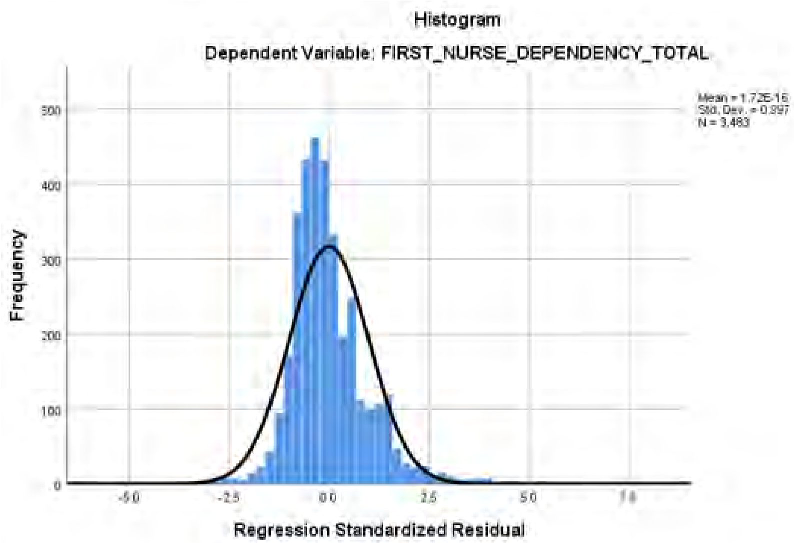
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22276.109	11	2025.101	301.648	.000[b]
	Residual	23302.432	3471	6.713		
	Total	45578.541	3482			
2	Regression	23025.599	13	1771.200	272.439	.000[c]
	Residual	22552.942	3469	6.501		
	Total	45578.541	3482			
	Residual	20939.544	3466	6.041		
	Total	45578.541	3482			
6	Regression	24858.038	17	1462.238	244.524	.000[g]
	Residual	20720.504	3465	5.980		
	Total	45578.541	3482			
13	Regression	25668.379	24	1069.516	185.754	.000[n]
	Residual	19910.162	3458	5.758		
	Total	45578.541	3482			

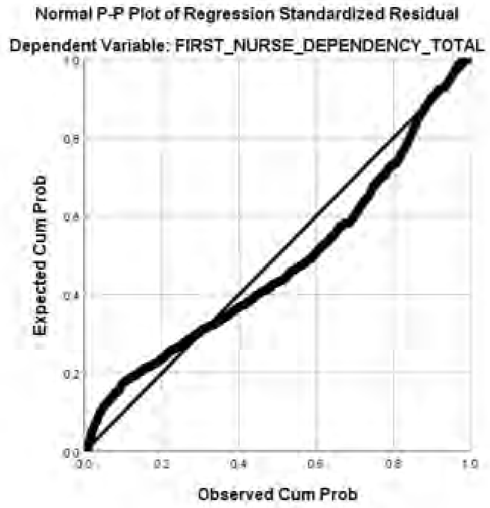
Coefficients[a]

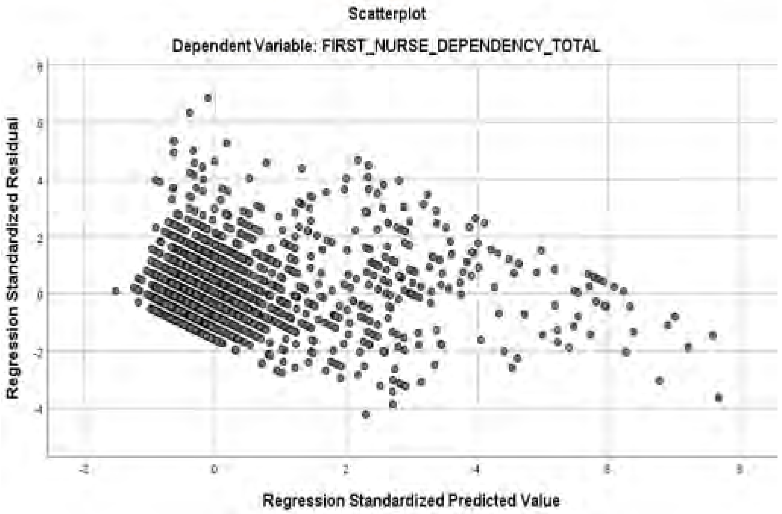
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	6.937	.061		114.534	.000	6.818	7.056		
	BSA_GRP= 0 %	-1.404	.477	-.036	-2.944	.003	-2.339	-.469	.992	1.008
	BSA_GRP= 0-0.9%	-.070	.118	-.008	-.599	.549	-.301	.160	.907	1.103
	BSA_GRP= 5-9%	1.351	.121	.142	11.159	.000	1.114	1.588	.909	1.100
	BSA_GRP=10-14%	3.884	.215	.223	18.028	.000	3.462	4.307	.964	1.037
	BSA_GRP=15-19%	7.272	.322	.276	22.563	.000	6.640	7.904	.984	1.017
	BSA_GRP=20-29%	8.761	.361	.296	24.267	.000	8.053	9.469	.987	1.013
	BSA_GRP=30-39%	10.903	.522	.254	20.897	.000	9.880	11.926	.994	1.006
	BSA_GRP=40-49%	14.294	.721	.241	19.820	.000	12.880	15.708	.997	1.003
	BSA_GRP=50-59%	14.796	.672	.268	22.027	.000	13.479	16.113	.996	1.004
	BSA_GRP=60-69%	14.230	1.060	.163	13.430	.000	12.152	16.307	.998	1.002
	BSA_GRP=70-100%	16.125	.651	.301	24.786	.000	14.850	17.401	.996	1.004
2	(Constant)	7.306	.078		94.168	.000	7.154	7.458		
	BSA_GRP= 0 %	-.961	.471	-.025	-2.039	.042	-1.884	-.037	.985	1.016
	BSA_GRP= 0-0.9%	-.077	.116	-.008	-.663	.507	-.305	.151	.901	1.110
	BSA_GRP= 5-9%	1.306	.119	.137	10.958	.000	1.073	1.540	.908	1.102
	BSA_GRP=10-14%	3.952	.212	.227	18.608	.000	3.536	4.368	.961	1.040
	BSA_GRP=15-19%	7.406	.318	.281	23.315	.000	6.783	8.029	.981	1.020

	BSA_GRP=20-29%	8.829	.356	.299	24.776	.000	8.130	9.528	.981	1.020
	BSA_GRP=30-39%	10.972	.514	.256	21.355	.000	9.965	11.980	.992	1.008
	BSA_GRP=40-49%	14.521	.710	.245	20.440	.000	13.128	15.913	.995	1.005
	BSA_GRP=50-59%	15.004	.662	.272	22.679	.000	13.707	16.301	.995	1.006
	BSA_GRP=60-69%	14.268	1.043	.164	13.678	.000	12.222	16.313	.998	1.002
	BSA_GRP=70-100%	16.411	.641	.307	25.598	.000	15.154	17.668	.993	1.007
	GROUP_AGE1=2.0	-.908	.094	-.124	-9.678	.000	-1.092	-.724	.865	1.156
	GROUP_AGE1=3.0	.140	.138	.013	1.015	.310	-.131	.411	.868	1.152
6	(Constant)	6.183	.117		52.849	.000	5.953	6.412		
	BSA_GRP= 0 %	-.756	.454	-.019	-1.665	.096	-1.646	.134	.975	1.025
	BSA_GRP= 0-0.9%	-.049	.114	-.005	-.429	.668	-.272	.174	.865	1.157
	BSA_GRP= 5-9%	1.013	.122	.107	8.293	.000	.774	1.253	.795	1.257
	BSA_GRP=10-14%	3.343	.220	.192	15.204	.000	2.912	3.775	.825	1.212
	BSA_GRP=15-19%	6.403	.330	.243	19.418	.000	5.756	7.049	.837	1.195
	BSA_GRP=20-29%	7.652	.378	.259	20.263	.000	6.912	8.393	.803	1.245
	BSA_GRP=30-39%	9.225	.526	.215	17.550	.000	8.194	10.256	.872	1.147
	BSA_GRP=40-49%	12.349	.722	.208	17.108	.000	10.934	13.765	.886	1.128
	BSA_GRP=50-59%	10.317	.728	.187	14.163	.000	8.889	11.746	.754	1.325
	BSA_GRP=60-69%	11.042	1.044	.127	10.577	.000	8.995	13.089	.916	1.092
	BSA_GRP=70-100%	12.896	.738	.241	17.465	.000	11.449	14.344	.689	1.452
	GROUP_AGE1=2.0	-.649	.096	-.089	-6.731	.000	-.839	-.460	.752	1.330
	GROUP_AGE1=3.0	.343	.136	.032	2.528	.012	.077	.610	.827	1.209
	inhalation_adjusted=1.0	6.149	.537	.143	11.453	.000	5.096	7.201	.836	1.196
	CATEGORY=01 Accidental: Recreation	.654	.091	.090	7.157	.000	.475	.833	.824	1.214
	BURNAREAS_TOTAL	.190	.026	.137	7.339	.000	.139	.241	.375	2.664
	network=North	.535	.088	.074	6.052	.000	.361	.708	.880	1.136

13	(Constant)	5.921	.121		48.792	.000	5.683	6.159		
	BSA_GRP= 0 %	-.753	.446	-.019	-1.687	.092	-1.628	.122	.972	1.029
	BSA_GRP= 0-0.9%	-.043	.112	-.005	-.388	.698	-.262	.176	.864	1.158
	BSA_GRP= 5-9%	1.024	.120	.108	8.517	.000	.789	1.260	.790	1.266
	BSA_GRP=10-14%	3.304	.217	.190	15.251	.000	2.879	3.729	.818	1.222
	BSA_GRP=15-19%	6.388	.324	.243	19.698	.000	5.752	7.024	.833	1.200
	BSA_GRP=20-29%	7.474	.377	.253	19.842	.000	6.735	8.212	.778	1.286
	BSA_GRP=30-39%	8.820	.527	.206	16.723	.000	7.786	9.855	.834	1.199
	BSA_GRP=40-49%	11.034	.738	.186	14.946	.000	9.587	12.482	.816	1.226
	BSA_GRP=50-59%	8.515	.771	.154	11.048	.000	7.004	10.026	.649	1.541
	BSA_GRP=60-69%	9.160	1.098	.105	8.341	.000	7.007	11.313	.797	1.255
	BSA_GRP=70-100%	9.815	.988	.183	9.939	.000	7.879	11.752	.371	2.698
	GROUP_AGE1=2.0	-.664	.095	-.091	-6.956	.000	-.851	-.477	.739	1.353
	GROUP_AGE1=3.0	-.061	.153	-.006	-.397	.691	-.361	.239	.627	1.595
	inhalation_adjusted=1.0	5.031	.558	.117	9.016	.000	3.937	6.124	.745	1.342
	CATEGORY=01 Accidental: Recreation	.723	.091	.100	7.939	.000	.544	.901	.798	1.253
	BURNAREAS_TOTAL	.174	.026	.125	6.796	.000	.123	.224	.371	2.693
	network=North	.731	.096	.101	7.613	.000	.543	.920	.717	1.395
	network=Midlands	.793	.126	.079	6.279	.000	.545	1.040	.794	1.260
	CATEGORY=06 Self Inflicted	1.632	.282	.067	5.786	.000	1.079	2.185	.949	1.054
	IBID_MP	4.058	.853	.103	4.757	.000	2.386	5.731	.270	3.706
	CATEGORY=09 Arson	4.220	.924	.052	4.566	.000	2.408	6.032	.965	1.036
	Injury_Grp=Contact	.558	.162	.039	3.452	.001	.241	.874	.968	1.033
	LOCALITY=14 Open Space	-.731	.235	-.035	-3.115	.002	-1.192	-.271	.980	1.020
	CATEGORY=Suspected neglect or NAI of child or adult	1.540	.654	.027	2.354	.019	.257	2.823	.965	1.037


Histogram
Dependent Variable: FIRST_NURSE_DEPENDENCY_TOTAL
Mean = 1.72E-16
Std. Dev. = 0.997
N = 3,483
Frequency
Regression Standardized Residual


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: FIRST_NURSE_DEPENDENCY_TOTAL
Expected Cum Prob
Observed Cum Prob


Scatterplot
Dependent Variable: FIRST_NURSE_DEPENDENCY_TOTAL
Regression Standardized Residual
Regression Standardized Predicted Value

Known on admission average ND total score

Model Summary[o]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.671[a]	.450	.448	2.05054	
2	.700[b]	.490	.488	1.97565	
6	.732[f]	.536	.533	1.88574	
14	.742[n]	.551	.548	1.85619	1.967

a. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=30-39%, BSA_GRP=_0 %, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%

b. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=30-39%, BSA_GRP=_0 %, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=Elderly, GROUP_AGE1=Adult

f. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=30-39%, BSA_GRP=_0 %, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=Elderly, GROUP_AGE1=Adult, IBID_MP , CATEGORY=01 Accidental: Recreation, Inhalation_ajusted=yes, CATEGORY=06 Self Inflicted

n. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=30-39%, BSA_GRP=_0 %, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=Elderly, GROUP_AGE1=Adult, IBID_MP , CATEGORY=01 Accidental: Recreation, Inhalation_ajusted=yes, CATEGORY=06 Self Inflicted, network=S.East, Injury_Grp=Contact, BURNAREAS_TOTAL, LOCALITY=14 Open Space, CATEGORY=Suspected neglect or NAI of child or adult, network=S.West, CATEGORY=09 Arson, LOCALITY=16 Mine Or Quarry

o. Dependent Variable: Avg Dep

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	11939.746	11	1085.431	258.146	.000[b]
	Residual	14594.571	3471	4.205		
	Total	26534.317	3482			
2	Regression	12994.158	13	999.551	256.086	.000[c]
	Residual	13540.159	3469	3.903		
	Total	26534.317	3482			
	Residual	12476.961	3466	3.600		
	Total	26534.317	3482			
6	Regression	14212.781	17	836.046	235.109	.000[g]
	Residual	12321.536	3465	3.556		
	Total	26534.317	3482			
	Residual	11931.014	3458	3.450		
	Total	26534.317	3482			
14	Regression	14623.467	25	584.939	169.772	.000[o]
	Residual	11910.850	3457	3.445		
	Total	26534.317	3482			

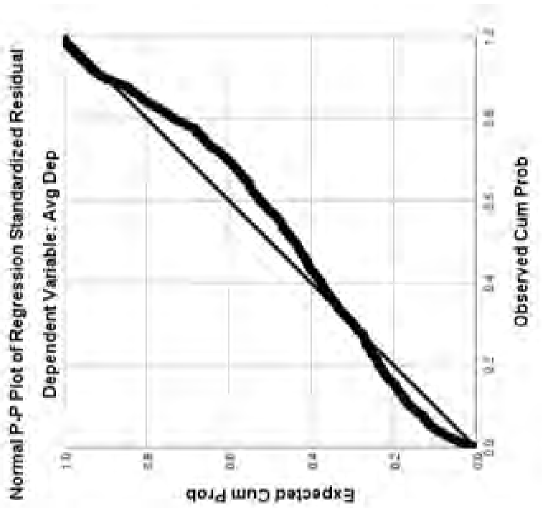
Coefficients[a]

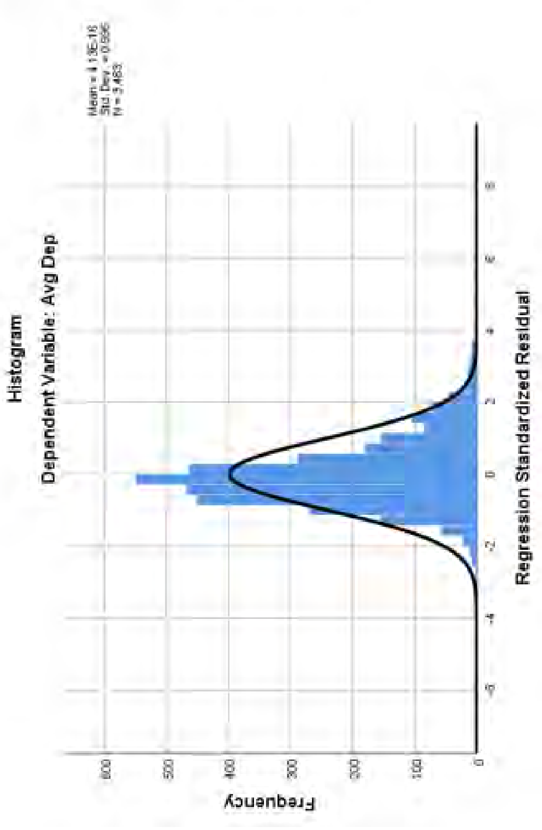
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	6.563	.048		136.911	.000	6.469	6.657		
	BSA_GRP= 0 %	-1.177	.377	-.039	-3.119	.002	-1.917	-.437	.992	1.008
	BSA_GRP= 0-0.9%	.013	.093	.002	.136	.892	-.170	.195	.907	1.103
	BSA_GRP= 5-9%	.787	.096	.108	8.211	.000	.599	.975	.909	1.100
	BSA_GRP=10-14%	2.307	.171	.173	13.529	.000	1.973	2.641	.964	1.037
	BSA_GRP=15-19%	4.526	.255	.225	17.747	.000	4.026	5.026	.984	1.017
	BSA_GRP=20-29%	5.843	.286	.259	20.449	.000	5.282	6.403	.987	1.013
	BSA_GRP=30-39%	7.245	.413	.222	17.547	.000	6.436	8.055	.994	1.006
	BSA_GRP=40-49%	10.562	.571	.233	18.506	.000	9.443	11.681	.997	1.003
	BSA_GRP=50-59%	11.178	.532	.265	21.027	.000	10.136	12.221	.996	1.004
	BSA_GRP=60-69%	11.533	.839	.173	13.754	.000	9.889	13.177	.998	1.002
	BSA_GRP=70-100%	14.754	.515	.361	28.655	.000	13.744	15.763	.996	1.004
2	(Constant)	6.940	.060		115.448	.000	6.823	7.058		
	BSA_GRP= 0 %	-.664	.365	-.022	-1.818	.069	-1.380	.052	.985	1.016
	BSA_GRP= 0-0.9%	.019	.090	.003	.216	.829	-.157	.196	.901	1.110
	BSA_GRP= 5-9%	.738	.092	.102	7.988	.000	.557	.919	.908	1.102
	BSA_GRP=10-14%	2.370	.165	.178	14.404	.000	2.048	2.693	.961	1.040
	BSA_GRP=15-19%	4.665	.246	.232	18.953	.000	4.182	5.147	.981	1.020
	BSA_GRP=20-29%	5.880	.276	.261	21.294	.000	5.339	6.421	.981	1.020
	BSA_GRP=30-39%	7.298	.398	.223	18.332	.000	6.517	8.078	.992	1.008
	BSA_GRP=40-49%	10.791	.550	.238	19.604	.000	9.712	11.870	.995	1.005
	BSA_GRP=50-59%	11.394	.513	.270	22.226	.000	10.389	12.399	.995	1.006
	BSA_GRP=60-69%	11.530	.808	.173	14.266	.000	9.945	13.114	.998	1.002
	BSA_GRP=70-100%	15.057	.497	.369	30.312	.000	14.083	16.031	.993	1.007

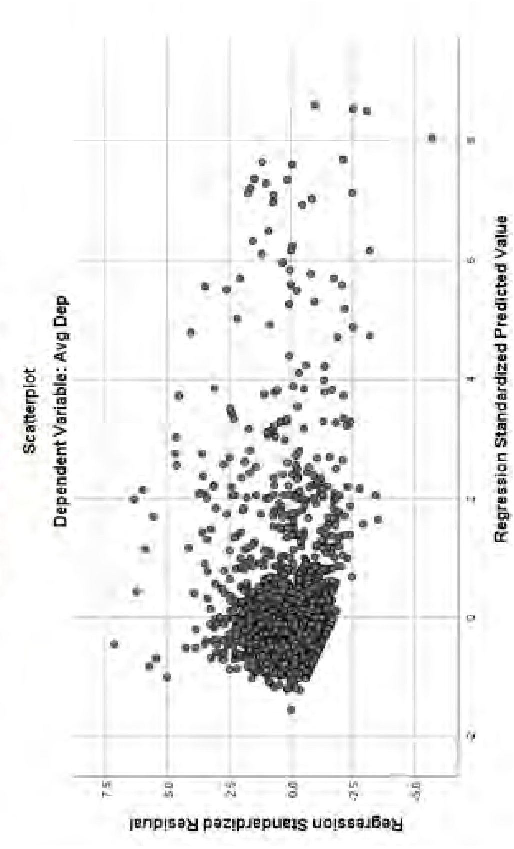
	GROUP_AGE1=Adult	-1.004	.073		-.180	-13.818	.000	-1.147	-.862	.865	1.156
	GROUP_AGE1=Elderly	.382	.107		.046	3.569	.000	.172	.592	.868	1.152
6	(Constant)	6.576	.074			88.919	.000	6.431	6.721		
	BSA_GRP= 0 %	-.637	.349		-.021	-1.829	.068	-1.321	.046	.984	1.016
	BSA_GRP= 0-0.9%	-.040	.086		-.006	-.470	.638	-.209	.128	.896	1.116
	BSA_GRP= 5-9%	.688	.088		.095	7.794	.000	.515	.861	.906	1.104
	BSA_GRP=10-14%	2.163	.158		.163	13.717	.000	1.854	2.473	.954	1.049
	BSA_GRP=15-19%	4.377	.236		.218	18.575	.000	3.915	4.839	.974	1.026
	BSA_GRP=20-29%	5.262	.270		.233	19.512	.000	4.733	5.791	.937	1.067
	BSA_GRP=30-39%	5.971	.392		.183	15.232	.000	5.202	6.740	.932	1.073
	BSA_GRP=40-49%	8.606	.550		.190	15.641	.000	7.527	9.684	.907	1.103
	BSA_GRP=50-59%	6.770	.574		.161	11.800	.000	5.645	7.894	.723	1.382
	BSA_GRP=60-69%	7.683	.831		.115	9.248	.000	6.054	9.312	.860	1.163
	BSA_GRP=70-100%	9.064	.718		.222	12.628	.000	7.657	10.471	.433	2.307
	GROUP_AGE1=Adult	-.871	.074		-.156	-11.783	.000	-1.016	-.726	.761	1.313
	GROUP_AGE1=Elderly	-.104	.119		-.013	-.869	.385	-.337	.130	.639	1.565
	IBID_MP	6.798	.667		.226	10.193	.000	5.490	8.105	.273	3.668
	CATEGORY=01 Accidental: Recreation	.586	.069		.106	8.471	.000	.450	.722	.854	1.171
	Inhalation_ajusted=yes	3.208	.436		.098	7.355	.000	2.353	4.063	.753	1.328
	CATEGORY=06 Self Inflicted	1.462	.221		.078	6.611	.000	1.028	1.896	.954	1.049
14	(Constant)	6.507	.087			74.792	.000	6.337	6.678		
	BSA_GRP= 0 %	-.581	.345		-.019	-1.684	.092	-1.258	.096	.972	1.028
	BSA_GRP= 0-0.9%	.014	.086		.002	.162	.871	-.155	.183	.866	1.155
	BSA_GRP= 5-9%	.575	.093		.079	6.166	.000	.392	.757	.787	1.270
	BSA_GRP=10-14%	1.922	.168		.144	11.461	.000	1.593	2.251	.817	1.224
	BSA_GRP=15-19%	3.992	.251		.199	15.913	.000	3.500	4.484	.833	1.200

	BSA_GRP=20-29%	4.772	.292	.212	16.369	.000	4.201	5.344	.777	1.288
	BSA_GRP=30-39%	5.417	.408	.166	13.276	.000	4.617	6.217	.834	1.199
	BSA_GRP=40-49%	7.667	.571	.169	13.426	.000	6.547	8.786	.816	1.226
	BSA_GRP=50-59%	5.660	.596	.134	9.491	.000	4.491	6.829	.649	1.541
	BSA_GRP=60-69%	6.294	.850	.095	7.408	.000	4.628	7.960	.797	1.255
	BSA_GRP=70-100%	7.875	.770	.193	10.232	.000	6.366	9.384	.365	2.738
	GROUP_AGE1=Adult	-.827	.074	-.148	-11.223	.000	-.971	-.682	.743	1.346
	GROUP_AGE1=Elderly	-.137	.118	-.017	-1.156	.248	-.369	.095	.628	1.592
	IBID_MP	6.975	.661	.232	10.558	.000	5.680	8.270	.269	3.715
	CATEGORY=01 Accidental: Recreation	.534	.070	.097	7.604	.000	.396	.672	.802	1.246
	Inhalation_ajusted=yes	2.947	.432	.090	6.824	.000	2.100	3.794	.744	1.344
	CATEGORY=06 Self Inflicted	1.545	.219	.083	7.045	.000	1.115	1.975	.939	1.065
	network=S.East	-.451	.080	-.068	-5.601	.000	-.608	-.293	.881	1.136
	Injury_Grp=Contact	.553	.125	.051	4.423	.000	.308	.798	.968	1.033
	BURNAREAS_TOTAL	.089	.020	.084	4.502	.000	.050	.127	.375	2.668
	LOCALITY=14 Open Space	-.626	.182	-.040	-3.442	.001	-.983	-.269	.977	1.023
	CATEGORY=Suspected neglect or NAI of child or adult	1.821	.506	.042	3.595	.000	.828	2.814	.964	1.038
	network=S.West	-.346	.103	-.040	-3.357	.001	-.547	-.144	.931	1.074
	CATEGORY=09 Arson	1.991	.714	.032	2.788	.005	.591	3.392	.966	1.035
	LOCALITY=16 Mine Or Quarry	-4.676	1.933	-.029	-2.419	.016	-8.465	-.886	.923	1.084

a. Dependent Variable: Avg Dep


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Avg Dep
Expected Cum Prob
Observed Cum Prob


Histogram
Dependent Variable: Avg Dep
Frequency
Regression Standardized Residual


Scatterplot
Dependent Variable: Avg Dep
Regression Standardized Residual
Regression Standardized Predicted Value

Known on admission maximum ND total score

Model Summary[o]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.712[a]	.508	.506	2.700	
2	.728[b]	.531	.529	2.637	
6	.751[f]	.564	.562	2.543	
14	.760[n]	.578	.575	2.504	1.993

a. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=30-39%, BSA_GRP=_0 %, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%

b. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=30-39%, BSA_GRP=_0 %, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=Elderly, GROUP_AGE1=Adult

f. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=30-39%, BSA_GRP=_0 %, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=Elderly, GROUP_AGE1=Adult, Inhalation_ajusted=yes, CATEGORY=01 Accidental: Recreation, network=S.West, BURNAREAS_TOTAL

n. Predictors: (Constant), BSA_GRP=70-100%, BSA_GRP=60-69%, BSA_GRP=40-49%, BSA_GRP=50-59%, BSA_GRP=30-39%, BSA_GRP=_0 %, BSA_GRP=20-29%, BSA_GRP=15-19%, BSA_GRP=10-14%, BSA_GRP=_5-9%, BSA_GRP=_0-0.9%, GROUP_AGE1=Elderly, GROUP_AGE1=Adult, Inhalation_ajusted=yes, CATEGORY=01 Accidental: Recreation, network=S.West, BURNAREAS_TOTAL, CATEGORY=06 Self Inflicted, Injury_Grp=Contact, CATEGORY=09 Arson, network=North, IBID_MP , LOCALITY=14 Open Space, CATEGORY=Suspected neglect or NAI of child or adult, CATEGORY=03 Accidental: Not Work Related

o. Dependent Variable: MAX_NURSE_DEPENDENCY_TOTAL

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	26084.376	11	2371.307	325.190	.000[b]
	Residual	25310.760	3471	7.292		
	Total	51395.136	3482			
2	Regression	27272.640	13	2097.895	301.693	.000[c]
	Residual	24122.496	3469	6.954		
	Total	51395.136	3482			
6	Regression	28980.893	17	1704.758	263.537	.000[g]
	Residual	22414.243	3465	6.469		
	Total	51395.136	3482			
	Residual	21706.975	3458	6.277		
	Total	51395.136	3482			
14	Regression	29716.049	25	1188.642	189.544	.000[o]
	Residual	21679.087	3457	6.271		
	Total	51395.136	3482			

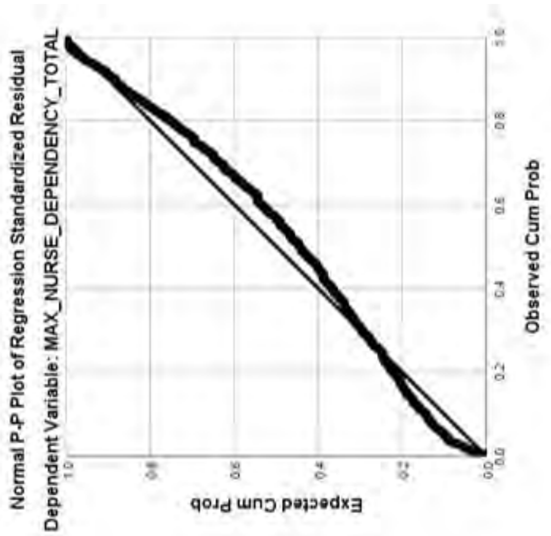
Coefficients[a]

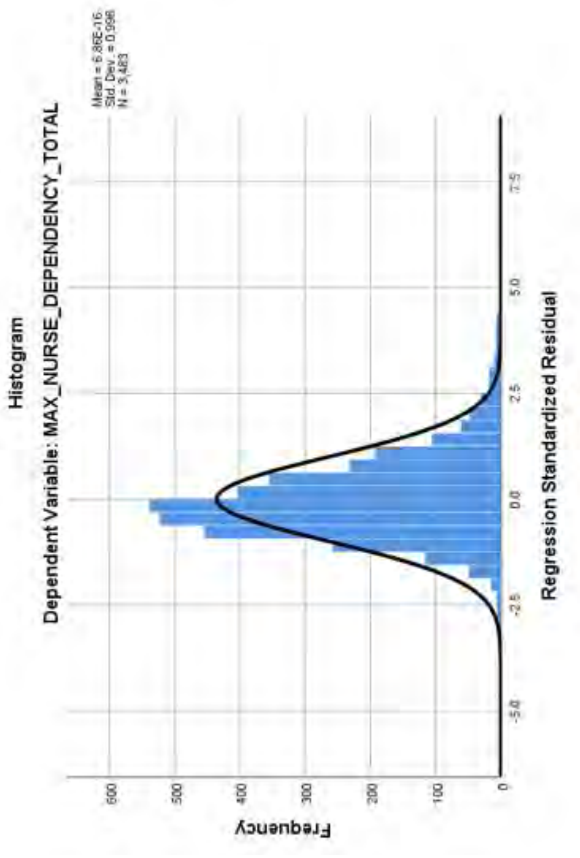
Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	7.682	.063		121.695	.000	7.558	7.806		
	BSA GRP= 0 %	-2.015	.497	-.048	-4.055	.000	-2.990	-1.041	.992	1.008
	BSA GRP= 0-0.9%	-.388	.123	-.040	-3.165	.002	-.628	-.148	.907	1.103
	BSA GRP= 5-9%	1.614	.126	.160	12.794	.000	1.367	1.862	.909	1.100
	BSA GRP=10-14%	4.356	.225	.235	19.398	.000	3.916	4.797	.964	1.037
	BSA GRP=15-19%	7.706	.336	.276	22.942	.000	7.048	8.365	.984	1.017
	BSA GRP=20-29%	10.167	.376	.324	27.022	.000	9.429	10.905	.987	1.013
	BSA GRP=30-39%	12.078	.544	.265	22.212	.000	11.012	13.144	.994	1.006
	BSA GRP=40-49%	14.780	.752	.235	19.664	.000	13.306	16.253	.997	1.003
	BSA GRP=50-59%	15.185	.700	.259	21.690	.000	13.812	16.557	.996	1.004
	BSA GRP=60-69%	13.485	1.104	.146	12.212	.000	11.320	15.650	.998	1.002
	BSA_GRP=70-100%	16.318	.678	.287	24.066	.000	14.989	17.647	.996	1.004
2	(Constant)	7.797	.080		97.172	.000	7.640	7.954		
	BSA GRP= 0 %	-1.592	.487	-.038	-3.267	.001	-2.547	-.637	.985	1.016
	BSA GRP= 0-0.9%	-.326	.120	-.033	-2.711	.007	-.561	-.090	.901	1.110
	BSA GRP= 5-9%	1.585	.123	.157	12.853	.000	1.343	1.827	.908	1.102
	BSA GRP=10-14%	4.349	.220	.235	19.802	.000	3.919	4.780	.961	1.040
	BSA GRP=15-19%	7.753	.329	.277	23.599	.000	7.108	8.397	.981	1.020
	BSA GRP=20-29%	10.034	.369	.320	27.224	.000	9.311	10.756	.981	1.020
	BSA GRP=30-39%	12.012	.531	.264	22.607	.000	10.971	13.054	.992	1.008
	BSA GRP=40-49%	14.836	.735	.236	20.193	.000	13.395	16.276	.995	1.005
	BSA GRP=50-59%	15.261	.684	.260	22.304	.000	13.919	16.602	.995	1.006
	BSA GRP=60-69%	13.296	1.079	.144	12.325	.000	11.181	15.411	.998	1.002
	BSA_GRP=70-100%	16.462	.663	.290	24.829	.000	15.162	17.762	.993	1.007

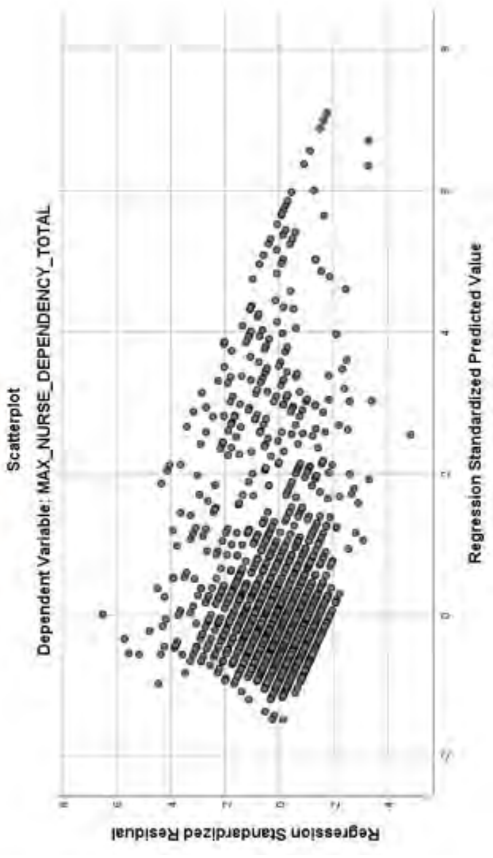
	GROUP_AGE1=Adult	-.642	.097	-.083	-6.621	.000	-.832	-.452	.865	1.156
	GROUP_AGE1=Elderly	1.185	.143	.103	8.285	.000	.904	1.465	.868	1.152
6	(Constant)	7.119	.112		63.389	.000	6.899	7.339		
	BSA_GRP= 0 %	-1.383	.472	-.033	-2.930	.003	-2.309	-.457	.976	1.025
	BSA_GRP= 0-0.9%	-.298	.118	-.030	-2.519	.012	-.529	-.066	.866	1.155
	BSA_GRP= 5-9%	1.284	.127	.127	10.120	.000	1.035	1.533	.798	1.254
	BSA_GRP=10-14%	3.763	.229	.203	16.461	.000	3.314	4.211	.826	1.211
	BSA_GRP=15-19%	6.843	.343	.245	19.954	.000	6.170	7.515	.837	1.195
	BSA_GRP=20-29%	8.933	.393	.285	22.736	.000	8.163	9.703	.803	1.246
	BSA_GRP=30-39%	10.397	.547	.228	19.014	.000	9.325	11.470	.872	1.147
	BSA_GRP=40-49%	12.915	.751	.205	17.207	.000	11.444	14.387	.887	1.128
	BSA_GRP=50-59%	11.000	.758	.188	14.519	.000	9.515	12.486	.755	1.325
	BSA_GRP=60-69%	10.353	1.086	.112	9.535	.000	8.224	12.482	.916	1.092
	BSA_GRP=70-100%	13.309	.768	.234	17.332	.000	11.804	14.815	.689	1.452
	GROUP_AGE1=Adult	-.400	.100	-.052	-3.998	.000	-.597	-.204	.755	1.325
	GROUP_AGE1=Elderly	1.370	.141	.120	9.715	.000	1.093	1.646	.831	1.204
	Inhalation_ajusted=yes	5.784	.559	.127	10.356	.000	4.689	6.880	.835	1.197
	CATEGORY=01 Accidental: Recreation	.699	.093	.091	7.542	.000	.517	.881	.864	1.157
	network=S.West	-.959	.137	-.079	-6.983	.000	-1.228	-.689	.982	1.018
	BURNAREAS_TOTAL	.159	.027	.108	5.934	.000	.107	.212	.377	2.650
14	(Constant)	6.937	.137		50.494	.000	6.668	7.207		
	BSA_GRP= 0 %	-1.423	.466	-.034	-3.053	.002	-2.337	-.509	.971	1.030
	BSA_GRP= 0-0.9%	-.335	.116	-.034	-2.873	.004	-.563	-.106	.864	1.157
	BSA_GRP= 5-9%	1.293	.125	.128	10.316	.000	1.048	1.539	.792	1.263
	BSA_GRP=10-14%	3.707	.226	.200	16.396	.000	3.263	4.150	.818	1.222
	BSA_GRP=15-19%	6.745	.338	.241	19.945	.000	6.082	7.408	.835	1.198

BSA_GRP=20-29%	8.692	.393	.277	22.123	.000	7.921	9.462	.778	1.285
BSA_GRP=30-39%	9.906	.550	.218	18.009	.000	8.827	10.984	.835	1.197
BSA_GRP=40-49%	11.595	.770	.184	15.058	.000	10.086	13.105	.817	1.225
BSA_GRP=50-59%	9.460	.804	.161	11.761	.000	7.883	11.037	.649	1.541
BSA_GRP=60-69%	8.636	1.146	.093	7.534	.000	6.388	10.883	.797	1.255
BSA_GRP=70-100%	10.819	1.031	.190	10.494	.000	8.798	12.841	.370	2.700
GROUP_AGE1=Adult	-.380	.100	-.049	-3.797	.000	-.576	-.184	.732	1.366
GROUP_AGE1=Elderly	1.087	.160	.095	6.798	.000	.774	1.401	.626	1.599
Inhalation_ajusted=yes	5.071	.581	.111	8.724	.000	3.932	6.211	.748	1.338
CATEGORY=01 Accidental: Recreation	.614	.110	.080	5.591	.000	.399	.829	.597	1.674
network=S.West	-.751	.146	-.062	-5.160	.000	-1.037	-.466	.846	1.182
BURNAREAS_TOTAL	.161	.027	.110	6.057	.000	.109	.213	.372	2.685
CATEGORY=06 Self Inflicted	1.678	.298	.065	5.628	.000	1.093	2.263	.925	1.081
Injury_Grp=Contact	.842	.169	.056	4.992	.000	.511	1.173	.968	1.033
CATEGORY=09 Arson	3.464	.966	.040	3.587	.000	1.571	5.357	.963	1.039
network=North	.340	.097	.044	3.500	.000	.150	.531	.763	1.311
IBID_MP	3.040	.890	.073	3.416	.001	1.295	4.786	.270	3.705
LOCALITY=14 Open Space	-.759	.245	-.035	-3.093	.002	-1.240	-.278	.978	1.022
CATEGORY=Suspected neglect or NAI	1.522	.685	.025	2.223	.026	.180	2.865	.959	1.042
CATEGORY=03 Accidental: Not Work Related	-.272	.129	-.028	-2.109	.035	-.525	-.019	.715	1.398

a. Dependent Variable: MAX_NURSE_DEPENDENCY_TOTAL


Normal P-P Plot of Regression Standardized Residual
Dependent Variable: MAX_NURSE_DEPENDENCY_TOTAL
Expected Cum Prob
Observed Cum Prob


Histogram
Dependent Variable: MAX_NURSE_DEPENDENCY_TOTAL
Mean = 6.86E-16
Std. Dev. = 0.998
N = 3,483
Frequency
Regression Standardized Residual


Scatterplot
Dependent Variable: MAX_NURSE_DEPENDENCY_TOTAL
Regression Standardized Residual
Regression Standardized Predicted Value