Nurse Practitioner Diagnostic Reasoning

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Abstract

Introduction: Nurse practitioners were introduced to increase patients' access to healthcare, improve patient outcomes, and provide a sustainable solution to ongoing workforce shortages. They provide a diagnostic role previously delivered by doctors, however, their ability to perform this role has been challenged.

Methodology: The study used a post-positivist mixed methods convergent parallel design to explore nurse practitioner diagnostic reasoning and compare it to that of registrars. Methods included a complex case scenario using think aloud protocol to determine diagnostic abilities, including identifying correct diagnoses, problems and actions; a previously validated intuitive/analytic reasoning instrument to identify diagnostic reasoning style; a maxims questionnaire to identify maxims used to guide diagnostic reasoning; and a demographic data sheet to identify variables influencing the results of the former.

The study included 30 nurse practitioners and 16 registrars. An expert panel determined the correct diagnoses/problems and actions for the case scenario using a Delphi technique. Registrar data provided normative data and norm-referenced testing compared the nurse practitioner data to the normative data.

Results: Nurse practitioners identified a mean of 10.30 (range=4-17, *Mdn*=10, mode=9, *SD*=3.09) correct diagnoses, problem and action items as identified by the expert panel whereas registrars identified a mean of 10.88 (range=6-21, *Mdn*=10, *SD*=3.88); there was no statistically significant difference between the two groups (U=238.5, z=-.04, p=.97). Nurse practitioners' diagnostic reasoning reflected an analytic-intuitive style whereas registrars reflected an analytic style, however, this difference was not statistically significant, $t(44)$=1.91, p=.06. Diagnostic reasoning style was not related to diagnostic reasoning abilities in either the nurse practitioner (r_s=-.14, n=30, p=.46) or registrar (r_s=.03, n=16, p=.90) groups. There was no difference in how nurse practitioners and registrars employ maxims to guide their diagnostic reasoning, $t(44)$=-.89, p=.38. Maxims used to guide diagnostic reasoning were not related to diagnostic reasoning abilities in either the nurse practitioner (r=-.17, n=30, p=.37) or registrar (r_s=-.08, n=16, p=.77) groups.

Conclusion: Nurse practitioners' diagnostic reasoning, although incorporating more System I processes than registrars, does not differ from that of registrars. This supports the nurse practitioner role as a sustainable solution firstly, to effectively meet the health needs of the New Zealand population and secondly, to address workforce shortages.

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Chapter one: Introduction

This thesis explores nurse practitioner diagnostic reasoning. My interest in this topic stems from being a prescribing nurse practitioner and my role in coordinating and teaching a post graduate nursing assessment and clinical decision making paper, which includes aspects of diagnostic reasoning. I am a member of the executive committee of New Zealand Nurse Practitioners, a professional body for nurse practitioners, and hence am exposed to criticisms pertaining to nurse practitioners' ability to perform what has historically been a medical role (Gorman, 2009). I have always been bemused by these criticisms.

My own role was introduced in response to inadequacies in early identification and management of physiologically unstable ward patients and requires expertise in early recognition of diagnoses and timely management. A historical control before and after study evaluating this role showed a significant reduction in intensive care readmissions <72 hours (Pirret, 2008a). The study highlighted the numerous diagnostic reasoning activities performed by the nurse practitioner, and although the study's design cannot rule out other factors influencing the results, it demonstrates nurse practitioners' diagnostic reasoning expertise has a positive effect on patient outcomes (Pirret, 2008a).

Chapter one, *Introduction*, begins by providing the background and rationale for this study including an outline of nurse practitioner practice in New Zealand and how the New Zealand title nurse practitioner differs from that used internationally. The chapter then explains the terms used in this thesis, followed by the research aim and the central research question and subquestions. The chapter finishes with an overview of the thesis. The background and rationale for this study will now be presented.

1.1. Background and Rationale

This section sets the scene by providing some background on nurse practitioner practice in New Zealand. This then leads onto the rationale for this study exploring nurse practitioner diagnostic reasoning.

1.1.1. Nurse practitioner practice in New Zealand

Nurse practitioners were introduced to increase patients' access to healthcare and improve patient outcomes (Ministry of Health, 2002a). More recently they are recognised as a solution to doctor[1] shortages. Combining advanced nursing practice with skills from medicine, nurse practitioners diagnose, assess and manage patients and can order diagnostic tests and x-rays and prescribe; historically these roles were considered exclusive to medicine (Forde, 2008; Ministry of Health, 2009). They promote health, encourage self-care and look beyond the diagnoses to consider non-medical interventions (Ministry of Health, 2002a).

Nurse practitioners are expert nurses with a clinically focused Master's degree (or equivalent), who have a minimum of four years experience in a specific area of practice and have passed the Nursing Council of New Zealand's nurse practitioner assessment (Nursing Council of New Zealand, 2008). This assessment requires applicants to demonstrate four domains: (1) professional responsibility and leadership, (2) management of nursing care, (3) interpersonal and interprofessional practice and quality improvement and (4)

[1] Unless otherwise stated, the term doctor in this thesis infers a medical doctor.

prescribing practice. Up until the end of 2012 prescribing practice was optional and nurse practitioners could register without prescribing authority (Nursing Council of New Zealand, 2008). Once the Medicines Amendment Bill is introduced, which is expected to be in 2013, new nurse practitioners will only be registered with prescribing authority (Nursing Council of New Zealand, n.d.). Expertise in diagnostic reasoning is included in the management of nursing care domain and needs to be demonstrated during the registration assessment process (Nursing Council of New Zealand, 2008). Hence, as part of their registration requirements, nurse practitioners are expected to have diagnostic reasoning expertise.

Although the concept of advanced nursing practice was being developed in the 1990s, it was not until March 2001 that the Nursing Council of New Zealand (Nursing Council) published a framework for the regulation of nurse practitioners. The Nursing Council trademarked the term nurse practitioner to protect the title, meaning only those who met Nursing Council requirements could use it (Jacobs & Boddy, 2008). In 2004, in response to the Health Practitioners Competency Assurance Act (2003), the Nursing Council designated four scopes of practice: nurse assistant, enrolled nurse, registered nurse and nurse practitioner (Jacobs & Boddy, 2008). The first New Zealand nurse practitioner registered in New Zealand in December 2001 (Cassie, 2012).

The uptake of nurse practitioner roles was initially impeded by early resistance from the medical discipline towards nurse practitioner prescribing (Jacobs & Boddy, 2008) and by some within the nursing profession who viewed diagnosis and prescribing a practice of medicine not nursing (Carryer, 2002; Litchfield, 2002). Seven years after the introduction of the nurse practitioner framework, there were only 46 nurse practitioners, 26 with prescribing authority (O'Connor, 2008). Over recent years the numbers have increased –

the 101st nurse practitioner registered in 2012 (Cassie, 2012). Of the 101 nurse practitioners registered at this time, two-thirds were prescribers and more than one-third were working in primary health care (Cassie, 2012).

The nurse practitioner workforce reflects the overall nursing workforce with most nurse practitioners being female. In a 2010 analysis of New Zealand nurse practitioners, only five of the 69 nurse practitioners were male (Nursing Council of New Zealand, 2010). Having discussed nurse practitioner practice in New Zealand, the rationale for this study will now be outlined.

1.1.2. Rationale for this study

Although nurse practitioners were introduced to increase patients' access to healthcare, improve patient outcomes and provide a solution to ongoing workforce shortages, their ability to perform this role has been challenged. Gorman (2009) views the role of the doctor in the future as a health professional who has largely a cognitive function, translating patients' signs and symptoms into a diagnosis; this role, he argues, cannot be substituted by a nurse practitioner. Gorman views medicine as having a strong diagnostic role at the front door of healthcare facilities, referring to nurse practitioners and other health professional-led intervention clinics when required.[2] This view suggests doctors are better suited to diagnosis and treatment whereas nurse practitioners are better suited to ongoing interventions once the diagnosis is made. This

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[2] This study acknowledges the evidence pertaining to registered nurses' abilities to provide doctor substitution for simple tasks and diagnosis of minor illnesses (Cox & Jones, 2000; Helford et al., 2010; Laurant et al., 2005). Substitution of doctors' roles by nurse practitioners requires nurse practitioners to diagnose and manage complex cases.

perspective is perhaps supported by the belief that nurse practitioners are ideally suited to health promotion and disease prevention.

Professor Gorman holds an influential position in New Zealand; he is currently Chair of Health Workforce New Zealand (HWNZ), which is responsible for health workforce funding (Cassie, 2009) and until recently was Head of the School of Medicine at the University of Auckland. Hence an opinion from such a prestigious doctor has the potential to limit nurse practitioner roles and negatively impact on the patient populations, such as Maori, where access to healthcare is often inadequate (Ministry of Health, 2002b; Taskforce on Whanau-Centred Initiatives, 2010).

Opinions about nurse practitioners may be influenced by studies illustrating intuition as the dominant clinical reasoning style used by nurses. Intuition, based on past experiences, uses tacit knowledge the nurse is unaware of and unable to articulate (Baid, 2006; Standing, 2008; Stolper et al., 2011). Research illustrates insufficient knowledge contributes to nurses relying on intuition when making decisions (Offredy, Kendall, & Goodman, 2008) and intuition being responsible for poor decisions (Thompson et al., 2007). New Zealand nurse practitioners must demonstrate expert diagnostic reasoning to register as a nurse practitioner, however, it remains unclear how much they rely on intuition in their everyday practice and if they do, how it contributes to inaccurate diagnoses and inappropriate action plans.

Multiple studies demonstrate nurse practitioners achieve similar patient outcomes to medical doctors. A systematic review by Newhouse et al. (2011) compared nurse practitioner and physician patient outcomes. They only included research undertaken in the United States of America (USA) due to international differences in nurse practitioner education and scope of practice. These differences are discussed later in this chapter. Newhouse et al. identified nurse practitioners and physicians were similar in their patient outcomes pertaining to patient satisfaction, management of chronic conditions, emergency department or urgent care visits related to chronic conditions, length of hospital stay, and patient mortality. Management of chronic conditions included hypertension, diabetes, asthma and heart failure.

Another systematic review focusing on patient satisfaction with care provided by primary health care nurse practitioners and doctors at first point of care contact, identified patients were more satisfied with care by a nurse practitioner (Horrocks, Anderson, & Salisbury, 2002). Although nurse practitioners completed more investigations and their consultations were longer, they offered more advice on self-care and communicated better. Most of the studies reviewed in this systematic review were related to patients presenting with acute minor illnesses and nurse practitioners working alongside general practitioners (Horrocks et al., 2002).

In a Netherland's study comparing patient preferences for, and satisfaction with, care provided by nurse practitioners and general practitioners, patients were generally very satisfied with care from nurse practitioners for education of chronic conditions and reassurance (Laurant et al. 2008). However, most patients preferred the general practitioner for medical aspects of their care. Nurse practitioners in this study had at least two years nursing experience and a Bachelor degree. Patients were referred to them by the general practitioner and they performed tasks according to agreed guidelines developed for the study. The experience and academic qualifications of these nurse practitioners and their limited scope of practice means the results of this study are difficult to generalise to the New Zealand context where nurse practitioners are more experienced, hold a Master's degree and practice independently.

Much of the literature comparing nurse practitioner patient outcomes to those of physicians, focus on patients referred by the physician to nurse practitioners for management of chronic conditions, patients presenting for the first time with minor illnesses or injuries, and nurse practitioners working alongside general practitioners. Management of chronic conditions and minor illnesses and injuries are likely to involve intuitive rather than analytic (cognitive) thinking (Croskerry, 2009). This means that although nurse practitioner patient outcomes compare favourably to those of doctors in many areas of care, the research on their ability to manage complex patients presenting for the first time and their use of analytic reasoning is limited.

Global research into nurse practitioner diagnostic reasoning provides insight into their diagnostic reasoning styles, however, international differences in use of the nurse practitioner title limit the generalisability of their results to the New Zealand context. To date no research pertaining to New Zealand nurse practitioner diagnostic reasoning exists thus this research exploring New Zealand nurse practitioner diagnostic reasoning aims to fill this void. Having presented the rationale for this study, the international differences in using the nurse practitioner title will now be outlined.

1.1.3. International use of the nurse practitioner title

The use of the nurse practitioner title in Australia is similar to that of New Zealand, however, this is not so in other countries such as the USA, Canada and the UK. Australia's nurse practitioner academic and registration requirements, like New Zealand, require a Master's degree and have a rigorous assessment process and legal protection of the nurse practitioner title. These similarities have resulted in a Trans Tasman Mutual Recognition Act 1997, which requires mutual recognition of qualifications (Carryer, Gardner, Dunn, & Gardner, 2007).

The USA formerly used the title nurse practitioner quite differently to New Zealand. Nurse practitioner practice developed in the USA in the 1960s and has contributed to the international development of nurse practitioner practice (Carryer, et al., 2007; Kleinpell, Ely, & Grabenkort, 2008; Martin, 1995). However, their early academic registration process differed significantly. Historically, the majority of USA nurse practitioner education programmes were outside the mainstream of nursing education (Cronenwett, 1995). Although at Master's degree level, these programmes were certificate programmes directed and staffed by physicians; hence, focus was placed on the medical aspects rather than the nursing aspects of the role (Kleinpell et al., 2008; Martin, 1995). This meant that USA nurse practitioners did not require a Master's degree to practice and physicians assessed practice. Hence in early research pertaining to nurse practitioner practice, a large number of participants are not Master's prepared thus making the results difficult to generalise to New Zealand nurse practitioners who require a Master's degree.

By the 1980s the USA established nurse practitioner Master's degree programmes and in 2002 endorsed national consensus based nurse practitioner competencies. This led to national nurse practitioner accreditation by 2005. In October 2004, the American Association of Colleges of Nursing recommended nurse practitioner education programmes move from a Master's to a Doctorate degree by 2015 (American Association of Colleges of Nursing, 2012). However, laws and regulations pertaining to nurse practitioner scope of practice (including prescribing authority) remain inconsistent from state to state (Poghosyan, Lucero, Rauch & Berkowitz, 2012).

The difference in use of the nurse practitioner title is also seen in Canada. In Canada, the nurse practitioner initiative began in the 1960s with education preparation initially beginning as certificate programmes (Edwards, Rowan, Marck, & Grinspun, 2011; Heale, 2012; Sangster-Gormley, Martin-Misener, Downe-Wamboldt, & Dicenso, 2011; Sloan, Pong, Rukholm, & Caty, 2006). From 1980 to the 1990s nurse practitioners had varying education preparation, which included diploma registered nurse with additional education and experience to registered nurse with a graduate degree. In the 1990s postgraduate programmes were offered, followed by post Master's certificate programmes toward the end of the decade (Sloan et al., 2006).

In 2005, the Canadian Nurses' Association, through the Canadian Nurse Practitioner Initiative, introduced a Canadian Nurse Practitioner Core Competency Framework and a national examination for primary health care (PHC) nurse practitioners (Sloan et al., 2006). However, shortly after its introduction, a survey illustrated only 30% of primary care nurse practitioners had a Master's degree. These low results were also reflected in acute care, with 49 of the 124 (39.5%) acute care nurse practitioners in Ontario being Master's prepared.

By 2011 nurse practitioner legislation and regulations were in place in most of the Canadian provinces and territories (Edwards et al., 2011; Sangster-Gormley et al., 2011) with most working on standardising the nurse practitioner title (Sangster-Gormley et al., 2011). The variation in use of the title means generalising Canadian nurse practitioner research to the New Zealand context requires caution.

The theme pertaining to the international difference in use of the nurse practitioner title continues in the UK. Implementation of advanced nursing practice roles began in the UK in the 1990s. In the UK, the role of nurse consultant reflects advanced nursing practice. In the Department of Health (DoH) 1999 publication *Making a Difference* the then Prime Minister, Tony Blair, promoted the need for nurse consultant positions to be established. The DoH publication stated nurse consultants would have a Master's degree, would be clinically focused and would practice autonomously with the same authority as medical consultants (Saggs, 2003).

Although the UK does allow registered nurse prescribing, nurses working in advanced practice positions have no nationally agreed standard. Currently there are many nurses working in advanced nursing practice roles who have a Master's degree, however, nurses are still able to do a one week course and then use the title advanced nurse practitioner (Coombes, 2008). Over recent years, the Royal College of Nursing has lobbied for a registered trade title for nurse practitioner similar to New Zealand (Coombes, 2008) but this has not yet occurred (Santry, 2010). Hence, although the UK nurse consultant resembles aspects of nurse practitioner practice requirements in New Zealand, there is no legislation protecting the title nurse consultant or nurse practitioner; thus UK literature pertaining to nurse practitioner research cannot be generalised to the New Zealand context.

1.1.4. Background and rationale summary

In summary, the implementation of nurse practitioner scope of practice in New Zealand was aimed at increasing patients' access to healthcare, improving patient outcomes and providing a sustainable solution to workforce shortages. However, nurse practitioners' abilities to substitute the role historically performed by doctors has been challenged. This has the potential to limit nurse practitioner positions and negatively impact on patient populations where access to healthcare is inadequate. Although there is research on nurse practitioner diagnostic reasoning, international variation in nurse practitioner academic and registration requirements limits the ability of this research being generalised to the New Zealand context. To date there is no research pertaining to New Zealand nurse practitioner diagnostic reasoning. This thesis attempts to fill that void. Having presented the background and rationale for this study, terms used in the study will now be defined.

1.2. Usage of terms

Although the definitions pertaining to *diagnostic reasoning*, *medical and nursing diagnoses*, *problems* and *action plan* are discussed in more depth in the following chapter, it is necessary to introduce these terms prior to presenting the research aim and central research question and subquestions. This thesis explores nurse practitioner diagnostic reasoning and compares it to that of registrars. In this study, the term diagnostic reasoning indicates the cognitive process involving data collection, identification of diagnoses and problems and the formulation of an action plan (Baid, 2006; Carneiro, 2003; Stausberg & Person, 1999).

The terms diagnoses, problems and action plan are key concepts in diagnostic reasoning and hence need defining. Medical and nursing disciplines interpret the term diagnosis differently. Generally nursing literature uses the term diagnosis to imply nursing diagnosis whereas medical literature uses it to indicate medical diagnosis. In this thesis, the term diagnosis denotes labelling of the disease or illness and the term problem means abnormal findings or problems needing intervention (Brykczynski, 1989, 1999; Elstein et al., 1993; Frauman & Skelly, 1999; Hoffman, Aitken, & Duffield, 2009; Muller-

Staub, Needham, Odenbreit, Lavin, & Van Achterberg, 2008). The term action plan in this study refers to applying interventions, prescribing and referring in response to identified diagnoses and problems (Baid, 2006; Carneiro, 2003; Weiss, 2011). Having outlined the terms used in this study, the research aim and central research question and subquestions will now be presented.

1.3. Research aim and questions

Arising from the background and rationale, the underpinning assumption giving rise to this research is the doubt pertaining to nurse practitioners' diagnostic reasoning (Gorman, 2009). This assumption and the need to investigate nurse practitioners' diagnostic reasoning abilities led to this study's research aim and central research question and subquestions.

The aim of this research is to explore nurse practitioner diagnostic reasoning. The central research question for this study is, how does nurse practitioner diagnostic reasoning compare to that of registrars? Within this question there are five subquestions, which are:

1. How do nurse practitioner diagnostic reasoning abilities compare to those of registrars?[3]
2. What diagnostic reasoning style do nurse practitioners use in the diagnostic reasoning process?

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[3] As specialists in training, registrars often manage complex patient cases. They discuss and seek guidance from a medical specialist as required. Nurse practitioners practise independently but collaborate with medical specialists when required. These same referral/collaboration lines suggest that although nurse practitioners and registrars may practice from different paradigms, their diagnostic reasoning abilities may not differ.

3. Does nurse practitioners' diagnostic reasoning style influence their diagnostic reasoning abilities?
4. What maxims guide nurse practitioner diagnostic reasoning?
5. Do maxims used by nurse practitioners influence their diagnostic reasoning abilities?

The research questions are based on three underlying assumptions arising from the previous discussion. Firstly, as nurse practitioners focus on health promotion and disease prevention, when compared to registrars, they may have inferior diagnostic reasoning abilities. Secondly, as nurse practitioners are very experienced nurses, their style of diagnostic reasoning is likely to utilise more System I processes (intuitive reasoning) than registrars. Thirdly, when compared to registrars, nurse practitioners may rely on more maxims (learned from experience) to guide their diagnostic reasoning.

Exploring nurse practitioner diagnostic reasoning and comparing it to that of registrars will illuminate nurse practitioners' diagnostic reasoning abilities and contribute to future workforce initiatives aimed at best meeting New Zealand's healthcare needs. Having presented this study's aim, central research question and subquestions, an overview of the remainder of the thesis will be outlined.

1.4. Thesis overview

Following this chapter, Chapter two, *Literature Review*, reviews and critiques the existing literature pertinent to this study. It describes the literature review process, presents definitions of diagnostic reasoning and synthesises the existing literature to illuminate varying ontological and epistemological perspectives relevant to diagnostic reasoning.

Chapter three, *Methodology*, outlines the theoretical perspective and research design underpinning this study. After considering the ontological and epistemological issues related to this study, a theoretical approach of post-positivism and a mixed methods research design are argued as being appropriate to answer the central research question and subquestions. Quantitative and qualitative methods chosen to collect data, participant selection and ethical processes are explained. Lastly procedures ensuring validity and reliability pertaining to the research design are shared.

Chapter four, *Data Analysis*, describes data analysis techniques used to answer the central research question and five subquestions. This chapter explains how the registrar data provided normative data and how the Delphi technique was used to determine what the expert panel considered correct diagnoses, problems and actions and logical and rational maxims. The chapter justifies the norm-referenced tests used to identify differences between nurse practitioner and registrar diagnostic reasoning and examine within-group differences.

Chapter five, *Results*, identifies nurse practitioners' diagnostic reasoning abilities (including identifying correct diagnoses, problems and actions), their diagnostic reasoning style and maxims used to guide their diagnostic reasoning. Differences between nurse practitioner and registrar diagnostic reasoning are presented and factors influencing nurse practitioners' diagnostic reasoning outlined.

Chapter six, *Discussion*, discusses the research findings and how they relate to the wider literature and the New Zealand healthcare context.

Chapter seven, *Conclusion*, summarises the thesis, addresses the study's limitations and the implications related to the findings.

1.5. Chapter summary

In summary, this thesis explores nurse practitioner diagnostic reasoning and compares it to registrars. In this study the term diagnostic reasoning denotes the cognitive process involving data collection, identification of diagnoses and problems, and the formulation of an action plan. The chapter outlined the rationale for undertaking the study and how global differences in the use of the nurse practitioner title limit generalisability of international research to the New Zealand context. The study's research questions are stated and an overview of the thesis provided. The thesis is presented in seven chapters. Having introduced the thesis, the next chapter focuses on the literature pertaining to diagnostic reasoning.

Chapter two: Literature review

This chapter presents the literature review on diagnostic reasoning. The ontological and epistemological perspectives within the literature influenced the design of this post-positivist mixed methods study. As outlined in the introduction, this thesis explores nurse practitioner diagnostic reasoning and attempts to answer the central research question, how does nurse practitioner diagnostic reasoning compare to that of registrars? Within the central research question, the research has five subquestions, which are:

1. How do nurse practitioner diagnostic reasoning abilities compare to those of registrars?
2. What diagnostic reasoning style do nurse practitioners use in the diagnostic reasoning process?
3. Does nurse practitioners' diagnostic reasoning style influence their diagnostic reasoning abilities?
4. What maxims guide nurse practitioner diagnostic reasoning?
5. Do maxims used by nurse practitioners influence their diagnostic reasoning abilities?

As researchers almost never conduct studies in an intellectual vacuum, they need to undertake their investigation within the context of existing knowledge (Chatburn, 2011). A literature review assists in ascertaining what is already known about the research subject thus enabling the researcher to either selectively replicate a study to avoid unintentional duplication, or identify the most suitable research methodology and methods that are able to answer the research question (Fink, 2005). The format used in the literature review will now be outlined.

2.1. Format of literature review

To enable a clear and focused discussion of the literature pertaining to diagnostic reasoning, the literature review is presented in six parts. The first part describes the processes undertaken to identify literature relevant to diagnostic reasoning. As diagnostic theory has been predominantly borrowed from psychology (Croskerry, 2009; Elstein, 2009), the second part provides a brief overview of cognitive psychology theory to illustrate the complexity of decision making. The third part defines how the term diagnostic reasoning is used in this study. The fourth part provides an outline of diagnostic reasoning theory while the fifth part outlines types of diagnostic reasoning. The sixth and final part focuses on factors influencing diagnostic accuracy. Having outlined the literature review format, the literature review now presents the literature research process.

2.2. The literature search process

An important part of familiarising oneself with the research subject is to be flexible and to think broadly about the key words and subject headings that could be related to the topic. Using the appropriate key words assists in identifying major literature relevant to the topic. As it is rarely possible for a computerised search to identify all relevant studies, additional research is found by examining the references of published studies (Chatburn, 2011).

A literature search was performed prior to designing the research and then repeated during and following collection and analysis of the data to identify more recently published research. These initial literature searches were conducted utilising online databases through CINAHL/EBSCO, and MEDLINE. The initial searches were performed using the key words: clinical decision making; clinical decision making and clinical judgement; and nurse practitioner. Due to the substantial amount of literature obtained using these key words, the search was refocused using the key words in the following order and with no date restriction: advanced nursing practice; advanced nursing practice and Master's education; clinical decision making and advanced nursing practice; clinical decision making and Master's level education; clinical decision making and clinical competence; clinical decision making and education; clinical decision making, education and Masters; Master's level education; advanced decision making; diagnostic reasoning; clinical decision making theory; information processing theory; decision making theory; developing diagnosis; diagnostics and nursing; and diagnosis and nurse practitioner.

As most of the relevant articles were identified using the key word diagnostic reasoning, this key word was used to search for missed literature in both the Scopus and Web of Science databases. From these searches relevant abstracts were read and relevant literature obtained. Additional literature was obtained from citations in published articles. The literature review was limited to publications written in English. Having outlined the process used to identify literature relevant to diagnostic reasoning, a brief overview of general decision making theory is now presented.

2.3. General decision making theory

Decision making is making choices between alternatives whereas reasoning reflects the cognitive processes of problem solving which leads to a conclusion (Goldstein, 2011). There are two types of reasoning: inductive and deductive. Inductive reasoning is when conclusions about what is probably true is based on evidence whereas in deductive reasoning conclusions follow a premise or hypothesis (Goldstein, 2011).

Decision making and reasoning are dynamic and complex processes. Circumstances surrounding the problem situation can change as the problem evolves and these changing circumstances can change the initial problem. The complexity is further increased by each problem solver's perceptions; as the problem changes, the problem solver's knowledge and response also need to change (Qudrat-Ullah, Spector, & Davidsen, 2008). Thus dynamic factors, such as the ill-structured aspects of the problem and the problems solver's varying academic, cultural and experiential backgrounds, will vary and contribute to the complexity of decision making (Qudrat-Ullah et al., 2008).

Early decision making theory failed to appreciate the complexity of decision making. The first model of decision making was the rational-economic model that assumed individuals were rational, logical and well informed (Stanovich, 2010). This model outlined a four-step process for decision making: identify the problem, identify potential solutions, choose the best solution, and implement it (McLennan, 1995). It was criticised, however, for its emphasis on quantifiable components with some suggesting qualitative and intuitive methods resulted in better decisions (Redekop, 2009; Stanovich, 2010).

In the 1950s Simon's decision making model emerged, which recognised decisions makers are constrained by personal and environmental factors; Simon referred to this as bounded rationality (Stanovich, 2010). From Simon's work it is now recognised that two types of rationality are used when making rational or good decisions: epistemological and instrumental rationality (Stanovich, 2010). Epistemological rationality, also termed theoretical or evidential rationality, is the influence individual's values and beliefs have on the decision making process (Stanovich, 2010). Instrumental rationality, also termed practical rationality, is behaving in a manner that gives the individual what they want, given the physical and mental resources. Both these types of rationalities work together to assist the person in determining "what is true and what to do" (Stanovich, 2010, p. 2). Factors negatively affecting epistemology and instrumental rationality include limited information processing, premature closure, premature commitments, information overload, conservation of financial resources, time, overconfidence, heuristics, and value biases (Ho, Oh, Pech, Dirden, & Slade, 2010; Nutt & Wilson, 2010; Redekop, 2009; Stanovich, 2010). In contrast, factors improving rationality include staying centred and using an exploratory mindset (Nutt & Wilson, 2010).

Personality theory also influences cognitive thinking and behaviour. Cognitive-Experience Self Theory (CEST) emerged in the 1970s, providing a framework to understand human behaviour. This theory outlines four equally important needs that drive human behaviour: the need "to maximise pleasure and minimise pain, for relatedness, to maintain stability and coherence, and to enhance self esteem'' (Sladek, Bond, Huynh, Chew, & Phillips, 2008, p. 2).

Over recent years, with the emergence of dual process theory, both intuitive and analytical decision making processes have been given credence (Redekop, 2009; Stanovich, 2010). In dual process theory, the use of intuitive (Type I) or analytic (Type II) decision making processes are determined by the type of decision required. Type I processes are rapid and do not require input from higher processes therefore do not require conscious attention (Stanovich, 2010). When using Type I processes, shortcuts, known as heuristics, are often used to speed up the decision making process (Stanovich, 2010). Type II processing is slow and requires awareness; Type II processing is critical when major or important decisions need to be made (Stanovich, 2010).

Probability reasoning, based on the mathematical formula described in Bayes' theorem, is often used in Type II processing to determine the likelihood of a good or bad outcome (Stanovich, 2010). Although it is now accepted that both Type I and Type II processes are required in decision making, Type I processes need to be stimulated by explicit knowledge (Redekop, 2009).

The balance of Type I and II processes is based on experience and learning and is described as pattern recognition (Redekop, 2009). In management theory, pattern recognition has been linked to common sense (Redekop, 2009). Common sense infers "those untutored cognitions, intuition, or mental instincts that are elucidated in the course of every day experience and help to structure that experience" (Redekop, 2009, p. 339). More recently, many cognitive scientists are suggesting the mind is equipped with innate intuitive theories to make sense of the world and are not the result of experience (Redekop, 2009).

Experts in a particular field usually solve problems faster and more successfully than novices (Goldstein, 2011). In general, experts are only experts in their particular field; when they are working outside their area of expertise they function as novices (Goldstein, 2011). Expertise in decision making requires focused and deliberate practice, which requires a high level of motivation, dedication, self-discipline and skill. It requires individuals to identify tasks they have not mastered and years of improving performance to gain mastery; this can often take over 10 years of experience to develop (Qudrat-Ullah et al., 2008). Other identified characteristics of decision making expertise include being able to identify informational inputs from the environment, understanding those informational inputs, intelligence and a high level of education (Ho et al., 2010). Thus years of experience alone will not develop decision making expertise (Qudrat-Ullah et al., 2008).

Experts not only have increased knowledge when compared to novices but also have their knowledge organised so it can be accessed more readily when required (Goldstein, 2011). Experts categorise the knowledge features based on the underlying principles involved, such as pathophysiology. This differs from novices who categorise their knowledge based on what the objects look like. This means that while experts may be slow to start analysing a problem due to their need to understand it first, they are more effective in solving it (Goldstein, 2011). Although being an expert has a number of advantages, they are less open to new ways of looking at problems, which means younger and inexperienced individuals are often responsible for revolutionary discoveries (Goldstein, 2011).

Being expert doesn't prevent errors in reasoning. Cognitive psychology has found laypeople and experts alike tend to make "consistent, systematic, and often insidious mistakes in reasoning which reflects a poor grasp of logical and probability theory" (Nestor & Schutt, 2012, p. 19). People in general tend to favour subjective impressions and personal anecdotes over factual statistics (Nestor & Schutt, 2012). Having provided some insight into the complexity of decision making, definitions pertaining to diagnostic reasoning are now discussed.

2.4. Defining diagnostic reasoning

Diagnostic reasoning is viewed as a complex and difficult process. Diagnostic reasoning expertise determines clinical competence and is considered the classical objective of both medical and nurse practitioner practice (Croskerry, 2009; Kassirer, 1989; Ortendahl, 2008; Ritter, 2003; Stausberg & Person, 1999; Szaflarski, 1997). Poor diagnostic reasoning can result in inappropriate treatment and can lead to progression of the disease and development of complications (Zunkel, Cesarotti, Rosdahl, & McGrath, 2004).

There is variation within the nursing discipline and between the medical and nursing disciplines in the way diagnostic reasoning is defined. In the general nursing literature, the formulation of diagnoses is seen as the end point of diagnostic reasoning (Frauman & Skelly, 1999; Lee, Chan, & Phillips, 2006; Zunkel et al., 2004). Zunkel et al. (2004) describe it as a "dynamic thinking process that is hypothesis driven and leads to a diagnosis that best explains the symptoms and clinical evidence in a given clinical situation" (p. 162). Lee et al. (2006) provide a similar definition defining diagnostic reasoning as "the active process of information processing in which a series of clinical judgments is made during and after data collection, culminating in informal judgements or formal diagnoses." (p. 58).

Where general nursing literature sees the diagnosis as the end point of diagnostic reasoning, advanced nursing and medical practice view the action plan as the end point (Baid, 2006; Carneiro, 2003; Durning, Artino, Pangaro, van der Vleuten, & Schuwirth, 2011; Pelaccia, Tardif, Triby, & Charlin, 2011). Action plans include applying interventions, prescribing and referring in response to identified diagnoses and problems (Baid, 2006; Carneiro, 2003; Weiss, 2011). Identifying and addressing both diagnoses and problems ensures a more appropriate action plan and may prevent patient harm (Pauker & Wong, 2010; Schwartz, Weiner, Harris, & Binns-Calvey, 2010).

The importance of the endpoint of diagnostic reasoning being the action plan is emphasised in recent literature focusing on diagnostic error. These errors often occur at multiple stages in the diagnostic process, including data collection, generating diagnoses and implementing action plans (Schiff et al., 2009; Sevdalis, Jacklin, Arora, Vincent, & Thomson, 2010; Winters et al., 2012). Inclusion of the action plan as the end point better reflects the role of New Zealand nurse practitioners; promoting health and improving patient outcomes requires not only identifying diagnoses and problems but also implementing timely and appropriate action plans.

Although both medical and nursing disciplines require generation of a diagnosis in the diagnostic reasoning process, they interpret the term diagnosis differently. Generally the nursing literature uses the term diagnosis to mean nursing diagnosis whereas the medical literature uses it to denote medical diagnosis. As this study explores the nature of nurse practitioner diagnostic reasoning, which includes formulating diagnoses, it is imperative to define how the term diagnosis is used in this study.

The term medical diagnosis denotes labelling a disease; this disease label is determined after analysing the patient's health history, including the signs and symptoms, and the physical examination and clinical data (Baid, 2006). A diagnosis is an explanation of the signs and symptoms the patient presents with and, where possible, provides a causal explanation (Elstein et al., 1993; Schwartz & Elstein, 2008). For many nurses, making medical diagnoses falls outside their scope of practice (Baid, 2006). In contrast, nursing diagnosis (also referred to as problems) means patient problems or signs and symptoms pertaining to a disease (Baid, 2006; Hoffman et al., 2009; Muller-Staub et al., 2008; Paans, Sermeus, Nieweg, Krijnen, & van der Schans, 2012) and provides no causal explanation as to what is causing these signs and symptoms.

As improved patient outcomes are dependent not only on identifying and treating the diagnoses but also on identifying other health issues that impact on patients' health status, New Zealand nurse practitioners need to identify both diagnoses and problems to implement effective action plans. Hence, in exploring the nature of nurse practitioner diagnostic reasoning, nurse practitioners' abilities in identifying both diagnoses and problems and how these are incorporated into their action plan need to be illuminated.

In this study exploring nurse practitioner diagnostic reasoning, the term diagnostic reasoning is defined as the cognitive process involving data collection, identification of diagnoses and problems, and the formulation of an action plan. The term diagnosis denotes labelling of the disease or illness and the term problem means abnormal findings or problems that need intervention. The term action plan (or actions) indicates applying interventions, prescribing and referring in response to identified diagnoses and problems. Having defined diagnostic reasoning, diagnostic reasoning theory will now be outlined.

2.5. Diagnostic reasoning theory

Diagnostic reasoning theory echoes general decision making theory. Although all diagnostic reasoning begins with history taking and clinical examination (Scott, 2009), the past 35 years have seen different types and models of diagnostic reasoning developed in an attempt to understand and explain the diagnostic reasoning process (Elstein, 2009; Ericsson, 2007). Historically, these were often seen as separate approaches and were criticised for oversimplifying the diagnostic process, providing only partial insight to the cognitive processes used by clinicians (Forde, 1998).

Hammond's cognitive continuum theory, proposed by Hammond in 1981 and developed from psychology, recognised different challenges required different approaches to thinking (Cader, Campbell & Watson, 2005; Loftus & Smith, 2008; Standing, 2008); in 1988 Hamm applied this theory to medicine (Cader et al., 2005; Croskerry, 2009; Standing, 2008). Hammond proposed a continuum between intuitive and analytical approaches consisting of six broad categories; at one end is the most intuitive mode (mode six) where the individual's opinion is justified by authority of his or her experience while at the other end is the most analytical mode (mode one) of highly controlled experimentation (Lauri & Salantera, 2002; Offredy et al., 2008; Standing, 2008; Stolper et al., 2011). Different tasks serve as catalysts for using different modes of thinking ranging from intuition to analysis (Lauri & Salantera, 2002; Standing, 2008). Lauri and Salantera (2002) developed a tool reflecting Hammond's cognitive continuum theory to measure nurses' modes of decision making (Lauri & Salantera, 2002; Lauri, Salantera, Gilje, & Klose, 1999; Lauri et al., 1998). This tool is discussed in more depth later in the thesis.

Whereas historically theory has proposed diagnostic reasoning as using separate intuitive and analytic approaches, recent developments in cognitive psychology research has seen the emergence and acceptance of dual process theory. Rather than diagnostic reasoning being on a continuum, dual process theory recognises experienced clinicians jointly use System (Type) I and II processes; however the degree to which each process is used is dependent on the clinical situation (Croskerry, 2009; Djulbegovic, Hozo, Beckstead, Tsalatsanis, & Pauker, 2012; Elstein, 2009; Offredy et al., 2008; Pelaccia et al., 2011; Stolper et al., 2011; Weiss, 2011).

System I (intuitive) processing uses inductive reasoning developed through experience, which enables clinicians to recognise overall patterns in the information presented and rapidly perform the required action (Coderre, Wright, & McLaughlin, 2010; Croskerry, 2009; Ely, Graber, & Croskerry, 2011; Heiberg Engel, 2008). System I processing is a passive and reflexive system that never sleeps (Croskerry, 2009; Djulbegovic et al., 2012) and is used automatically when salient features of the patient presentation are initially recognised. It is influenced by environmental information (including the positives and negatives the clinician may initially have about the patient), pattern recognition and the use of heuristics (Croskerry, 2009). System II processing is thought to endorse or check the answers gained from System I processing (Croskerry, 2009; Djulbegovic et al., 2012) thereby playing a monitoring role over it. If the patient presentation is not initially recognised, time permits or the clinician is uncertain, System II processes are used instead (Croskerry, 2009; Pelaccia et al., 2011; Stolper et al., 2011).

System II (analytic) processing requires more ideal conditions to calculate the probabilities of the likelihood of a patient having a certain disease (Croskerry, 2009; Stolper et al., 2011). Rather than using inductive reasoning it uses deductive reasoning that is more robust and logically sound (Croskerry, 2009). It involves slower, step-by-step, conscious, logical and defensible processes, which more closely reflect rationality (Coderre et al., 2010; Croskerry, 2009; Ely et al., 2011; Heiberg Engel, 2008; Szaflarski, 1997). This analytic approach requires explicit knowledge of physical or psychological states, conditions or diseases and their associated probabilities, pathophysiologic mechanisms and clinical manifestations (Croskerry, 2009; Szaflarski, 1997). Hence, System II processes use linear systems developed through learning that are less prone to error and continue to develop as the clinician matures (Croskerry, 2009).

The vigilance of System II processing to step in when System I processing triggers a sense of alarm is reduced by contextual factors such as fatigue or distraction (Pelaccia et al., 2011). Although System I processes reflect the brain's innate response, repetitive System II processing can eventually lead to System I processing (Croskerry, 2009).

Recent research demonstrates doctors thinking style influences their use of evidence-based clinical guidelines. Sladek et al. (2008) assessed the relationship between 74 medical personnel's self-reported thinking styles, knowledge and clinical practice related to the recently published acute coronary syndrome guidelines. Medical personnel included consultants, registrars, residents and interns. The results demonstrated participants who favoured System I (non-analytic) processing were less likely to incorporate the guideline into their practice when compared to those who favoured System II (analytic) processing. However, thinking styles, although related to the use of the guidelines in practice, were not related to awareness or detailed knowledge of them (Sladek et al., 2008).

Theories forming the foundations of System I and ll processes are the intuitive-humanistic and information processing theories. The intuitive-humanistic model is only discussed in nursing literature. This model focuses on the relationship between nursing experience and knowledge and decision making (Banning, 2007). This model is based on the use of intuition (introduced in Chapter one, *Introduction*, and discussed later in this chapter) and has been criticised for its lack of accurate reasoning. Supporters of this model view intuition as being able to link both physical, spiritual and personal data into the decision making process (Banning, 2007).

Information processing theory was developed from the work of Newell and Simon (Banning, 2007; Fonteyn & Ritter, 2008;

Lundgren-Laine & Salantera, 2010; Schwartz & Elstein, 2008). Information processing theory is when one uses an information-processing system to interact with a problem task (Hamers, Huijer Abu-Saad, & Halfens, 1994; Ritter, 2003; Taylor, 2000). The memory of the information processing system consists of three parts: the short term memory, the long term memory and the working memory (Lundgren-Laine & Salantera, 2010). The short term memory, although very fast, holds only a limited amount of information for a short period of time, normally no more than five to seven chunks. This limits the amount of information processed at any one time and what is there will eventually be lost unless stored in the long term memory (Fonteyn & Ritter, 2008; Goldstein, 2011; Hamers et al., 1994; Hoffman et al., 2009).

Chunks are recognisable units of information developed through learning (Hamers et al., 1994) that increases individuals' ability to hold information in the short term memory and to quickly move information between the long and short term memory (Goldstein, 2011; Khun, 2002). Knowledgeable and experienced clinicians can chunk simple units into familiar patterns enabling them to make more efficient use of their short term memory (Fonteyn & Ritter, 2008).

Long term memory stores information gained from education and experience for a long period of time. Although slower than the short term memory, stored knowledge can be retrieved by short term memory when required (Fonteyn & Ritter, 2008; Goldstein, 2011; Hamers et al., 1994; Hoffman et al., 2009; Muir, 2004). The working memory temporarily stores information and operates as a processing unit between the long and short term memory (Goldstein, 2011; Lundgren-Laine & Salantera, 2010). All processes receive information from, and return information to, the short term memory (Hamers et al., 1994). As knowledge is stored in long term memory, it plays an important role in diagnostic reasoning, as without knowledge, diagnoses cannot be made (Hamers et al., 1994). A high level of stored knowledge, superior organisation of that knowledge and the ability to quickly retrieve it contributes to expert diagnostic reasoning (Harjai & Tiwari, 2009). Having presented a broad outline of diagnostic reasoning theory, different types and models of diagnostic reasoning will now be discussed.

2.6. Types of diagnostic reasoning

Different types and models of diagnostic reasoning use either System I or II processes. Intuition and pattern recognition use System I processes whereas the hypothetico-deductive model, which incorporates probabilistic, causal and deterministic reasoning use System II processes. These types of System II processes often overlap and complement each other (Kassirer, 1989). As they are used in the hypothetico-deductive model, they will be discussed prior to presenting the hypothetico-deductive model.

Less commonly discussed diagnostic reasoning theories using System I and II processes are context related, and include rule out the worst case scenario and the event driven method, which is also known as utility theory (Sandhu, Carpenter, Freeman, Nabors, & Olson, 2006; Taylor, 2000). These theories are used predominantly in the acute care setting where, because of the patient's physiological instability, the clinician often completes the health history, physical examination, and performs diagnostic tests concurrently (Szaflarski, 1997). However, a rule out method is also used in primary care to rule out serious illness (Thompson, Harnden, & Del Mar, 2009). This means New Zealand nurse practitioners working in acute or primary health care may incorporate less common types of diagnostic reasoning into their practice. The dominant types and models of diagnostic reasoning will now be outlined.

2.6.1. Intuition

Intuition uses System I processes. Until recently the term intuition in diagnostic reasoning was predominantly discussed in nursing literature with medical literature generally linking intuition to pattern recognition (discussed next in the literature review). More recently, dual process theory has seen the emergence of a discourse on both intuition and pattern recognition in the medical literature.

Intuition is based on past experiences (Baid, 2006; Rew & Barrow, 2007; Stolper et al., 2011) and is the most subjective and private form of cognition (Standing, 2008). Hammond views intuition (mode six) as uncertain and inconsistent with rules lacking rationality and never made explicit (Offredy et al., 2008; Stolper et al., 2011). Hammond's view forms the basis of other definitions of intuition including tacit knowledge used without conscious awareness (Szaflarski, 1997), understanding without rationale (Banning, 2007; Benner & Tanner, 1987), immediate knowing of something without the conscious use of reason (Banning, 2007) and a process where the nurse knows something about the patient but is unable to verbalise it or cannot determine the source of knowledge (Banning, 2007; Rew & Barrow, 2007; Standing, 2008; Young, 1987).

In medical literature intuition is described as a gut feeling or a feeling of goodness or badness about something (Pelaccia et al., 2011; Stolper et al., 2011; Stolper et al., 2013). These gut feelings are at times very unreliable and misleading (Boyd, 2011). Stolper et al. (2011) view intuition or gut feelings as the outcome of a highly personalised knowledge base that helps clinicians deal with the complexity of their tasks. Recently a validated questionnaire has been developed to measure family physicians' gut feelings (Stolper et al., 2013).

Recent research suggests intuition remains a dominant mode of decision making in nursing. A UK study exploring and testing prescribing knowledge of 25 nurses showed the majority of participants had insufficient knowledge of diagnoses and pharmacological management with many relying on experience and intuition to make decisions (Offredy et al., 2008). This study only included two nurse practitioners; with differing nurse practitioner academic and registration requirements in the UK and the sample being predominantly registered nurses, the generalisation of these results to the New Zealand context is limited.

In relation to nurse practitioner use of intuition, Kosowski and Roberts (2003) used an interpretative phenomenological study to describe the use of intuition by 10 novice USA nurse practitioners. The authors described intuition as "the decision to act on a sudden awareness of knowledge that is related to previous experiences, perceived as a whole, and difficult to articulate" (p. 53). The participants were graduates from a recent nurse practitioner programme with an average of two years nurse practitioner experience. The results demonstrated these nurse practitioners used intuition or gut feeling to alert them to issues, which was followed by a search for more objective data to support their concerns.

The use of intuition to trigger clinicians' search for more objective data can contribute positively to the diagnostic reasoning process. Emotions or affect can elicit positive or negative feelings towards an object; these feeling can create a mental shortcut, known as the affect heuristic, which precedes analytical thinking (Stolper et al., 2011). This means intuition can alert clinicians to something not being right and trigger them to switch to an analytical mode of reasoning and revaluate their diagnoses and treatments (Kosowski & Roberts, 2003; Stolper et al., 2011).

Although intuition is dominant in nursing, there is medical research that demonstrates its use in medicine. In a study of 93 general practitioners in Germany when developing a *dealing with uncertainty* questionnaire, waiting until the reason for the diagnosis to become clear was closely related to intuition (Schneider et al., 2010). Intuition also correlated with knowledge of the family and occupational situation. In situations of uncertainty, intuition was more dominant in female participants whereas ordering more tests was more dominant in males (Schneider et al., 2010).

Reliance on intuition results in poor decisions. Thompson et al. (2007) assessed how 245 acute care nurses from four countries (UK, Netherlands, Australia and Canada) used clinical information to determine whether a patient was at risk of a critical event. They showed nurses predominantly used non-linear intuitive reasoning and applied strong but wrong decision rules to their clinical judgment (Thompson et al., 2007). Although this study did not include nurse practitioners, the results suggest intuition lacks accuracy and hence is a mode of reasoning unlikely to improve patient outcomes. As New Zealand nurse practitioners were introduced to improve patient outcomes, relying on intuition may be detrimental to the success of the role.

As alluded to in Chapter one, how much New Zealand nurse practitioners rely on intuition in their everyday practice is unclear. Intuition remains the dominant mode of decision making in nursing (Offredy et al., 2008; Thompson et al., 2007) and has been associated with gender (Schneider et al., 2010). Most New Zealand nurse practitioners are female which may mean New Zealand nurse practitioners incorporate intuition into their practice more than registrars where females are less dominant and there is more emphasis on analytic reasoning processes.

In the nursing literature, intuition is thought to have components of pattern recognition (Banning, 2007; Benner & Tanner, 1987); hence it is now timely to discuss the second type of System I processing, pattern recognition.

2.6.2. Pattern recognition

Pattern recognition, like intuition, uses System I processes. Pattern recognition is defined by Offredy (1998) as the process of making a judgment based on a few critical pieces of information. Others define pattern recognition as the ability to recognise relationships among cues (Benner & Tanner, 1987; Muir, 2004; Ritter, 2003; Standing, 2008). Pattern recognition is an inductive reasoning process used to interpret patterns through categorisation (Baid, 2006).

Pattern recognition requires direct automatic retrieval of information from well structured networks of stored knowledge pertaining to symptoms of disease and memory of past cases (Carneiro, 2003; Croskerry, 2009; Offredy, 1998; Schwartz & Elstein, 2008; Stolper et al., 2011; Szaflarski, 1997). Pattern recognition enables an almost instantaneous realisation that the patient's signs and symptoms fit within a previously learned pattern of a disease (Forde, 1998; Pelaccia et al., 2011); this instantaneous realisation can occur within 10 seconds of a patient encounter (Khun, 2002).

Diagnostic reasoning uses pattern recognition in less challenging cases when clinicians encounter patients with familiar clinical presentations (Fisher & Fonteyn, 1995; Mamede, Schmidt, & Rikers, 2007; Schwartz & Elstein, 2008). Pattern recognition enables short cuts or maxims to reduce cognitive load (Allen, Arocha, & Patel, 1998; Burman, Stepans, Jansa, & Steiner, 2002; Fisher & Fonteyn, 1995; Kassirer, 1989; Kempainen, Migeon, & Wolf, 2003; Mamede et al., 2007; Mamede, Schmidt, & Penaforte, 2008; Sandhu et al., 2006). These shortcuts work as heuristics or rules of thumb based on experience, personal theories and tradition and are not necessarily evidence based or based on physiological rationale (Fisher & Fonteyn, 1995; Kempainen et al., 2003; Mamede et al., 2007; Vickrey, Samuels, & Ropper, 2010). This reliance on rules enables the patient to be treated without relying on a complex storage system of examples and episodes (Kassirer, 1989).

Historically, pattern recognition was seen as a diagnostic reasoning style only used by expert clinicians. Recent literature highlights it is not related to expertise and is used by both novice and expert clinicians (Pelaccia et al., 2011). Young, Brooks, and Norman (2011) illustrated novice clinicians utilise familiar patient information, which is the basis of pattern recognition, when forming diagnoses. In their study 36 undergraduate psychology students were trained in diagnosing four simple psychiatric diagnoses and asked to complete a vignette. Twelve students completed it immediately, 12 after 24 hours and 12 in one week. The results showed novices used familiar but irrelevant factors, such as name, occupation, age and similar situations to support diagnoses (Young et al., 2011). These results are in contrast to experts who use well-formed illness scripts to support diagnoses.

Expert clinical knowledge is arranged in prototypes where clinicians link client symptoms to models in memory (Harjai & Tiwari, 2009; O'Neill, 1995; Schwartz & Elstein, 2008). A diagnosis is determined by comparing the memorised prototypes with the patient's presenting history and signs and symptoms (Harjai & Tiwari, 2009; Norman, Young, & Brooks, 2007; O'Neill, 1995; Schwartz & Elstein, 2008). In medicine, these memorised prototypes are referred to as illness scripts (Bowen, 2006; Coderre, Mandin, Harasym, & Fick, 2003; Custers, Stuyt, & De Vries Robbe, 2000; Lee et al., 2010). The process does not occur in a linear fashion but with the clinician arranging and rearranging the patient cues and comparing them to the prototypes in the memory (Harjai & Tiwari, 2009; O'Neill & Dluhy, 1997; Schwartz & Elstein, 2008). This non-linear process is referred to as the iterative process of pattern recognition (Forde, 1998; Grossman & Rodriguez, 2007). Pattern recognition, therefore, does not depend on generic thinking skills but mastery of specific information (O'Neill & Dluhy, 1997; Schwartz & Elstein, 2008).

Two views exist on the types of knowledge used in pattern recognition. One view suggests biomedical and clinical knowledge are two separate and incompatible forms of knowledge, hence, in pattern recognition clinical knowledge rather than biomedical knowledge is used (Boshuizen & Schmidt, 1992; Klomp, Eberhard, Hren, Hedderich, & Schmidt, 2009; Norman et al., 2007; Rikers, Loyens, & Schmidt, 2004; Rikers, Schmidt, & Moulaert, 2005; Schmidt & Boshuizen, 1993). With this view, a diagnosis can be reached with knowing how a set of signs and symptoms relate to a diagnosis without having any biomedical knowledge pertaining to what caused the illness (Rikers et al., 2005). The ability of achieving a diagnosis based purely on clinical knowledge is explained by Norman et al. (2007) using prototype and exemplar theory. Prototype theory assumes a clinician's experience with individual examples of disease states is averaged into prototypes containing most of the critical features. Exemplar theory assumes clinicians are able to identify critical features of specific diseases because they have acquired a large number of examples; hence they can link critical features to disease states by making an unconscious similarity match.

The other view on the type of knowledge used in pattern recognition suggests biomedical knowledge (such as biochemistry, anatomy and physiology) and clinical knowledge are linked and both are used

(Rikers et al., 2005). This second view forms the basis of encapsulation theory where biomedical knowledge becomes encapsulated with clinical knowledge (de Bruin, Schmidt, & Rikers, 2005; Klomp et al., 2009; Rikers, Loyens, te Winkel, Schmidt, & Sins, 2005; Rikers et al., 2005; Woods, 2007). Although the literature highlights these two views on pattern recognition, there is agreement that when there is uncertainty around the diagnosis of a complex case, biomedical knowledge is used (Rikers et al., 2005).

In one study, encapsulation theory was seen as the reason physicians, when compared to medical students, were faster and more accurate in judging biomedical and diagnostic items related to a case presentation (Rikers et al., 2005; Rikers, Loyens, et al., 2005). In another study, encapsulation theory was also seen as the reason why physicians scored higher in the diagnostic performance tests and medical students scored higher in the basic science tests (de Bruin et al., 2005). The authors concluded that family physicians do not revert to biomedical reasoning due to the routine nature of the cases. Rather they use encapsulation theory where basic science knowledge is activated in expert diagnostic reasoning through its relationship with clinical knowledge.

Nurse practitioner research suggests nurse practitioners use pattern recognition in their diagnostic reasoning. In a grounded theory study Burman et al. (2002) conducted telephone interviews using two vignettes, one with an acute illness (upper respiratory tract infection [URTI]) and one with a chronic illness (Type II Diabetes Mellitus [DM]) to explore the diagnostic reasoning of 36 US primary care nurse practitioners. All but seven participants had Master's degrees with five having Bachelor's degrees. The findings demonstrated nurse practitioners predominantly use pattern recognition, which also contained the use of cognitive schemas, intuition and hypothesis testing. Burman et al. (2002) defined cognitive schemas as profiles or mental images of what a disease state looks like and, although not described in the study, these cognitive schemas appear to be similar to illness scripts discussed in the medical literature. As most of the participants did have Master's degrees, the sample closely reflects the academic preparation of New Zealand nurse practitioners. However, because of differing registration requirements, when relating the study to the New Zealand context, the results must be viewed with caution.

Using the term set recognition rather than pattern recognition when describing advanced nursing practice, Brykczynski (1989, 1999) identified the importance of developing sets to quickly and accurately categorise patients and make decisions. Tang et al. (2003) describe a set as a collection of things that can be regarded as a single object, or put more simply, as a set of symptoms that make up a diagnosis. Hence, set recognition uses the same process as illness scripts.

Pattern recognition, particularly in the nursing literature, is often linked to intuition making its definition less clear (Buckingham & Adams, 2000; O'Neill, 1995). O'Neil (1995) suggests pattern matching to prototypes may account for a large component of what is known as intuition and Benner (1984) identifies pattern recognition as a component of intuitive thought. Having discussed intuition and pattern recognition, types and models of diagnostic reasoning that use System II processing will now be presented. This will begin by outlining probabilistic reasoning.

2.6.3. Probabilistic reasoning

Probabilistic reasoning has historically been viewed as using System II processing. More recently this has been challenged by Pennycook and Thompson (2012) who in a study of 62 Canadian volunteers identified prior probability (discussed in the following paragraph) could also be calculated using System I processes. They, however, acknowledged participants used analytic reasoning to determine which piece of information (either statistical or personality descriptions) was most reliable in establishing prior probability (Pennycook & Thompson, 2012).

In probabilistic reasoning, the clinician uses previous experience, knowledge and information gained from the health history and presenting clinical findings to estimate the prevalence, or prior probability, of all pertinent diseases (Arroll et al., 2012; Offredy, 1998; Radwin, 1990; Szaflarski, 1997; Taylor, 2000). Previously this required all possible diagnoses, also called differential diagnoses, to be exhaustive (Kassirer, 1989; Szaflarski, 1997); if a possible diagnosis was left out, it risked never identifying a possible cause of the patient's signs and symptoms.

Recent research of 16 physicians in Brazil illustrated they rarely made an exhaustive list of all possible differential diagnoses (Ferreira et al., 2010). Rather they used shortcuts, focusing on questioning and examining the patient until an initial hypothesis was achieved. The authors describe this as hypothesis specific heuristics. The rest of the consultation was based on supporting the hypothesis rather than generating an alternative one. One participant explained this approach by saying "we would not be able to finish our clinic if we were to think about differential diagnoses all day" (Ferreira et al., 2010, p. 4).

Probabilistic reasoning utilises Bayes' theorem (Soltani & Moayyeri, 2007; Standing, 2008). Bayes' theorem, a mathematical formula commonly used in medicine, estimates probabilities to calculate a likelihood ratio to determine whether the patient is highly likely or highly unlikely to have a disease (Carneiro, 2003; Kassirer, 1989;

Kempainen et al., 2003; Moosapour, Raza, Rambod, & Soltani, 2011; Moreira, Bisoffi, Narváez, & Van Den Ende, 2008; Schwartz & Elstein, 2008; Soltani & Moayyeri, 2007; Standing, 2008; Szaflarski, 1997).

Clinicians incorporate diagnostic testing to decrease the uncertainty about diagnostic hypotheses (possible diagnoses) that cannot be resolved through gathering the health history and physical examination. Pre-test and post-test probability assists in determining the likelihood ratio. Pre-test (prior) probability describes the clinician's belief about the likelihood of a disease prior to testing, whereas post-test (posterior) probability reflects the clinician's belief about the likelihood of the patient having a disease after the test results are available (Moreira et al., 2008; Schwartz & Elstein, 2008).

As formulating accurate diagnoses and diagnostic testing are closely linked, clinicians need to demonstrate competence in selecting and interpreting diagnostic tests. When the probability of the disease rises above the diagnostic threshold, the diagnosis is confirmed and no further tests are necessary. When diagnostic thresholds become too high, extensive diagnostic workups become inefficient, expensive and expose patients to unnecessary risks (Arroll et al., 2012; Cahan, Gilon, Manor, & Paltiel, 2003; Kassirer, 1989; Soltani & Moayyeri, 2007; Szaflarski, 1997).

Arroll et al. (2012) suggest data collected in the health history and physical examination is a diagnostic test itself with a sensitivity and specificity. They suggest completing these aspects of the diagnostic reasoning process increases the pre-test probability to a medium or high probability. A medium probability is the stage where further routine testing, such as blood tests and x-rays, can be performed. High probability is the state where treatment can be initiated or more expensive tests can be warranted (Arroll et al., 2012).

Research suggests clinicians overestimate competing diagnoses. In a study of 84 residents estimating the probability of differential diagnoses in a case scenario of a patient with chest pain, 65% of participants exhibited subadditivity where the total sum of probabilities was greater than 100% (range 44% to 290%); this occurred regardless of experience (Cahan et al., 2003). The authors concluded that in this particular study, the probabilities were not consistent with Bayes' theorem and were inaccurate and biased. They promote the use of explicit tools to estimate the pre-test probability, such as published likelihood ratios calculated for clinical signs and symptoms, and applying the diagnostic threshold approach. The authors suggest that the degree of subadditivity seen in this study may be explained by the limited information given to participants to rule out or support some of the differential diagnoses provided within the case scenario (Cahan et al., 2003).

Clinicians frequently use heuristics in the form of a maxim to simplify probabilistic reasoning. The maxim *common problems occur commonly* or w*hen you hear hoof beats, don't look for zebras, look for horses* is based on probabilistic reasoning and is used to discriminate between competitive diagnostic hypotheses (Frauman & Skelly, 1999; Gallagher, 1996; Szaflarski, 1997; Vickrey et al., 2010). Historical nurse practitioner research identified nurse practitioners employ this maxim (Brykczynski, 1989, 1999) which raises the issue of whether maxims are used by New Zealand nurse practitioners and their influence on nurse practitioner diagnostic reasoning. Lee et al. (2006) view probability theory as having limited use in nursing but Brykczynski's research and diagnostic reasoning literature suggest that although registered nurses may not require it, nurse practitioners do. Having discussed probabilistic reasoning, the literature review now presents causal reasoning.

2.6.4. Causal reasoning

Causal reasoning also uses System II processing. Causal reasoning applies anatomic, physiologic and biochemical mechanisms to explain the relationship between the cause and effect of the clinical data (Coderre et al., 2010; Ely et al., 2011; Gallagher, 1996; Kassirer, 1989; Sandhu et al., 2006). Hence, causal reasoning requires examination of physiological data to see whether it explains a diagnosis (Szaflarski, 1997). The final stages of the hypothetico-deductive approach, where hypotheses are validated (discussed later in this chapter), rely heavily on causal reasoning (Gallagher, 1996). Causal reasoning is also used to link biomedical knowledge to the clinical picture and provide an explanation for a given finding when the finding cannot be immediately linked to a diagnosis (Kassirer, 1989; Stolper et al., 2011). Kassirer (2010) argues relying on pathophysiological concepts to diagnose makes this model of diagnostic reasoning the "most narrow diagnostically when compared to other strategies" (p. 1120).

In causal reasoning a number of criteria are used to validate hypotheses (diagnoses) and include: internal consistency, parsimony, completeness and plausibility (Gallagher, 1996; Sandhu et al., 2006; Szaflarski, 1997). Internal consistency requires checking to see if the dots connected form a recognisable pattern (Gallagher, 1996). Parsimony assesses whether the dots connect to form the simplest pattern with the aim of forming a single diagnosis; or put simply, do the hypotheses offer the simplest possible explanation for the patient's presentation (Gallagher, 1996; Sandhu et al., 2006). Completeness, also known as adequacy, assesses whether the pattern includes all the dots or in other words, is the patient presentation consistent with the hypothesis (Gallagher, 1996; Sandhu et al., 2006). Plausibility assesses whether the pattern formed by the dots is a credible one (Gallagher, 1996). Thus causal reasoning is used to link all the patient's clinical findings to a diagnosis.

The New Zealand Nursing Council of New Zealand competencies for nurse practitioner scope of practice require nurse practitioners to apply physiological knowledge to the assessment process (Nursing Council of New Zealand, 2008). How much of this knowledge nurse practitioners incorporate into their diagnostic reasoning is unknown. Having outlined causal reasoning, deterministic reasoning is now presented.

2.6.5. Deterministic reasoning

Deterministic reasoning, like probabilistic and causal reasoning, uses System II processing. Deterministic reasoning, also known as categorical reasoning, depends on knowledge that exists in the form of unambiguous rules. These rules outline routine clinical practice and often exist in the form of diagnostic clinical practice guidelines, clinical algorithms or decision trees used to interpret and treat certain conditions (Banning, 2007; Ferreira et al., 2010; Kassirer, 1989; Standing, 2008; Szaflarski, 1997). These clinical practice guidelines or algorithms use flow charts to simplify the decision making process and are less intellectually challenging, saving both time and anxiety when clinicians are required to make rapid decisions (Sandhu et al., 2006). Well designed algorithms incorporate principles of statistics and epidemiology in a clinically useful format (Elstein, 2009), and although they are evidence-based as much as possible, they often reflect consensus opinions (Alpert, 2010). As algorithms are disease specific rather than patient specific, accurate and complex algorithms are not user friendly, a factor that discourages their use (Ferreira et al., 2010).

Algorithms and clinical practice guidelines provide a framework for clinicians' decision making rather than replacing the decision making process (Alpert, 2010; Grimmer & Loftus, 2008). As clinicians rely on combining information gained from the social environment and the algorithm's quantitative data (Ferreira et al., 2010), they must be familiar with the scientific basis behind the algorithm and use probabilistic reasoning to determine whether the algorithm is appropriate for a particular patient (Alpert, 2010; Sandhu et al., 2006).

Although algorithms provide a sense of security they can restrict thinking and lead to serious errors and omissions (Ferreira et al., 2010; Frauman & Skelly, 1999; Pirret, 2007). The study by Ferreira et al. (2010) discussed earlier in the chapter, illustrated clinicians used hypothesis specific heuristics in preference to clinical practice guidelines. This enabled them to gather contextual information gained during the patient assessment to determine the level of complexity and the management plan for the patient. Ferreira et al. argue the use of hypothesis specific heuristics, rather than deterministic reasoning, leads to better decisions and a lesser cost.

In nurse practitioner literature, clinical protocols have been criticised for increasing the risk of poor diagnostic reasoning (Carryer et al., 2007; Pirret, 2008b). Carryer et al. (2007), in response to the trend in Australia to use clinical protocols to determine and limit nurse practitioner practice, say "capable clinicians intent on following rules, may miss the very cues to which their education ability and wisdom are designed to respond, which may increase the risk of poor decision-making" (p. 112). Unlike Australia, clinical protocols have not restricted New Zealand nurse practitioner practice. New Zealand does have evidenced based guidelines developed by the New Zealand Guidelines Group, which are likely to influence diagnostic tests ordered and action plans implemented by nurse practitioners and doctors. These guidelines, however, guide practice rather than restrict it. Having outlined probabilistic, causal and deterministic reasoning, the hypothetico-deductive model is now presented.

2.6.6. The hypothetico-deductive model

As discussed previously, probabilistic, causal and deterministic reasoning are used in the hypothetico-deductive model (Kassirer, 1989). This model has historically been viewed as the predominant model used in medical problem solving (Ritter, 2003) and the model of expert reasoning (Elstein et al., 1993; Joseph & Patel, 1990; White, Nativio, Kobert, & Engberg, 1992). More recently, however, it is seen as a model predominantly used by novice clinicians, with expert clinicians only using it when analysing complex or unfamiliar cases (Elstein, 2009). The reason for it becoming so dominant in diagnostic reasoning literature is related to diagnostic reasoning research design that lends itself to hypothetico-deductive reasoning (Elstein, 2009). This means that most diagnostic reasoning research incorporates hypothetico-deductive reasoning thereby giving the impression that it is the dominent model.

The hypothetico-deductive model is a procedure of testing hypotheses and then modifying them as a result of the outcome of the test (Groen & Patel, 1985). The hypothetico-deductive model embraces two patterns of reasoning: inductive and deductive (Baid, 2006). Inductive (or forward) reasoning is where data collection guided by the patient's signs and symptoms leads to the generation of a hypothesis (Buckingham & Adams, 2000; Carneiro, 2003; Forde, 1998; Szaflarski, 1997). Deductive reasoning, also referred to as backward (retrograde) reasoning, starts with generated hypotheses, which are then used to predict the presence or absence of data which clinicians then search for to confirm or deny hypotheses

(Buckingham & Adams, 2000; Carneiro, 2003; Forde, 1998; Szaflarski, 1997). The hypothetico-deductive approach starts with the inductive approach based on only a few pieces of patient data then proceeds in a deductive manner to achieve the final diagnosis (Forde, 1998).

The hypothetico-deductive model consists of a series of stages: cue acquisition, hypothesis generation and hypothesis testing (Banning, 2007; Radwin, 1990). During the cue acquisition stage the clinician gathers clinical information about the patient and infers relationships among the cues and groups the cues together (Pelaccia et al., 2011; Radwin, 1990). The hypothesis generation stage is where the clinician searches for further information to confirm or eliminate any of the diagnostic hypotheses being considered (Pelaccia et al., 2011; Radwin, 1990). Initially early hypotheses are generated from the patient's age, sex, ethnicity and presenting complaints, however, in some cases they may emerge during the physical examination and following results of diagnostic tests (Kassirer, 1989; Szaflarski, 1997). Following early cues, three to five hypotheses are generated; due to the limited capacity of short term memory, only seven hypotheses are active at any one time (Elstein, 2009; Kassirer, 1989; Mehlhorn, Taatgen, Lebiere, & Krems, 2011; Szaflarski, 1997). The first diagnostic hypothesis is produced on average within 28 seconds with the correct diagnosis being achieved within six minutes (Carneiro, 2003; Pelaccia et al., 2011); the quality of these early hypotheses determine accuracy of diagnoses (Custers et al., 2000; Pelaccia et al., 2011; Radwin, 1990).

The hypothesis testing stage is the final phase where hypotheses are retained or rejected (Radwin, 1990). This stage identifies what findings should be present or absent if the patient has a given disorder. Here hypotheses are modified and refined, with some hypotheses being made more specific, some being deleted and some new ones added. Following this point a diagnosis is made (Radwin, 1990) that is sufficiently acceptable to establish a prognosis, and after considering the risks and benefits of each option (Weiss, 2011), a management plan is determined (Djulbegovic et al., 2012; Kassirer, 1989; Sandhu et al., 2006).

As mentioned earlier in this chapter, the hypothetical-deductive model utilises causal reasoning with the final stage of hypothesis validation relying on it heavily (Gallagher, 1996). Hypothesis generation and validation requires knowledge of symptoms pertaining to certain disease processes or disorders, pathophysiology and anatomy; overall, knowledge is used in that sequence, with knowledge of pathophysiology and anatomy only being used if knowledge of symptoms fails to identify the disease (Stausberg & Person, 1999).

Nurse practitioner research suggests nurse practitioners use hypothetico-deductive reasoning. Using a computer-simulated case scenario, White et al. (1992) studied the diagnostic reasoning of 21 family and six obstetric/gynaecology USA nurse practitioners; 20 had completed Master's degrees while seven had completed a short non-degree programme. The results demonstrated all the nurse practitioners used hypothetico-deductive reasoning. The study also highlighted differences between the inexperienced and experienced nurse practitioners, with inexperienced nurse practitioners having a greater number of working hypotheses and nurse practitioners with high specialty knowledge being more efficient in reaching a diagnoses and formulating an action plan. Case scenarios, such as that used in the White et al. (1992) study, have been criticised as not reflecting the real practice environment, however, participants were asked to rate the credibility of the computer based scenario thus improving the validity of the study. Although 20 (74%) participants had a Master's degree, it is unclear how the seven non-Master's degree nurses influenced the results. That, along with differing registration requirements in New Zealand, makes the results difficult to translate to the New Zealand setting.

Consensus in the literature on how the hypothetico-deductive model is defined and used enables research on diagnostic reasoning to be organised into distinct stages. These stages allow investigators to study ways in which types of information are gathered and used and how hypotheses are generated and evaluated (Lee et al., 2006). It is a decision making process that is easily communicated to others in the decision making team (Lee et al., 2006). The hypothetico-deductive model, however, has been criticised for oversimplifying the diagnostic process by failing to capture all the variables involved and therefore not representing the reality of clinical practice (Lee et al., 2006). Having discussed diagnostic reasoning theory, dual process theory and how it relates to nurse practitioner practice will be briefly presented.

2.6.7. Dual process theory and nurse practitioner practice

Although dual process theory has recently emerged, historical and more recent nurse practitioner diagnostic reasoning research demonstrates nurse practitioners combine System I and II processes within their practice. Brykczynski (1989, 1999) in an interpretative study of 22 US nurse practitioners demonstrated they use intuition, pattern recognition and maxims to make both medical and nursing diagnoses. Maxims included *real disease declares itself*, *follow-up everything*, and *common things occur commonly*. Whether these maxims resonate in New Zealand nurse practitioner diagnostic reasoning is unknown. If they do, their influence on nurse practitioners' abilities in identifying accurate diagnoses and problems and implementing appropriate action plans would be useful to know.

Nurse practitioners' use of System I and II processes is further supported by Offredy (1998) who used semi structured interviews and observational field notes to study the types of patients/cases requiring consultation with either the GP or nurse practitioner. Participants included 20 UK nurse practitioners who had completed the Royal College of Nursing UK diploma/degree course and were working in primary health care practice. No study participants held Master's degrees. The study found participants used different types of reasoning including the hypothetico-deductive model, deterministic reasoning, pattern recognition and intuition depending on the patient's presenting problem. As outlined in Chapter one, in the UK the title nurse practitioner is not protected, meaning any organisation can use the term when employing staff. Thus, UK nurse practitioners have no academic or registration requirements, therefore, the practice of UK nurse practitioners may not reflect the practice of New Zealand nurse practitioners. Hence, how the study results reflect the New Zealand context is unknown.

Ritter (2003) used think aloud verbalisations to determine the use of hypothetico-deductive or intuitive reasoning by 10 USA nurse practitioners. All the nurse practitioners had a minimum of three years experience, a Master's degree in nursing, current licensure as a nurse practitioner, and leadership roles within a clinical area or professional groups. The results showed nurse practitioners used hypothetico-deductive reasoning and intuition. Although the participants all had Master's degrees, the small sample size limits the generalisation of the results to the New Zealand context. As discussed earlier in the chapter, Kosowski and Roberts (2003) in an interpretative phenomenological study of 10 novice USA nurse practitioners demonstrated they used intuition or gut feeling to alert them to issues, which was followed by a search for more objective data to support their concerns.

There is limited research comparing nurse practitioner diagnostic reasoning to that of doctors. Sakr et al. (1999) compared the care United Kingdom (UK) emergency department nurse practitioners and junior doctors gave to patients presenting with minor injuries. Following assessment by the nurse practitioner or junior doctor, an experienced registrar assessed the patient. The differences between the registrar's assessment and the nurse practitioners' and junior doctors' assessments were then compared. The study demonstrated nurse practitioners and junior doctors performed the assessment adequately with regards to taking the health history, examination of the patient, interpreting radiographs and treatment decisions. Patients seen by nurse practitioners required less unplanned follow-up care. The frequency of diagnostic error made by the two groups was similar, with nurse practitioners making errors in 9.2% of cases compared to 10.7% in the junior doctor group. This study made the assumption that the registrar assessment was correct, which may not be the case. Once again, the differences between the academic and registration requirements of UK and New Zealand nurse practitioners make these results difficult to generalise to the New Zealand context.

Van der Linden, Reijinen, and de Vos, (2010) in a descriptive cohort study in the Netherlands, compared the electronic records of 741 patients with minor illnesses and injuries treated by emergency nurse practitioners to 741 patients treated by senior house officers. Although the nurse practitioner group missed more injuries, due to failure to interpret radiographs, no statistically significant difference was detected between the two groups in relation to missed injuries and inappropriate management. The results are difficult to generalise to the New Zealand context as the nurse practitioner group was very inexperienced (0.1-1.3 years) and were also working as emergency staff nurses (van der Linden et al., 2010).

An earlier study by Offredy (2002) used six patient scenarios to compare the cognitive processes of 11 UK primary care nurse practitioners and 11 general practitioners they worked with. The nurse practitioners had completed the Royal College of Nursing nurse practitioner degree programme. The study identified both groups used similar cognitive processes when generating both correct and incorrect responses. The differences between the two groups were attributed to the general practitioners having more knowledge and experience than the nurse practitioners. This was related to nurse practitioners' lack of familiarity with the case presentations due to the restrictions general practitioners placed on the type of consultations they performed (Offredy, 2002.) In this study the reason nurse practitioners referred the patient to the general practitioner was due firstly, to the scenario being outside their agreed role and secondly, to their uncertainty with the diagnosis or medication.

The limitations placed on the roles UK nurse practitioners perform is clearly described by Offredy (2002) in an example where one nurse practitioner referred the patient to the general practitioner as her role ended after the history taking. This example highlights the differences between nurse practitioner practice in the UK and New Zealand and the difficulties associated with interpreting the results of UK research to the New Zealand context. In New Zealand nurse practitioners practise independently but collaborate with medical specialists when required. Having discussed diagnostic reasoning theory, factors influencing diagnostic accuracy will now be outlined.

2.7. Factors influencing diagnostic accuracy

The effect of diagnostic error on patient morbidity and mortality is significant (Croskerry, 2009; Sevdalis et al., 2010). As already discussed, no matter what model of diagnostic reasoning is used, it involves many separate steps. Each step is characterised by uncertainties, biases, errors, motives and values, all of which can lead to diagnostic error (Forde, 1998; Sandhu et al., 2006).

Diagnostic error, also referred to as cognitive error or cognitive strain, occurs when clinical cues either lead to an incorrect hypothesis or are interpreted as being supportive of a particular diagnostic hypothesis when they are not (Custers et al., 2000). Research identifies various factors that influence diagnostic accuracy; these will now be outlined.

2.7.1. Collecting inappropriate information

Diagnostic accuracy diminishes if clinicians collect excessive information, ignore meaningful information and place too high a value on irrelevant information (Allen et al., 1998; Radwin, 1990). Each individual has a certain amount of cognitive resources to carry out cognitive tasks; when this is exceeded it is referred to as cognitive load (Goldstein, 2011; Stolper et al., 2011; Workman, Lesser, & Kim, 2007). Excessive information can exceed the cognitive load by lowering the clinician’s response time and increase their error in carrying out a particular task (Workman et al., 2007).

Studies have found a positive correlation between diagnostic accuracy and critical cues (Radwin, 1990). Critical cues are highly valid and reliable items of information that help to distinguish one diagnosis from another (Radwin, 1990; White et al., 1992). Expert medical clinicians, who have well formed illness scripts, know which questions to ask and what findings to look for when searching for diagnostic answers (Allen et al., 1998; Khun, 2002; McColl & Groves, 2007).

Research demonstrates error in the diagnostic reasoning process predominantly occurs in the initial data gathering stage. In a study involving 72 Dutch residents and review of 246 records of patients presenting to five hospitals with dyspnoea, researchers found most of the diagnostic errors occurred when collecting the health history, performing the physical examination or requesting diagnostic tests (Zwaan, Thijs, Wagner, Van Der Wal, & Timmermans, 2012).

Early nurse practitioner research identified nurse practitioner diagnostic error was related to the inappropriate use or interpretation of cues. Rosenthal et al. (1992), when reviewing how well four USA nurse practitioners diagnosed chlamydial infection in 492 patients, demonstrated they made diagnostic errors. These stemmed from inconsistent use of clinical cues and collecting cues that were unrelated to the diagnostic problem. No information on the academic preparation of the participants was provided. The results of this study need to be viewed with caution as it is an old study and, although reviewing 492 patients, it only included four nurse practitioners; this small sample size limits the study's generalisability. However, the results echo those of White et al. (1992), presented earlier in this chapter when discussing hypothetico-deductive theory, who found that nurse practitioners who made incorrect diagnoses and ordered inappropriate tests did not understand what the results indicated.

2.7.2. Diagnostic reasoning style

Varying diagnostic reasoning approaches can negatively affect diagnostic accuracy. Both System I and II processes are prone to error (Norman & Eva, 2010; Pelaccia et al., 2011). As both forms of processing contribute to a final decision (Pelaccia et al., 2011), for a diagnostic error to occur both systems need to fail; System I by generating the error and System II by not detecting and correcting it

(Sherbino et al., 2012). When analytical approaches are used, errors are infrequent, unexpected and large, whereas with intuitive approaches they are expected, frequent and mostly small (Hammonds, 2007, as cited in Standing 2008; Sherbino et al., 2012).

Clinicians use strategies to reduce cognitive strain and prevent cognitive error, such as using a consistent approach when gathering data or using probability theory and the maxim *common problems occur commonly* (Gallagher, 1996; Radwin, 1990). Failure to estimate probability of diagnoses leads to error (Carneiro, 2003). Base rate neglect occurs when clinicians neglect to assess post-test probability using Bayesian principles. This means they fail to correctly assess both prior probability and the strength of the evidence (Schwartz & Elstein, 2008).

Clinical algorithms may also cause diagnostic error. Although algorithms are designed to help clinicians interpret findings they have been criticised for not dealing effectively with the uncertainty of clinical practice, not being based on rigorous evidence, and having ambiguous branch points (Kassirer, 1989).

Lawson and Daniel (2010) recommend a pattern of if/then/therefore reasoning and making inferences using abduction, retroduction, deduction and induction to reduce diagnostic error. They reason these inferences share similarities with hypothetico-deductive reasoning and rather than functioning subconsciously, should operate consciously (Weiner et al., 2010). Abduction generates alternative hypotheses whereas retroduction tests a hypothesis to explain observations (Weiner et al., 2010). As explained earlier in this chapter, inductive reasoning is when conclusions about what is probably true is based on evidence whereas in deductive reasoning conclusions follow a premise or hypothesis (Schneider et al., 2010).

2.7.3. Experience

Experienced clinicians with a high level of specialty knowledge and clinical expertise make fewer mistakes (Allen et al., 1998; Khun, 2002) by balancing System I and II processes (Lucchiari & Pravettoni, 2012). Education and experience improve the balancing of System I and II processes and should lead to less errors. Coderre et al. (2003), using think aloud protocols of four common gastroenterology cases to compare the diagnostic reasoning of 20 gastroenterology specialists and 20 final year students, found the specialists achieved higher diagnostic success.

Using a wider sample population, Allen et al. (1998) used a two-stage study to assess diagnostic accuracy in a USA outpatient clinic. Stage one used a simulated patient presentation and included five expert physicians, five residents and five final year students. Stage two used participant observation of eight live clinical interactions and included four expert physicians and four residents. The results demonstrated physicians generated accurate diagnostic hypotheses based on few initial cues. Residents failed to gather or use the evidence needed to support or refine their initial inaccurate hypotheses or to find evidence to develop accurate or alternative hypotheses. Not surprisingly the students demonstrated inefficient evidence gathering that was based on an inability to develop accurate diagnostic hypotheses and insufficient knowledge of underlying pathophysiology.

The role of experience in understanding and performing diagnostic tests and implementing action plans was further supported in a Canadian study of 53 paediatric emergency registrars using 60 questions nested into 36 cases (Carrière, Gagnon, Charlin, Downing, & Bordage, 2009). The results highlighted the variation in participant group knowledge (48-82%) and demonstrated experience was related to higher scores.

The questioning of New Zealand nurse practitioners expertise in making medical diagnoses has been a motive for this thesis. Although the size of Allen et al.'s (1998) study prevents the results from being generalised, both their study and that of Carrière et al. (2009) demonstrate the expertise of registrars in formulating medical diagnoses is also questionable and needs to be considered in the research design of this thesis.

There is debate in the literature around whether age, which is usually associated with experience, reduces error. Choudary, Fletcher and Soumerai (2005) in a systematic review found as physicians age their clinical knowledge increased but their adherence to guidelines and patient outcomes reduced. These findings are in contrast with other research suggesting age and experience increases non-analytic thinking without causing diagnostic error (Weiss, 2011).

Experts still make mistakes but are thought to be better than more junior clinicians at detecting and recovering from them. In a laboratory study involving 13 surgeons, 11 surgical residents and one anaesthetic resident and using vignettes and a think aloud technique, Patel et al. (2011) illustrated experts picked up more errors when compared to residents, although the difference was not statistically significant. Detecting errors was not related to years of experience. The study did highlight experts' abilities in justifying their errors and picking them up with partial information; residents needed all the information before recognising them.

2.7.4. Specialty knowledge

Historically it was thought that clinicians who had high specialty knowledge in one area could not transfer those cognitive skills to an area of low specialty knowledge (Chi, Glaser & Farr, 1998 and Johnson, 1988 as cited in Fisher & Fonteyn, 1995). However, Joseph and Patel (1990) challenged this view. Using think aloud protocols and an endocrine case presentation to assess the decision making of four endocrinologists with high specialty knowledge and five cardiologists with low specialty knowledge, they demonstrated no difference in diagnostic accuracy. They did, however, identify that when compared to the cardiologists, the endocrinologists focused more on critical and relevant cues and organised their information in a more coherent manner using strong causal relations. The endocrinologists also produced fewer new diagnostic hypotheses and produced accurate diagnoses earlier than the cardiologists. The small sample size (N=10) of Joseph and Patel's study is an obvious weakness, however, the study was reanalysed by Elstein et al. (1993) using coding schemes who found the same results, thus improving the generalisability of the study.

2.7.5. Premature closure

Diagnostic error is also caused by premature closure (Elstein, 2009; Frauman & Skelly, 1999; Levy, Sherwin, & Kuhn, 2007; Lucchiari & Pravettoni, 2012; Norman & Eva, 2010; Scott, 2009). Premature closure is the acceptance of a diagnosis before sufficient verification has occurred and failure to consider other plausible alternatives once it has been reached (Levy et al., 2007). Premature closure, combined with faulty hypothesis generation, is identified as the major shortcoming of both the hypothetico-deductive model and pattern recognition (Sandhu et al., 2006). Lucchiari and Pravettoni (2012) propose premature closure is indicative of cognitive stress and the need for the clinician to make a diagnosis to reduce that stress. This view is supported by Holtman (2011) who argues novice clinicians manage uncertainty by closing off potential avenues of enquiry rather than mastering knowledge.

In a USA study examining 100 cases of diagnostic error by medical staff working in internal medicine, system issues contributed to 65% of errors and cognitive factors to 74%. Premature closure was the most common cognitive problem with faulty data gathering occurring less commonly and inadequate knowledge rarely encountered (Graber, Franklin, & Gordon, 2005).

2.7.6. Value biases and heuristics

Cognitive errors are also caused by value biases and heuristics (Croskerry, 2009; Fisher & Fonteyn, 1995; Harjai & Tiwari, 2009; Kempainen et al., 2003; Mamede et al., 2007; O'Neill, 1995; Szaflarski, 1997; Weiner et al., 2010). Although 40 cognitive biases have been described (Lucchiari & Pravettoni, 2012; Scott, 2009), the common value biases include stereotyping, prejudice and overconfidence (Lucchiari & Pravettoni, 2012; Mamede et al., 2008; Norman & Eva, 2010; Standing, 2008).

When used by experienced clinicians, heuristics reduce the need to ask unnecessary questions and order unnecessary diagnostic tests thereby making the process more manageable and efficient (Gallagher, 1996; Kassirer, 1989; Norman & Eva, 2010; O'Neill & Dluhy, 1997). It is a fast process, requiring little effort and is mostly correct but it can occasionally fail and lead to very poor patient outcomes (Croskerry, 2009).

Commonly discussed heuristics in recent literature include base rate neglect, framing, anchoring, availability, representativeness, confirmation bias, blind obedience (Lucchiari & Pravettoni, 2012;

Vickrey et al., 2010) and outcome bias (de Bruin, Camp, & van Merrienboer, 2010; Pennycook & Thompson, 2012). These heuristics are defined in Table 1.

Table 1

Definitions of commonly discussed heuristics

Base rate neglect	The tendency to ignore the true rate of disease in favour for a more rare and exotic disease (Norman & Eva, 2010).
Framing	When diagnostic reasoning overvalues an item of clinical information presented early in the diagnostic process (Vickrey et al., 2010).
Anchoring	Where clinicians fail to adjust probabilities when new clinical information becomes available (Banning, 2007; Levy et al., 2007; Sandhu et al., 2006; Scott, 2009; Standing, 2008; Vickrey et al., 2010).
Availability	Where easy recall of similar examples overestimates the likelihood of a diagnosis (Bornstein & Emler, 2001; Pauker & Wong, 2010; Scott, 2009; Vickrey et al., 2010).
Representativeness	Where the clinical presentation resembles other patients presenting with a well-characterised disease and the clinicians overestimate the likelihood of the patient having the same disease (Bornstein & Emler, 2001; Pauker & Wong, 2010; Schwartz & Elstein, 2008; Vickrey et al., 2010).
Confirmation bias	The tendency to selectively look for information that confirms the likely diagnosis and overlooks information that argues against it (Bornstein & Emler, 2001; Goldstein, 2011; Tschan et al., 2009).
Blind obedience	When clinicians show inappropriate deference to authority or technology (Vickrey et al., 2010).
Outcome bias	Where the clinician uses a single case experience to ignore their entire knowledge base and change their diagnosis (de Bruin et al., 2010).

2.7.7. Contextual factors

More recently contextual errors have been recognised as contributing to inappropriate medical care delivery. Contextual error occurs when contextual variables, such as patients' social settings and education needs, are not considered in the plan of care (Pauker & Wong, 2010). In a USA study of 111 internal medicine physicians, failure to probe contextual issues reduced the likelihood of an error free plan. Physicians provided an error free plan in 73% of uncomplicated encounters, which reduced to 38% in complicated encounters. This further reduced to 22% in contextually complicated encounters and to 9% in combined medically and contextually complicated encounters (Weiner et al., 2010). Research with 124 USA fourth year medical students showed simple training workshops can improve clinicians' performance in probing for contextual issues (Schwartz et al., 2010). Weiner et al. (2010) call for strategies to improve physician assessment of contextual variables and reiterate the need to set new measures to ensure physicians individualise patient care.

Arroll et al. (2012) claim pre and post-test probability requires clinicians to know the types of disease and their signs and symptoms within their practice area. As clinicians rely on their experience and knowledge of the patient population and their work environment, failure to relate a presenting condition to this context leads to incorrect diagnoses and inappropriate treatment (Arroll et al., 2012). This view is echoed by Durning et al. (2011) who propose doctors working in a clinic may underestimate the seriousness of a presentation whereas doctors working in an emergency department may overestimate it.

Although contextual factors reduce diagnostic error, they can also influence clinicians' use of evidence-based practices (Callaghan, 2012; Harjjaj, Salek, Basra, & Finlay, 2010). In a New Zealand study examining factors affecting diagnostic decisions within the Accident Compensation Corporation (ACC) context, Callaghan (2012) identified patient history and the examination findings were the most influential factors but 37 other factors influenced general practitioners' decisions. Some of the factors rated highly included patient expectations and the closeness of the general practitioner and patient relationship (Callaghan, 2012). Although the study had a low response rate (52%), which the author acknowledges as likely to influence the reliability of the results, it does highlight diagnostic reasoning cannot be separated from the environment in which it is practised.

Recent research involving medical physicians in the USA revealed they were only slightly aware of the influence context had on their diagnostic reasoning (Durning et al., 2011). Using think aloud and free text answers, 25 participants viewed three videotapes in which contextual factors were altered. Contextual factors included the patient challenging the doctor's credentials, language difficulties due to English as a second language, the patient suggesting an incorrect diagnosis, and an atypical presentation of the condition. Results illustrated participants overlooked key findings in the assessment process when two or more contextual factors were present. These contextual factors increased participants' cognitive load and limited their ability to process information (Durning et al., 2011). The study found the participants (who were experts) retrospectively recognised the data they overlooked and the contextual factors influencing their diagnostic reasoning (Durning et al., 2011).

Contextual factors have always been a part of the nursing assessment process in the form of identifying nursing diagnoses or problems; thus contextual error may not be an issue in nurse practitioner practice. Recognising the importance of contextual variables reiterates the need for this study to assess clinicians' abilities in identifying diagnoses and problems and how these are addressed in the action plan.

2.7.8. Environmental factors

Environmental factors also restrict diagnostic accuracy. Suboptimal conditions, such as time, fatigue, and resource constraints can lead to diagnostic error (Croskerry, 2009; Durning et al., 2011; Pelaccia et al., 2011; Sevdalis et al., 2010). In a review of transcripts, discussions and interviews with 16 physicians in a Brazilian hospital, limited time, knowledge and memory constraints encouraged clinicians to incorporate heuristics rather than clinical practice guidelines (Ferreira et al., 2010). As in general decision making theory the constraints placed on these clinical encounters are referred to as bounded rationality (de Bruin et al., 2010; Ferreira et al., 2010) or ecological rationality (de Bruin et al., 2010).

An ethnographic observational study illustrated how frequently five emergency physicians were interrupted during their working day. Half of their decisions were planned, 34% opportunistic, such as calling in to see a patient while passing, and 21% interrupted, such as by a pager (Franklin et al., 2011). This research focused on workflow rather than on diagnostic accuracy, however, the results provide insight into everyday factors clinicians face when performing diagnostic tasks.

2.7.9. Reflective practice

Whereas numerous factors cause diagnostic error, reflective practice is thought to improve diagnostic reasoning (Lucchiari & Pravettoni, 2012; Mamede et al., 2010; O'Neill, 1995). Reflective practice has been defined as the ability of the clinician to think critically about their own reasoning and decisions (Elstein, 2009; Mamede et al., 2008).

Diagnostic abilities are thought to improve when clinicians critically reflect on their practice. This process, also referred to as metacognition, increases awareness of how clinicians' values and attitudes influence diagnoses (Lucchiari & Pravettoni, 2012; Mamede et al., 2008). Elstein (2009) sees the hypothetico-deductive model providing opportunities to reflect when seeking alternative diagnoses.

Coderre et al. (2010) argue expert clinicians prevent their actions occurring subconsciously by retaining their ability to reflect and change their actions. In psychology, reflection is sometimes regarded as the fifth stage of competence. These stages begin with unconscious incompetence before moving through conscious incompetence, conscious competence and unconscious competence (Coderre et al., 2010).

Reflection reduces availability bias.[4] Mamede et al. (2010) highlighted this when assessing the diagnostic abilities of 18 first year and 18 second year Rotterdam internal medicine students. The students reviewed six clinical cases, followed by eight similar cases and then four cases using reflective reasoning. The authors found availability bias was greater in the second year students; in the final four cases both groups counteracted this effect using reflective reasoning. The researchers speculated one reason for the greater use of availability bias in the second year group was the inexperience in the first year group which prevented them from making extensive use of pattern recognition (Mamede et al., 2010).

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[4] Availability bias is when easy recall of similar examples overestimates the likelihood of a diagnosis (Bornstein & Emler, 2001; Pauker & Wong, 2010; Scott, 2009; Vickrey et al., 2010

2.7.10. Evidence based medicine

Evidence based practice is thought to improve diagnostic reasoning. Evidence based practice integrates the best research evidence, clinical expertise, context and patient choice (Sackett, Straus, Richardson, & Haynes, 2000). As knowledge is a significant component of both evidence based practice and diagnostic reasoning, problems can occur when clinicians are unable to retrieve that knowledge and have insufficient personal knowledge (Elstein, 2009). Computer assisted evidence based practice devices have been developed to support diagnostic accuracy, however, ongoing difficulties with their use have prevented their acceptance (Elstein, 2009); any evidence suggesting their usefulness is counteracted by observations demonstrating their inability to match doctors' diagnostic performance (de Bruin et al., 2010).

2.8. Chapter summary

This study explored nurse practitioner diagnostic reasoning and compared nurse practitioner diagnostic reasoning to that of registrars. Most of the literature pertaining to diagnostic reasoning stems from the medical discipline. The literature review provided a number of definitions for diagnostic reasoning but for this study, diagnostic reasoning is defined as the cognitive process involving data collection, identification of diagnoses and problems, and the formulation of an action plan. In this study the term diagnosis denotes labelling of the disease or illness, the term problem means any abnormal findings or problems that need intervention, and the term action plan indicates applying interventions, prescribing and referring in response to identified diagnoses and problems.

Diagnostic reasoning theory provides an understanding of the cognitive processes used in diagnostic reasoning. Dual process theory is characterised by both System I and II processes. Intuition and pattern recognition use System I processes whereas the hypothetico-deductive model incorporating probabilistic, causal and deterministic reasoning use System II processes. Many factors influence diagnostic accuracy and include inappropriate collection of data, diagnostic reasoning style, experience, specialty knowledge, premature closure, heuristics and value biases, contextual and environmental factors, reflective practice and evidenced based practice.

Nurse practitioner research has predominantly originated in the USA and UK; both countries have different models of nurse practitioner practice and registration requirements to New Zealand. These factors limit the generalisability of the results to the New Zealand context. Although the ability of nurse practitioners to make medical diagnoses has been questioned, to date no research has been completed on the diagnostic reasoning of New Zealand nurse practitioners. This thesis attempts to fill that void. Exploring nurse practitioner diagnostic reasoning will illuminate the role nurse practitioners have in improving access to healthcare, promoting health and improving patient outcomes in areas where historically there have been health inequalities. Having identified the literature surrounding diagnostic reasoning, the next chapter outlines the theoretical approach taken to answer the research question.

Chapter three: Methodology

Chapter three, *Methodology*, justifies the methodology chosen to explore nurse practitioner diagnostic reasoning and answer the central research question and subquestions. The central research question is, how does nurse practitioner diagnostic reasoning compare to that of registrars? The subquestions are:

1. How do nurse practitioner diagnostic reasoning abilities compare to those of registrars?
2. What diagnostic reasoning style do nurse practitioners use in the diagnostic reasoning process?
3. Does nurse practitioners' diagnostic reasoning style influence their diagnostic reasoning abilities?
4. What maxims guide nurse practitioner diagnostic reasoning?
5. Do maxims used by nurse practitioners influence their diagnostic reasoning abilities**?**

Giddings and Grant (2006) advise researchers to consider personal and environmental factors prior to locating research within a certain paradigm. For this study, this meant considering factors including my personal values and biases and the dominant research traditions in the political science, medical and nursing disciplines. I am a prescribing nurse practitioner and required a paradigm accepting my inability to be totally objective and value free. For the research results to contribute to future health workforce development, the study required data collection, analysis and reporting methods acceptable to medical, nursing and governmental bodies responsible for workforce planning.

After considering the personal and environmental factors and the ontological and epistemological issues illuminated in the literature review, a theoretical approach of post-positivism and a mixed methods research design was deemed the most suitable methodology to meet the research aim and answer the research questions. This chapter justifies the chosen methodology and begins by presenting post-positivism.

3.1. A post-positivist approach

Post positivism emerged as a moderated form of positivism and retains many of positivism's philosophical assumptions (Giddings & Grant, 2006; Teddlie & Tashakkori, 2009); hence understanding post-positivism requires an understanding of positivism. This section of the chapter begins with presenting the philosophical assumptions associated with positivism before specifically arguing post-positivism as the most appropriate paradigm within which to locate this study.

3.1.1. Positivism

Positivism emerged from the Enlightenment period in response to a need for accurate knowledge. Auguste Comte conceived the term positivism in the 19th century to describe the philosophical underpinnings of the scientific method. Compte used methods, such as observation, experiment and comparison, to outline established scientific laws for natural and social science research (Crook & Garratt, 2011; Crotty, 1998). Positivism developed to logical positivism in the early 20th century through the work of a small group of philosophers known as the Vienna Circle (Crotty, 1998). Logical positivism, also known as logical empiricism, focused on epistemology and logic (Crotty, 1998). The Vienna Circle viewed the scientific method as the only way to obtain knowledge and introduced the scientific principles of verification and objectivity (Crotty, 1998). Verification means, unless verified, no statement is true and objectivity means no knowledge exists unless an independent value free investigator directly observes it (Crotty, 1998; Giddings & Grant, 2007). The need for directly observable knowledge led to a dualist epistemology where results are interpreted either as observable or unobservable or true or false (van Fraasen, 1999).

Verification and objectivity led to the philosophical assumptions of determinism and reductionism. Determinism means all effects have determinable causes and actions have predictable outcomes. Reductionism means experience can be reduced to concepts for describing and testing (Giddings & Grant, 2007). Although positivism has developed over time, the philosophical underpinnings of positivism remain those of verification, objectivity, determinism, reductionism and the belief that the scientific method is the only way to gain truth (Giddings & Grant, 2007; Jones, 2011).

3.1.2. Post-positivism

Post-positivism emerged from positivism following criticisms pertaining to positivism's epistemology and ontology. Wener Heisenberg (1901-1976) and Niels Bohr (1885-1962), both well-respected physicists and quantum theorists, challenged some of the positivist assumptions (Clarke, 1998; Crotty, 1998; Giddings & Grant, 2007). Heisenberg, one of the founders of quantum theory, voiced the principle of uncertainty, saying it was impossible to determine the position and momentum of subatomic particles with any certainty (Crotty, 1998). This challenged the epistemological dualist view of positivism where truth is only what is observed through the senses. Bohr argued for a new kind of concept reality, not a positivist epistemology requiring directly observable, predictable and certain results (Crotty, 1998).

Post-positivism continued to develop in the 1960s and 1970s when Karl Popper, Thomas Khun and Paul Feyerabend challenged the positive view of objective truth, provable hypotheses and unbiased value free researchers (Crotty, 1998; Giddings & Grant, 2007). Karl Popper (1902-1994) was born in Vienna and was associated with the Vienna Circle before spending the World War II years in New Zealand followed by many years in London (Crotty, 1998). Popper contested the positivist view of verification, proposing truth is more accurately gained through falsification (Crook & Garratt, 2011; Crotty, 1998; Grebel, 2011; Nestor & Schutt, 2012). Knowledge, he argued, can be verified numerous times as truth but only needs to be falsified or proven untrue once to demonstrate it is not true (Crook & Garratt, 2011; Crotty, 1998; Nestor & Schutt, 2012). Popper's example *all swans are white* elucidated only one black swan is needed to prove the hypothesis false (Flyvbjerg, 2006; Nestor & Schutt, 2012). Popper proposed a hypothetico-deductive approach to inquiry to ensure every effort is made to falsify hypotheses (Crotty, 1998).

Thomas Khun (1922-1996) opposed the positivist assumption of objectivity. Khun postulated researchers' paradigms, which determine their methodological approach, prevent them from being objective and value free (Crook & Garratt, 2011; Crotty, 1998). He described scientific inquiry as a human affair with "human interests, values, fallibilities, and foibles" (Crotty, 1998, p. 36). He also proposed the concept of scientific revolution, occurring when the findings of the inquiry cannot be explained in the researcher's current paradigm and a paradigm shift occurs devising a new way of viewing reality (Crotty, 1998).

Paul Feyerabend (1924-1994) viewed the positivist paradigm as anarchic, limiting the development of scientific and cultural knowledge. He proposed a pluralistic methodology where *anything* *goes* enabling scientists to test out their perceptions without the constraints of a particular paradigm (Crotty, 1998). He propounded the concept counterinduction, where rather than proving something false, current conceptual knowledge is compared to a new concept or to a concept imported from another body of knowledge (Crotty, 1998).

As positivism's epistemology and ontology were questioned, a moderated form of positivism emerged, referred to as post-positivism (Giddings & Grant, 2006; Teddlie & Tashakkori, 2009). Post-positivism continues to support the positivist view requiring the undertaking of precise, logical and methodologically correct research (Clarke, 1998; Teddlie & Tashakkori, 2009). Post-positivism retains, but reinterprets, positivism's assumptions of determination, reductionism and verification (Giddings & Grant, 2006). Whereas positivists assume "effects have determinable causes and actions have predictable outcomes" (Giddings & Grant, 2006, p. 54-55), post-positivists recognise the complexity and interacting nature of factors influencing outcomes (Giddings & Grant, 2006). Like positivism, post-positivism agrees experience can be described and conceptually tested (reductionism), however, it emphasises the need to consider the influences of human experience within the research design (Giddings & Grant, 2007). With verification, positivists aim to prove hypotheses whereas post-positivists aim to support hypotheses (Giddings & Grant, 2007).

Although post-positivism has retained some positivist philosophical assumptions, there are philosophical areas from which post-positivism diverges from positivism. Whereas positivism sees the scientific method as the only way to gain truth, post-positivism views truth with some uncertainty and values knowledge gained from both observable and unobservable means (Giddings & Grant, 2007). Post-positivism supports the concept pluralism in favour of positivism's dualism and using multiple methods to support hypotheses with methods being determined by the research question (Clarke, 1998; Crotty, 1998; Giddings & Grant, 2006). Like positivism, post-positivism requires the researcher to be as neutral as possible but argues the researcher's social and cultural background makes being objective and value free impossible (Crook & Garratt, 2011; Giddings & Grant, 2007). Table 2 outlines a summary of the philosophical assumptions pertaining to positivism and post-positivism.

Post-positivism's philosophical assumptions make it an ideal paradigm in which to locate this study. Positivism remains the dominant paradigm within the medical discipline, understood by the nursing discipline, and increasingly valued by governmental bodies (Giddings & Grant, 2007; Lather, 2006; Somekh & Lewin, 2011). As medical, nursing and governmental bodies influence nurse practitioner practice development (Jacobs & Boddy, 2008), having research located within a paradigm accepting many of positivism's underlying assumptions means the results of this study are more likely to be valued and contribute to health workforce planning. Post-positivism requires the researcher to be as neutral as possible, but accepts the impossibility of me as a prescribing nurse practitioner being totally objective and value free. Post-positivism, unlike positivism, accepts quantitative and qualitative methods identified in the literature review as being epistemologically acceptable. Post-positivism is, therefore, argued as the most suitable paradigm in which to locate this study. Having justified post-positivism as the most appropriate paradigm, mixed methods will be now justified as the most appropriate research design.

Table 2

Philosophical assumptions of positivism & post-positivism [5]

Philosophical assumptions	**Positivism**	**Post-positivism**
Scientific method	Scientific evidence is the only way to gain truth	Knowledge is gained through observable and unobservable means
Truth	Truth is certain	Truth may be highly probable but not certain
Objectivism	Research is undertaken by an objective and value free researcher	Recognises researcher as not being objective and value free
Verification	Hypotheses are proved	Hypotheses are supported
Determinism	Effects have determinable causes and predictable outcomes	Effects and outcomes are influenced by complex and interactive factors
Reductionism	Experience is reduced to concepts to be described and tested	Experience can be reduced to concepts to be described and tested but human factors need to be factored in

[5] This table has been developed from one described in Giddings and Grant (2007).

3.2. Mixed methods research

Mixed methods research was considered the most suitable design for this post-positivist study. Mixed methods research, also referred to as integrated or combined research, mixed methodology and mixed research, developed from the merging of quantitative and qualitative research approaches (Cresswell & Plano Clark, 2011; Simons & Lathlean, 2010). The need for scholarly research using both qualitative and quantitative methods was first voiced in the late 1950's (Cresswell & Plano Clark, 2011). Mixed methods research emerged in the late 1980s as qualitative research became more accepted and researchers began to combine quantitative and qualitative methods within a single study (Bazeley, 2009; Cresswell & Plano Clark, 2011).

Cresswell and Plano Clark (2011) portray the evolution of mixed methods as having five distinct periods: the formative period, the paradigm debate period, the procedural development period, the advocacy and expansion period and the reflective period. During each of these periods varying philosophical assumptions pertaining to mixed method research emerged (Cresswell & Plano Clark, 2011).

The formative period occurred between the late 1950s up until the 1980s when the psychology and sociology disciplines began to collect, analyse and merge quantitative and qualitative data in their studies (Cresswell & Plano Clark, 2011). The paradigm debate period developed in the 1970s and 1980s when qualitative researchers viewed quantitative and qualitative research as coming from separate paradigms with distinct philosophical assumptions. This led to debate on not only combining quantitative and qualitative methods, but also merging the paradigms, and resulted in the embracing of pragmatism as the best philosophical foundation for mixed methods research (Cresswell & Plano Clark, 2011; Simons & Lathlean, 2010).

The procedural development period occurred in the 1980s when data collection and analysis techniques and procedures for conducting mixed methods research began to emerge (Cresswell & Plano Clark, 2011). From this period, varying researchers from multiple disciplines, including public health, nursing and education, began to propose multiple types of mixed methods research designs, each with distinct procedures (Cresswell & Plano Clark, 2011). The advocacy and expansion period began in the late 1990s when authors advocated acknowledging mixed methods research as a separate methodology, method or approach (Cresswell & Plano Clark, 2011). The reflective period commenced around 2003 and has focused on criticisms of how mixed methods research has developed, its current state, and how it needs to develop (Cresswell & Plano Clark, 2011). During this reflective period, the focus of well known mixed methods research authors (such as Tashakkori and Teddlie, Greene, and Cresswell) centred on understanding the philosophical issues pertaining to mixed methods research and how mixed methods research is conducted (Cresswell & Plano Clark, 2011).

Mixing philosophical frameworks remains one of the most contested and controversial aspects of mixed methods research (Andrew & Halcomb, 2009; Greene, 2008; Simons & Lathlean, 2010). An emerging trend, however, is for mixed methods research to have a theoretical worldview. This means the philosophical assumptions underpinning a theoretical worldview need to be considered prior to implementing mixed methods research and articulated within the design (Cresswell & Plano Clark, 2011; Giddings & Grant, 2006). While the debates on philosophical frameworks continue, all participants in these debates agree the research question and hypothesis determines a mixed methods research design (Greene, 2008).

Historical influences have seen varying definitions and designs of mixed methods research evolve. This study used a mixed methods research design described by Cresswell and Plano Clark (2011) and Giddings and Grant (2006). These authors prescribe to framing the study within a philosophical worldview, collecting, analysing and mixing both quantitative and qualitative data in a single study, giving priority to one or both forms of data, and combining the procedures into a specific research design that determines how the study is conducted. Being able to both frame mixed methods within a philosophical worldview and use both quantitative and qualitative methods enables mixed methods research to fit within post-positivism (Giddings & Grant, 2006, 2007), the paradigm in which this study is located.

Different mixed methods research designs have distinctive characteristics. A convergent parallel mixed methods design was chosen for this study. A convergent parallel design uses both qualitative and quantitative methods to answer a central or single overarching question, prioritises the methods equally, and during initial data analysis keeps the two quantitative and qualitative strands independent, only comparing, merging and relating them in the later phase (Cresswell & Plano Clark, 2011). In equally prioritising the qualitative and quantitative methods, each method provides different but equally valuable data. A convergent parallel design is useful when the same topic requires complementary data and the researcher wants to merge the strengths and weaknesses of the qualitative and quantitative methods (Cresswell & Plano Clark, 2011; Giddings & Grant, 2006) to create better understanding of the research topic (Cresswell & Plano Clark, 2011).

In this study, qualitative and quantitative data were collected and analysed separately, with no priority given to either. Data were transformed, merged and compared in the latter part of the analysis.

Having justified post-positivist mixed methods research as the most appropriate design to explore nurse practitioner diagnostic reasoning, the methods used in the study are now outlined.

3.3. Methods

A mixed methods research design uses both qualitative and quantitative methods. This post-positivist mixed methods research study used four methods: a qualitative case scenario using think aloud protocol; a quantitative web-based questionnaire, incorporating an intuitive/analytic reasoning instrument and a maxims questionnaire; and a demographic data sheet. All these methods had equal priority and provided different but equally valuable data. The case scenario using think aloud protocol identified participants' diagnostic reasoning abilities including accuracy in identifying correct diagnoses, problems and actions; the intuitive/analytic reasoning instrument identified participants' diagnostic reasoning style; the maxims questionnaire identified maxims used to guide diagnostic reasoning; and the demographic data sheet identified variables influencing any of the former. Registrar data provided normative data and the nurse practitioner data compared to the normative data during data analysis.[6] Each of the data collection methods is now outlined.

3.3.1. Case scenario using think aloud protocol

A case scenario using think aloud protocol measured participants' diagnostic reasoning and their linking of data to the correct diagnoses, problems and action plan. In this study, the observational

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[6] Normative data is statistical information describing the set of scores from a clearly defined population sample (Dremsa, 2010; Fawcett, 2007) and is discussed in more depth in the next chapter.

nature of think aloud protocol compensated for the less objective self-reports in the intuitive/analytic reasoning instrument and maxims questionnaire.

Think aloud protocol, also known as verbal protocol analysis, is a qualitative method based on psychological research and information processing models developed by Newell and Simon in the 1970s (Arocha & Patel, 2008; Bucknall & Aitken, 2010; Hoffman et al., 2009; Lundgren-Laine & Salantera, 2010). Joseph and Patel (1990), in their seminal study using think aloud to analyse hypothesis generation of experts, identified think aloud as combining protocol and discourse analysis. They describe protocol analysis as allowing one to study "how the problem solving moves in relation to transition of knowledge" (p. 33). They describe discourse analysis as allowing one to study "detailed semantic description that captures complex relationships in the protocols" (p. 33).

Qualitative methods, such as think aloud protocol, traditionally incorporate qualitative data analysis techniques including transcribing, coding and constructing categories and themes (Bucknall & Aitken, 2010; Lundgren-Laine & Salantera, 2010). Mixed methods research designs, such as that used in this study, enable qualititative data to be transformed into quantitative data, a method known as quantitising (Bazeley, 2009; Cresswell & Plano Clark, 2011; Sandelowski, 2000). How quantitising was used in this study is discussed further in Chapter four, *Data analysis*.

Think aloud protocol illuminates the step-by-step cognitive processes clinicians use in decision making, revealing information stored in the working memory at a given time (Lundgren-Laine & Salantera, 2010; Waymack, 2009); as well as understanding the cognitive process it also identifies faulty reasoning (Bucknall & Aitken, 2010).

Diagnostic reasoning literature views think aloud protocol as a well accepted, reliable and valid epistemological approach to assess both medical and nurse practitioner diagnostic reasoning (Coderre et al., 2003; Durning et al., 2011; Lundgren-Laine & Salantera, 2010; Ritter, 2003). In diagnostic reasoning research, think aloud protocol has been used to analyse how clinicians select and organise information for hypothesis generation and how their problem solving moves in relation to transitions in knowledge (Joseph & Patel, 1990; Lundgren-Laine & Salantera, 2010). The think aloud protocol provides rich and extensive data for analysis. When compared to other information processing methods, it provides more information by not only tracing the decision making process but also explaining it (Kuusela & Paul, 2000; Lundgren-Laine & Salantera, 2010).

Think aloud can be completed in natural or simulated settings. Natural settings enhance external validity but the research is more difficult to control and background noise, poor recording or unclear speech can reduce the accuracy of data (Bucknall & Aitken, 2010). Simulated settings have the advantage of being cost effective, able to approximate clinical situations and allow control over environmental factors that influence the quality of the data collected (Bucknall & Aitken, 2010; Fisher & Fonteyn, 1995).

The weakness of think aloud protocol relates to its unreliability in identifying the cognitive processes used in non-analytical reasoning (Coderre et al., 2003; Higgs, Jones, & Christensen, 2008; Kuusela & Paul, 2000; Norman et al., 2007) and its inability to access higher mental processes, especially in simulated settings (Bucknall & Aitken, 2010; Lee et al., 2006; Lundgren-Laine & Salantera, 2010). As outlined in Chapter one, *Literature review*, System II processing or analytic reasoning, which reflects higher mental processes, is activated in more complex cases when the patient's signs and symptoms are not readily linked to a specific illness (Croskerry, 2009; Stolper et al., 2011). This means this study required a complex case scenario to engage System II processes.

This study used both concurrent and retrospective think aloud pertaining to a case scenario depicting a real clinical case. Concurrent think aloud reflects cognitive processes occurring at the current time and provides more accurate data when compared to retrospective think aloud which gathers verbalisations after the task (Bucknall & Aitken, 2010; Hoffman et al., 2009; Kuusela & Paul, 2000). For this study, a case scenario providing data on a patient's health history, physical examination and laboratory and radiology findings, was presented to each participant (see Appendix A). An expert panel reviewed the case scenario and deemed its suitability to access System II processes.[7]

Participants were tested individually in a private office in their workplace by the researcher. All participants completed the same case scenario and signed a participant confidentiality agreement (see Appendix B). The case scenario was presented using a computerised scenario-based learning (SBL) programme. Prior to completing the case scenario, each participant received verbal and written directions (see Appendix C) and completed a short practice session on another case scenario to ensure unfamiliarity with the computer programme did not influence the data collected. No time limit was allocated to complete the scenario as concurrent thinking may slow down the diagnostic reasoning process (Kuusela & Paul, 2000).

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[7] The expert panel consisted of a Professor of General Practice, an Associate Professor of Rheumatology and an experienced nurse practitioner working in diabetes and lifelong conditions who also holds a Doctor of Philosophy degree.

The case scenario data were divided into segments and presented one segment at a time. Presenting one segment at a time provides more control of the stimuli and more information about participants' cognitive processes (Joseph & Patel, 1990). Participants chose the order and rate in which each segment was presented and were able to access the information presented in prior segments. Both the computer programme and the researcher recorded the order of participants' selected segments and time taken to complete the case scenario. Participants were prompted to think aloud at regular intervals if required.

After presentation of the entire case, participants provided a summary of their final diagnoses, problems and action plan. This utilised retrospective think aloud and provided the opportunity for participants to articulate diagnoses, problems and actions they may not have articulated during concurrent think aloud. At the end of the case scenario, they were asked to comment on how the case presentation reflected the type of patients they see in their normal practice setting. A portable MP3 recorder audiotaped participants' verbalisations.

3.3.2. Web-based questionnaire

A web-based questionnaire, administered using *Survey Monkey*, incorporated a previously validated intuitive/analytic reasoning instrument and a maxims questionnaire (see Appendix D). The intuitive/analytic reasoning instrument and maxims questionnaire rely on self-reporting and reflect perceived rather than actual diagnostic reasoning behaviours and are less objective than observational methods (Sandelowski, 2000). In this study, the questionnaire measured diagnostic reasoning style and maxims used to guide the diagnostic reasoning process and compensated for the qualitative strand's (case scenario using thinking aloud) unreliability in measuring non-analytical reasoning.

3.3.2.1. Intuitive/analytic reasoning instrument

A previously validated intuitive/analytic-reasoning instrument developed by Lauri and Salantera (2002) measured participants' style of diagnostic reasoning. Professor Salantera granted permission to use the instrument [8] (see Appendix E). The instrument was developed on the basis of three theoretical perspectives: (1) the Dreyfus model of skill acquisition (Lauri & Salantera, 1995, 2002), (2) the information processing theory (Lauri & Salantera, 1995) and (3) Hammond's cognitive continuum theory (Lauri & Salantera, 2002). The instrument was designed to reflect the four main stages of the decision making process: collecting data, processing data, identifying problems and planning care (Lauri & Salantera, 2002). With the addition of identifying diagnoses, these stages reflect the stages of diagnostic reasoning and the definition of diagnostic reasoning used in this study.

The intuitive/analytic reasoning instrument consists of 56 items, 14 items for each decision making stage: data collection, data processing, problem identification and action planning. Of the 56 items, half measured analytic decision making processes and half measured intuitive decision making processes (Lauri & Salantera, 2002) (see Appendix F). The instrument uses a 5-point Likert-type scale: never/almost never, rarely, sometimes, often and always/almost always (Lauri & Salantera, 2002). The instrument's theoretical range of scores reflects analytic or intuitive decision

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[8] Professor Salantera was one of the authors of the published works in which the instrument was used and validated.

making processes; a low score represents analytic processes and a high score represents intuitive processes.

The total summed scores gained from the 56-items determine four types of decision making styles: analytic, analytic-intuitive, intuitive-analytic, and intuitive. Scores < 160 indicate an analytic decision making style, scores ≥ 160 - ≤ 170 indicate an analytic-intuitive or intuitive-analytic decision making style, and scores >170 indicate an intuitive decision making style (Lauri & Salantera, 2002).

The instrument was validated using an international data set from 1460 nurses from seven different countries and five different nursing specialties. The countries included Canada, Finland, Norway, USA, Northern Ireland, Switzerland, and Sweden. The nursing specialties included intensive care, psychiatric, long and short term care and public health. In the validation study, nurses' mean score was 165, with 60% of them scoring between 160-170 points indicating either an analytic-intuitive or intuitive-analytic decision making style, 26% scoring >170 indicating an intuitive decision making style and 14% scoring <160 points indicating an analytic decision making style (Lauri & Salantera, 2002). As with any measurement tool based on self-report, the weakness of the instrument relates to its measure of perceived decision making processes rather than actual decision making processes.

The instrument's versatility in measuring decision making in clinicians from multiple specialties made it suitable for use in this study in which participants' area of specialty practice differs significantly. As the intuitive/analytic reasoning instrument has historically been used in nursing, the instrument's wording was reviewed and altered to reflect both medical and nursing diagnostic reasoning language. The wording changes did not alter the instrument's intent and Professor Salantera approved the changes (see Appendix G). Thus for this study the instrument was used to measure participants' diagnostic reasoning style during data collection, identifying diagnoses and problems, planning care and implementing the action plan.

3.3.2.2. Maxims questionnaire

A maxims questionnaire provided insight into maxims used by participants to guide diagnostic reasoning. As outlined in the literature review, the early stages of provisional hypothesis formation (diagnosis) rely heavily on probabilistic reasoning, using the maxim *common problems occur commonly* (Gallagher, 1996). Brykczynski (1989, 1999) identified nurse practitioners used maxims such as (1) common things occur commonly, (2) follow-up everything and (3) real disease declares itself. Although these maxims have been handed down over many years, with some being logical and helpful, many of them have not been subjected to evidence-based testing (Alpert, 2009a; Alpert, 2009b; Bernstein, 2009). Some maxims are illogical and irrational and do not reflect expert practice (Bernstein, 2009).

The maxims component of the web-based questionnaire uses a 5-point Likert-type scale (never/almost never, rarely, sometimes, often and always/almost always) to measure 13 maxims employed in participants' daily practice. The questionnaire included maxims identified in the literature review (common things occur commonly, follow-up everything and real disease declares itself) and others identified by Bernstein (2009) and obtained from the Art of Medicine Section of the hand held device program of Clinical Medical Consult 2009. Associate Professor Bernstein granted permission to use these maxims (see Appendix H). Some of the questionnaire's maxims are identified in other journals as being useful in clinical practice (Alpert, 2009a; Alpert, 2009b; Scott, 2009).

3.3.3. Demographic data sheet

A demographic data sheet identified factors influencing nurse practitioners' diagnostic reasoning to enable these factors to be considered when explaining the results of this study (see Appendix I). Having discussed the methods used to explore nurse practitioner diagnostic reasoning, participant selection will now be outlined.

3.4. Participant selection

Studies using think aloud protocol have traditionally been small due to the amount and complexity of data requiring analysis. This post-positivist mixed methods research needed a manageable sample size but one big enough to meet statistical test requirements (Cresswell & Plano Clark, 2011). All studies require a minimal power of 0.80 to reduce statistical error; a level of power as near to 1 as possible prevents statistical error (Clark-Carter, 2010). In this study, a prospective (priori) power analysis using power tables provided by Clark-Carter (2010) calculated the sample size [9] using the two-tailed within and between-group *t*-test and the two-tailed Pearson's product-moment correlation coefficient (*r*). As shown in Table 3, the between-group *t*-test required 30-40 participants in each group to achieve an effect size of 0.8 and a power between 0.86 and 0.94. When using the Pearson's product-moment correlation coefficient, 10 to 19 participants were required to achieve a similar power and effect size.

The study aimed to recruit 30-40 nurse practitioners and 30-40 registrars. Issues with recruiting the required number of registrars

[9] These power tables were reviewed by a statistician prior to being used in this study.

were predicted during the study's consultation process, which is outlined later in this chapter. This indeed proved to be the case. The problems associated with recruiting registrars and its effect on the study's power is further discussed in Chapter five, *Results*.

Table 3

Power tables for statistical tests

Test type	**Effect**	**Power**	**Sample size**
Two-tailed within-group *t*-test	0.8	0.82	15
Two-tailed within-group *t*-test	0.8	0.99	30
Two-tailed between-group *t*-test	0.8	0.86	30
Two-tailed between-group *t*-test	0.8	0.94	40
Two-tailed Pearson's product-moment correlation coefficient	0.8	0.83	10
Two-tailed Pearson's product-moment correlation coefficient	0.8	0.99	19

Purposive sampling was used to recruit nurse practitioners working in adult practice areas with a patient population reflected in the case scenario using think aloud.[10] Nurse practitioners in practice areas of neonatal, child, youth health, mental health and specialist areas of wound, organ transplantation, oncology, ophthalmology, and urology were excluded from the study as the case study was not designed to reflect their patient population.

[10] This enabled the same case study to be used for all participants thus increasing validity.

The Nursing Council of New Zealand provides a list of nurse practitioners' areas of practice (see Appendix J). As the study's selection criteria meant most of the remaining nurse practitioners were invited into the study, randomisation was not performed nor was it required. An electronic invitation and information sheet sent via the Nurse Practitioners New Zealand (NPNZ) network recruited nurse practitioners meeting the study's inclusion criteria. Nurse practitioners not members of NPNZ were individually contacted by the researcher and invited into the study.

Registrars were recruited using snowball and purposive sampling. Nurse practitioners identified registrars they worked with who were interested in participating in the study; if they were, nurse practitioners provided the researcher with the registrars' contact details. The researcher then contacted the registrars individually and invited them to participate in the study. In situations where snowball sampling was unable to be used or proved unsuccessful, professional networks were utilised to recruit registrars from comparable practice areas. The sampling methods enabled nurse practitioner and registrars to be matched according to specialty (matched pairs). Matched pairs allow some control of independent variables that may influence the dependent variables being studied (Daniels, 2010). Having discussed participant selection, ethical considerations are now presented.

3.5. Ethical considerations

The study conformed to the ethical standards of scientific inquiry. The researcher consulted with ethnic, organisational and professional groups during the study's developmental phase. Prior to finalising the study design, the researcher engaged and received support from representatives of Maori Health, Counties Manukau District Health Board; New Zealand Nurse Practitioner Advisory Committee - New Zealand (NPAC-NZ), which has now been disestablished; and District Health Board New Zealand (DHBNZ). NPAC-NZ included representatives from the four professional nursing groups in New Zealand which included the New Zealand Nurses' Organisation, the College of Nurses Aotearoa, the New Zealand College of Mental Health Nurses and the National Council of Maori Nurses; NPAC-NZ worked closely with both the Nursing Council of New Zealand and the Ministry of Health to address both professional and legislative issues affecting nurse practitioner practice. The New Zealand Nurses' Education Fund (NERF) of the New Zealand Nurses' Organisation (NZNO) critiqued the research proposal as part of a successful funding application. Appendices K, L, M, and N provide evidence of consultation, review and support.

Ethics approval was gained from the Massey University Human Ethics Committee/Health (see Appendix O).[11] All participants received an information sheet (see Appendix Q) and provided written consent (see Appendix R). Logistic reasons allowed the web-based survey to be completed prior to written consent with completion of the survey implying consent. Written consent for all methods was gained prior to completion of the case scenario using

[11] Although this was a multicentre study, the Health & Disability Ethics Committee deemed this study as one that collects non-sensitive data in which the participants remain anonymous therefore not requiring ethical approval from them (see Appendix P).

think aloud and data analysis. The researcher complied with the requirements outlined in the Massey University *Code of Ethical Conduct for Research, Teaching and Evaluations Involving Human Participants* (Massey University, 2010).

The small number of nurse practitioners in New Zealand means they are easily identified in relation to their area of practice. To ensure participant anonymity, care was taken to ensure data were not linked to individual nurse practitioners. Throughout the research process, information was kept confidential and anonymous. Coded numbers allocated to each participant ensured the participant was not linked to any specific data. Documentation of participants' names and coded numbers was stored securely and separate to other collected research data. Having discussed the ethical considerations pertaining to this study, research soundness is now discussed.

3.6. Research soundness

All quality research designs utilise procedures to ensure validity and reliability of the data, results and their interpretation (Clark-Carter, 2010; Cresswell & Plano Clark, 2011). The paradigm in which the study is located determines the types of validation strategies used in mixed methods research (Giddings & Grant, 2009). Giddings and Grant (2009) suggest reliability, validity and generalisability processes be applied to post-positivist mixed methods studies. As this research is a post-positivist mixed methods research design, content, construct, internal and external validity and reliability were considered.

Content validity refers to the extent in which a test is sufficient enough to capture the full range of the concept being measured (Linden & Hewitt, 2012; Nestor & Schutt, 2012). In this research multiple methods including a case scenario using think aloud protocol, an intuitive/analytic-reasoning instrument and a maxims questionnaire were used to capture sufficient data to measure diagnostic reasoning.

Construct validity refers to the extent to which a test measures a theoretical concept (Clark-Carter, 2010; Gregory, 2011; Linden & Hewitt, 2012). In this study construct validity improved using a previously validated intuitive/analytic reasoning instrument; an expert panel to review the case scenario's ability to access higher mental process and determine the logical and rational maxims; and a confidentiality agreement for the think aloud protocol. A participant direction sheet and practice run of another computerised case scenario prior to the think aloud improved validity by ensuring unfamiliarity with the computerised programme presenting the case scenario did not influence the data collected.

Internal validity refers to the confidence in which changes in a dependent variable are caused by changes in an independent variable (Clark-Carter, 2010). Similarity and randomisation minimises threats to internal validity (Clark-Carter, 2010; Lewin, 2011). In this study purposeful and snowball sampling ensured the nurse practitioner and registrar groups reflected similar specialty areas. As the selection criteria meant most nurse practitioners meeting the inclusion criteria were invited into the study, no randomisation was performed. Being able to recruit most of the nurse practitioners that met the study's selection criteria enabled the sample to be representative of nurse practitioners working in general adult areas of practice. In other research assessing diagnostic reasoning, internal validity has been addressed by using coding schemes in the data analysis (Elstein et al., 1993; Joseph & Patel, 1990); this study's data analysis stage incorporated coding schemes outlined by Elstein et al. (1993) which are discussed further in Chapter four, *Data Analysis*.

External validity, also referred to as generalisability, relates to the ability of the results to be generalised to other populations or studies that have measured the same variable (Clark-Carter, 2010; Lewin, 2011). As discussed in the literature review, Elstein et al. (1993) developed coding schemes to improve the generalisability of protocol analysis studies (see Appendix S). In this study these coding schemes have been applied to the case scenario think aloud data.

Reliability refers to the ability of the research methods and results to be reproducible (Clark-Carter, 2010; Lewin, 2011). This study used an observation protocol to describe the process for the case scenario using think aloud (see Appendix T). When combined with the study description provided in this thesis, it allows the study to be reproduced by others researching similar sample populations (Cresswell & Plano Clark, 2011). Only one researcher collected, transcribed and coded the case scenario think aloud data thereby removing issues related to interobserver reliability (Nestor & Schutt, 2012).

3.7. Chapter summary

In summary, a post-positive convergent parallel mixed method design was chosen to answer the central research question and subquestions. A case scenario using think aloud protocol measured participants' diagnostic reasoning abilities, a validated intuitive/analytic reasoning instrument identified participants diagnostic reasoning style, a maxims questionnaire illuminated maxims used by participants to guide their diagnostic reasoning, and a demographic data sheet identified factors influencing nurse practitioners' diagnostic reasoning abilities, diagnostic reasoning style and use of maxims.

The study aimed to recruit 30-40 nurse practitioners and an equal number of registrars using purposive and snowball sampling. The study conformed to all ethical standards required and utilised procedures to ensure content, construct, internal and external validity and reliability of the research design. Having presented the methodology used in the study, the next chapter describes how data were analysed.

Chapter four: Data analysis

Having outlined the study methods in Chapter three, *Methodology*, this chapter focuses on the techniques used to analyse the data. Convergent parallel mixed methods studies require qualitative and quantitative data to be collected and analysed separately before comparing, merging and relating the results. This merging may include comparing the separate results or transforming the data for additional analysis (Cresswell & Plano Clark, 2011). In this study it meant analysing the data obtained from the case scenario using think aloud, the intuitive-analytic instrument, maxims questionnaire and the demographic data sheet separately before comparing, transforming and merging the data for additional comparisons. As mentioned in the previous chapter, registrar data provided normative data and the nurse practitioner data were compared to the normative data. This required the nurse practitioner data to be analysed separately to the registrar data before making comparisons.

Data collected from each of the methods contained scale, nominal and ordinal variables. Comparing nurse practitioner data to the registrar normative data necessitated parametric and non-parametric statistical tests and standard scores. Statistical tests were determined after considering the type of variable being compared and the assumptions for each test being met. Before discussing each of the statistical procedures performed, this chapter will begin by firstly discussing normative data.

4.1. Normative data

Normative data reflects statistical information from a clearly defined population sample (Dremsa, 2010; Fawcett, 2007; Gregory, 2011; Miller, McIntire, & Lovler, 2011; Portney & Watkins, 2009), such as the registrar group in this study. It provides a standard against which the performance of an individual or group can be compared (Dremsa, 2010; Gregory, 2011; Miller et al., 2011); the process for this comparison is referred to as a norm-based interpretation (Miller et al., 2011). In this study norm-based interpretations compared nurse practitioner data to registrar normative data.

The registrar data collected from the case scenario using think aloud, the intuitive/analytic reasoning instrument and the maxims questionnaire were analysed separately to provide normative data. Norm-referenced testing compared the nurse practitioner data to the registrar (normative) data. The norm-referenced tests used are discussed later in this chapter.

As the registrar data provided normative data and nurse practitioner data were being compared to it, there was a need to ensure the registrar data reflected correct or wise practice. As discussed in the literature review, Allen et al. (1998) and Carrière et al. (2009) identified registrars made more diagnostic errors than consultants. This factor needed to be considered in the study design. This was addressed using the Delphi technique to gain consensus from an expert panel[12] and provide an expected standard against which the registrar and nurse practitioner groups could be measured. The Delphi technique will now be discussed.

4.2. Delphi Technique

Prior to data analysis, the Delphi technique was used to obtain a consensus from the expert panel firstly, on diagnoses/problems and action plans they would expect a registrar to identify from the case scenario and secondly, the logical and rational maxims.

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[12] The same expert panel was used throughout the study.

The Delphi technique is a survey designed to collect and synthesise opinions from an expert group in order to generate group consensus (Keeney, 2010; Waltz, Strickland, & Lenz, 2010; Wilkes, Mohan, Luck, & Jackson, 2010). The technique is based on the assumption that group consensus is more valid than individual opinion. There is no agreement on the size of the group (Keeney, 2010).

Researchers have used the Delphi technique to: (1) develop health assessment tools, (2) assess quality in randomised trials and (3) assess diagnostic accuracy in systematic reviews (Wilkes et al., 2010). Agreeing on diagnostic accuracy creates difficulties. In a USA study of seven medical experts, Kanter, Brosenitsch, Mahoney and Staszewski (2010) found experts were similar when "agreeing on specificity related to proven diagnoses but disagreed when making a final judgement on correct or incorrect diagnoses" (p. 76). The Delphi process requires a consensus on agreed and acceptable standards and gaining 100% consensus generates challenges. Some suggest a 51% or 80% agreement (Keeney, 2010).

The Delphi technique employs a number of rounds, circulating questionnaires until a consensus is reached. The analysed result of the previous round determines the direction of each successive round (Keeney, 2010; Wilkes et al., 2010).

Two rounds of Delphi were used to achieve a 96% consensus in identifying the diagnoses, problem and actions expected of registrars. The expert panel did not agree on the need for spirometry to confirm the diagnoses of chronic obstructive pulmonary disease (COPD). The diagnoses, problem and action plan the expert panel expected registrars to identify are outlined in Box 1.

Expected diagnoses/problems	**Expected action plan**
? lower respiratory tract infection ? pleural effusion ? pulmonary embolism (PE) ? lung cancer (Ca) ? chronic obstructive pulmonary disease (COPD)	Computerised tomography (CT) or with pulmonary angiogram (CTPA) Sputum culture Change antibiotics - macrolide Lung function tests - spirometry
Gastric bleeding ? Gastric ulcer	Gastroscopy Proton pump inhibitor (PPI) Stop both aspirin Stop diclofenac Test H- Pylori
	Refer hospital for specialist team review/? hospital admission
Hypertension	Recheck, monitor and if required review antihypertensive medications
Reasonably well controlled Type II diabetes mellitus	Diabetic referral/ Diabetic education
Well controlled hyperlipidaemia	
Poor adherence to medications	

Box 1. Diagnoses, problems and actions the expert panel expected of registrars.

Two rounds of Delphi and 100% consensus identified nine maxims as being often or always/almost always logical and rational, two as sometimes being often or always/almost always logical and rational, and two as often or always/almost always being illogical and irrational. These are outlined in Box 2. Having discussed both normative data and the Delphi technique, coding of the case scenario using think aloud protocol will now be explained.

OFTEN OR ALWAYS/ALMOST ALWAYS LOGICAL AND RATIONAL
When facing competing hypotheses, favour the simplest one
Consider multiple separate diseases of a patient when the result of the history and physical examination are atypical for any one condition
Common things occur commonly
All drugs work by poisoning some aspect of normal physiology
Don’t order a test unless you know what you will do with the results.
If what you are doing is working, keep doing it. If what you are doing is not working, stop doing it.
Treat the patient not the x-ray
Never worry alone, get a consultation.
Follow-up everything
SOMETIMES LOGICAL AND RATIONAL
Real disease declares itself
Never give two diagnoses when you can find one that explains everything
OFTEN OR ALMOST ALWAYS ILLOGICAL AND IRRATIONAL
If you don’t know what to do, don’t do anything
All bleeding eventually stops

Box 2. Consensus of expert panel’s maxims

4.3. Case scenario coding

The audiotaped case scenario think aloud data were transcribed verbatim and analysed using coding and categorising described by Elstein et al. (1993).[13] Elstein et al. (1993) describe *rules for coding process constructs and knowledge utilisation* (see Appendix S). This coding was applied to: (1) each diagnosis and problem, (2) use of single or multiple cues to identify each diagnosis and problem, (3) action plan, (4) findings and (5) context statements (see Appendix U). Diagnoses were coded as treatment to diagnosis to reflect diagnostic inference when participants initiated an action plan specific to a diagnosis without articulating the diagnosis itself (see Appendix S). Coded data were recorded on a coding sheet (see Appendix V).

During the coding process the researcher transformed the qualitative data in the think aloud transcriptions into quantitative data. As mentioned earlier in Chapter three, *Methodology*, the process where qualitative data is transformed into quantitative data is referred to as quantitising (Bazeley, 2009; Cresswell & Plano Clark, 2011; Sandelowski, 2000). Case scenario think aloud data were assessed for how the case scenario reflected participants' normal practice.

4.4. Quantitative analysis

The quantitised data from the case scenario using think aloud and participant demographic data were entered into the Statistical Package for the Social Sciences (SPSS) version 19 for analysis. Data collected from the web-based questionnaire using survey monkey

[13] Joseph and Patel (1990) are one of the few studies using think aloud that describe the method in detail. Elstein et al. (1993) reanalysed this data using coding schemes.

and incorporating the intuitive/analytic reasoning instrument and the maxim questionnaire were exported from Survey Monkey into SPSS for analysis. Recoding of the analytic items within the intuitive/analytic reasoning instrument enabled calculation of each participant's total score [14] (see Appendix W).

Data from the case scenario using think aloud, the intuitive/analytic reasoning instrument, the maxims questionnaire, and the demographic data sheet were analysed separately to provide nurse practitioner and registrar group norms. Norms denote statistical information describing a defined population (Waltz et al., 2010). Data from each of the methods were firstly subjected to exploratory data analysis (EDA). The convergent parallel design enabled diagnoses, problems and actions to be analysed separately before transforming the data into a single score reflecting diagnostic reasoning abilities. Following EDA, maxims scores were transformed into a single score reflecting how frequently participants use maxims. Norm-referenced tests were applied to the data to identify nurse practitioner and registrar group differences in their diagnostic reasoning abilities, diagnostic reasoning style and use of maxims. These tests will now be outlined.

4.5. Norm-referenced tests

In this study, norm-referenced tests compared the nurse practitioner data to each of the normative (registrar) data. Norm referenced-tests compare participants' performance scores to expected or normal performance (Fawcett, 2007; Portney & Watkins, 2009; Teddlie & Tashakkori, 2009; Waltz et al., 2010). The tests "allow scores to be considered in the context" (Fawcett, 2007, p. 161). In the study it

[14] The instrument's author (Professor Salantera) provided the codes for each of the intuitive/analytic items.

gave meaning to the nurse practitioner data by enabling nurse practitioner performance to be compared to normal performance in the context of how registrars perform. The validity of the tests are, however, related to the representativeness of the sample used to define normal performance and may change if another sample is used (Portney & Watkins, 2009; Waltz et al., 2010).

Norm-referenced tests used in this study related to the type of variables being analysed, that being dependent or independent and either scale, nominal or ordinal. The types of norm-referenced tests included the independent *t*-test, chi-square test, Fisher's Exact test, Mann-Whitney U test, z-test and percentile rank. In this study the critical probability, often referred to as alpha (α), was set at 0.05. As the study did not predict the direction the differences between nurse practitioners and registrars would take, two-tailed tests were used when comparing groups. Each of the norm-referenced tests performed on the data to answer each of the research questions will now be discussed in more depth.

4.5.1. Independent *t*-tests

Independent *t*-tests compared the differences in nurse practitioner and registrar scale variables. The *t*-test (t) is a parametric test having more strength than nonparametric tests. It compares two groups by comparing a mean score of a continuous (scale) variable (Clark-Carter, 2010; Morgan, Leech, Gloeckner, & Barrett, 2011; Pallant, 2011). Parametric tests require the population scores from each group to be normally distributed and have homogeneity of variance (Clark-Carter, 2010; Morgan et al., 2011; Pallant, 2011; Sheskin, 2011).

This study used histograms, skewedness and kurtosis values, the 5% trimmed mean, the Kolmogorow-Smirnov statistic, normal Q-Q plots and box plots to assess normality. An acceptable skewness is zero one to plus one (Morgan et al., 2011). The assumptions pertaining to the Kolmogorow-Smirnov statistic are commonly violated in larger samples (Pallant, 2011). Levene's test assessed for equality of variances (Pallant, 2011).

4.5.2. Mann-Whitney U test

The Mann-Whitney U test (*U*) analysed differences between the nurse practitioner and registrar maxims, ordinal data and comparative data failing *t*-test assumptions. Mann-Whitney U test is a non-parametric test commonly used to measure differences between scale (Pallant, 2011) and ordinal variables (Morgan et al., 2011; Sheskin, 2011). It has similar power to the *t*-test if the sample size is adequate (Clark-Carter, 2010; Morgan et al., 2011). Like the *t*-test, it assumes the scores obtained from the groups are independent of each other and have an underlying continuity from high to low (Morgan et al., 2011; Sheskin, 2011). Some writers suggest the Mann-Whitney U requires homogeneity of variance (Clark-Carter, 2010; Morgan et al., 2011; Sheskin, 2011). Mann-Whitney U, however, is commonly justified when *t*-test assumptions of normality and homogeneity of variance are violated (Morgan et al., 2011; Sheskin, 2011). When using the Mann-Whitney U, Clark-Carter (2010) suggests the variance in one group should be no greater than four times the variance of the other group.

Mann-Whitney U assesses difference between the two groups by converting raw scores into ranks and evaluating the difference in ranked means (Clark-Carter, 2010). It places the data in numerical order and then calculates how many "data points are not in the hypothesised order" (Clark-Carter, 2010, p. 207). Once analysed it provides a U score and a z score. The U value reflects the mean ranks of the dependent variable for each group (Morgan et al., 2011;

Pallant, 2011); it is calculated by logging how many of one group's score are to the left of each participant's score in the other group (Clark-Carter, 2010). The z-score is discussed later in this chapter.

4.5.3. Chi-square and Fisher's Exact tests

The Chi-square test (χ^2) analysed differences between the nurse practitioner and registrar nominal variables. Chi-square measures the difference between observed and expected count and expects counts in 80% of the cells to be greater than five (Morgan et al., 2011; Pallant, 2011). Chi-square overestimates the chi-square value when using a two times two table such as in this study. Analysis included the Yates' Correction for Continuity, which compensates for this over estimation (Pallant, 2011). The analysis also included the Fisher's Exact test when chi-square assumptions were violated (Morgan et al., 2011; Pallant, 2011).

4.5.4. z-test

The z-test measured differences in nurse practitioner and registrar intuitive/analytic reasoning scores reflecting diagnostic reasoning style. The z-test is an appropriate test when the variance of the population or group is known (Clark-Carter, 2010). A z-test allows a single continuous individual score to be compared to other scores within that group or to a defined population (Clark-Carter, 2010). Unlike the *t*-test, z-tests are not dependent on sample size (Clark-Carter, 2010). The z-test establishes a z-score (z). In this study z-scores, calculated within SPSS, firstly identified how individual nurse practitioner and registrar z-scores compared to the mean scores of their groups and secondly, how the individual nurse practitioner z-scores compared to the mean score of the registrar group. A z-score reflects the distance between the individual score and the normative sample mean divided by the standard deviation of the normative sample distribution (Clark-Carter, 2010; Portney & Watkins, 2009; Waltz et al., 2010). Individual nurse practitioner scores were compared to the registrar normative group using a calculation described by Clark-Carter (2010) and Waltz et al. (2010) (see Box 3).

$$z = \frac{\textbf{single score of sample population – population mean of single score}}{\textbf{standard deviation of population}}$$

$$z = \frac{\textbf{nurse practitioner single score} - \textbf{registrar mean score}}{\textbf{standard deviation of registrar scores}}$$

Box 3. Calculation comparing nurse practitioner z-scores to registrar mean.

A z-score is a standard score commonly used in normative studies (Dremsa, 2010; Waltz et al., 2010). Standard scores transform raw scores when raw scores gained from central tendency and variability are difficult to interpret (Miller et al., 2011). A z-score uses linear transformation, which changes the unit of measurement without changing the characteristics of the raw data (Miller et al., 2011).

Standard scores, such as the z-score, enable consistency in interpreting scores; the z-score remains the same, enabling individual scores from multiple groups with varying means and standard deviations to be compared to the normative group without their individual group means and standard deviation affecting their score (Dremsa, 2010; Waltz et al., 2010). Standard scores allow "one to describe the position of a single score in a set of scores by measuring its deviation from the mean of all normative scores in standard deviation units" (Waltz et al., 2010, p. 119).

A z-score is similar to a standard deviation unit except it can be presented as a whole number and a decimal point. As with standard deviation units, the mean distribution of test scores will always have a z-score of zero. A z-score of 1 is always one standard deviation above the normative sample mean whereas a z -score of minus one is one standard deviation below the normative sample mean (Miller et al., 2011). The z-score can vary from minus four to plus four reflecting four deviations below and above the mean (Waltz, et al., 2010).

4.5.5. Percentile rank

Percentile rank, like the z-score, is another standard score, used in norm-referenced measures as an indicator of relative performance (Waltz et al., 2010). Percentile rank was used to further illuminate differences between nurse practitioner and registrar intuitive/analytic instrument scores reflecting diagnostic reasoning style. Unlike z-scores, which use linear transformation, percentile rank uses area transformations, which changes both the unit of measurement and the unit of reference (Miller et al., 2011). Percentile rank of a sample raw score is the percentage of area in the histogram located to the left of the raw score it is being measured against (Waltz et al., 2010), which in this study is the registrar mean. Percentile rank was calculated as described by Waltz et al. (2010) and outlined in Box 4. Having discussed the norm-referenced tests, tests used for within-group analysis will now be outlined.

Step one	Count how many nurse practitioners obtained scores exactly equal to the registrars' mean score
Step two	Divide the number obtained in step one by half
Step three	Count the number of nurse practitioners who obtained scores less than the registrar mean score
Step four	Add the results obtained in steps two and three
Step five	Divide the results of step four by the total number of nurse practitioner scores (n=30)
Step six	Multiply the resulting value by 100

Box 4. Calculation for percentage ranks.

4.6. Within-group analysis

Once norm-referenced tests identified how nurse practitioners' norms compared to the registrar norms, nurse practitioner within-group analysis was performed to highlight factors influencing these norm-referenced test results. Two-tailed tests were used for within group analysis. Tests included the Mann-Whitney U and independent *t*-test, which have already been outlined, plus the Kruskal-Wallis test, Pearson's product-moment correlation coefficient and Spearman's rank-order (rho) correlation coefficient. The tests not previously discussed will now be presented.

4.6.1. Kruskal-Wallis test

The Kruskal-Wallis test was used to examine relationships between variables within the nurse practitioner group, such as specialty area, with other scales variables. The test allows three or more groups to be compared to scores of a scale variable. As with the Mann-Whitney U test, scores are converted to ranks and the mean rank of each group compared. The underlying assumptions pertaining to the Kruskal-Wallis are the same as the Mann-Whitney U test (Morgan et al., 2011; Pallant, 2011). Unlike the Mann-Whitney U, the Kruskal-Wallis test employs the chi-square to identify differences between variables (Sheskin, 2011).

4.6.2. Correlation analysis

Correlations identify the relationship between two quantitative variables (Chatburn, 2011; Waltz et al., 2010). Two types of correlation are available to do this: the Pearson's product-moment correlation coefficient (Pearson's *r*) and the Spearman rank order (rho) correlation coefficient (Morgan et al., 2011; Pallant, 2011; Sheskin, 2011). Which one is used is dependent on the type of variable being used and the frequency distributions of the variables.

The assumptions pertaining to Pearson's correlation require the two scale variables being analysed to have a linear relationship (demonstrated on a scatterplot) and normally distributed scores. The Pearson's *r* ranges from minus one (-1.0) reflecting a perfect negative correlation, through zero reflecting no correlation, to plus one (+1.0) reflecting a perfect positive correlation (Chatburn, 2011; Morgan et al., 2011; Sheskin, 2011). Cohen suggests measuring strength of correlation using the following guide: an *r* of .10 to .29 refers to a small strength of correlation, a *r* of .30 to .49 suggests a medium strength of correlation and a *r* of .50 to 1.0 suggests a large strength of correlation (Pallant, 2011).

Spearman's rank order (rho) coefficient (r_s) is intended for ordinal data or when the assumptions pertaining to Pearson's correlation are not met (Pallant, 2011; Sheskin, 2011). Spearman's rho ranks data for each variable then completes a Pearson's product-moment correlation (Morgan et al., 2011). In this study it was used because scores of variables either did not have a linear relationship demonstrated on a scatter plot graph or were not normally distributed.

4.7. Chapter summary

In summary, the registrar data provided normative data and norm-referenced tests compared nurse practitioner data to the registrar (normative) data. The Delphi technique determined expert opinion and revealed the correct diagnoses, problem and actions expected of the registrars when completing the case scenario and logical and rational maxims.

Coding described by Elstein at al. (1993) analysed the case scenario data and the qualitative data gained from the transcriptions quantitised to enable quantitative analysis. Data were entered in SPPS and subjected to EDA. Norm-referenced tests identified nurse practitioner and registrar group differences. Statistical tests identified nurse practitioner within-group differences. Having presented how data were analysed to answer the research questions, the next chapter presents the results.

Chapter five: Results

Chapter five, *Results*, presents the data exploring nurse practitioner diagnostic reasoning and by doing so answers the central research question, how does nurse practitioner diagnostic reasoning compare to that of registrars? The answer to this central question is informed by five subquestions, which are:

1. How do nurse practitioner diagnostic reasoning abilities compare to those of registrars?
2. What diagnostic reasoning style do nurse practitioners use in the diagnostic reasoning process?
3. Does nurse practitioners' diagnostic reasoning style influence their diagnostic reasoning abilities?
4. What maxims guide nurse practitioner diagnostic reasoning?
5. Do maxims used by nurse practitioners influence their diagnostic reasoning abilities?

The previous chapter outlined the four methods used in this study: a complex case scenario using think aloud protocol measuring participants' diagnostic reasoning abilities, an intuitive/analytic reasoning instrument determining participants' diagnostic reasoning style, a maxims questionnaire highlighting maxims participants used to guide diagnostic reasoning, and a demographic data sheet identifying variables influencing any of the former.

As outlined in Chapter three, *Methodology,* the study aimed to recruit 30 - 40 nurse practitioners and 30 - 40 registrars to enable match pairing. Thirty nurse practitioners were recruited, however, multiple professional networks failed to recruit the required number of registrars especially in the general practice specialty. As a result, data from 30 nurse practitioners and 16 registrars were collected between 1st February 2011 and 20th March 2012. All data collected were analysed.

With the unequal sample size, the harmonic mean, as described by Clark-Carter (2010), was used to recalculate the study's power. The equation used to calculate the harmonic mean is outlined in Box 5.

$$\textbf{\textit{harmonic mean}} = \frac{\textbf{2 x registrar sample size x nurse practitioner sample size}}{\textbf{registrar sample size + nurse practitioner sample size}}$$

$$\textbf{\textit{harmonic mean}} = \frac{\mathbf{2 \text{ x } 16 \text{ x } 30}}{\mathbf{16 + 30}}$$

$$= \frac{\mathbf{960}}{\mathbf{46}}$$

=20.87

Box 5. Calculation of harmonic mean.

Based on the harmonic mean (20.87) and using power tables produced by Clark-Carter (2010), the chi-square test (with one degree of freedom) provided a power of 0.97 with an effect size of 0.8. Between-group testing using the independent *t*-test calculated the study's power as 0.70 with an effect size of 0.8; this meant the study was at risk of a Type II error occurring when performing this test. A Type II error occurs when no statistically significant difference is found between the two groups when there is one (Clark-Carter, 2010).

As shown in Table 3, Chapter three, *Methodology*, 19 participants would achieve a study power of 0.99 and an effect size of 0.8 using Pearson's product-moment correlation coefficient. For the registrar group, and using power tables provided by Clark-Carter (2010), 16 registrars meant that the study's power using this test was 0.98 with an effect size of 0.8. This indicates the study was adequately powered for nurse practitioner and registrar within-group analysis when using this test. Using a within-group independent *t*-test and achieving an effect size of 0.8, the nurse practitioner group achieved a power of 0.99 and the registrar group 0.92.

In keeping with a post positivist convergent parallel mixed methods design and a norming study, the registrar and nurse practitioner data were analysed separately enabling the registrar data to be used as normative data. The data from each part of the case scenario (diagnoses, problems, actions) were examined prior to merging them to measure diagnostic reasoning abilities. Data obtained from the maxims questionnaire were analysed separately prior to transforming the data for additional comparisons. To enable the reader to make sense of the results, the demographic data will be presented first.

5.1. Demographic data

The 30 nurse practitioners and the 16 registrars recruited into the study came from a wide range of specialist practice areas including older adults, emergency care, primary health care/general practice, cardiology, respiratory, and palliative care; the largest number were from primary health care, the smallest number from palliative care. The nurse practitioners resided and worked in metropolitan, provincial and rural areas in both the North and South Island. Due to the small numbers of nurse practitioners in New Zealand, participant anonymity prevents the numbers of nurse practitioners from each region and specialty area being shared. Most of the registrars worked in a North Island metropolitan area however their specialty practice areas, like the nurse practitioners, included older adults, emergency care, general practice, cardiology, respiratory and palliative care.

5.1.1. Nurse practitioner demographic data

Twenty-seven female and three male nurse practitioners (n=30) participated in the study. They had a mean (M) of 2.2 years New Zealand nurse practitioner experience (range=0-6, Mdn=1.5, SD=1.6). [15] Twenty seven (90.00%) nurse practitioners had prescribing authority with 21 (70.00%) having ≤ two years prescribing experience.

The nurse practitioners' mean registered nurse experience was 28.2 years (range=5-40, Mdn=29.5, SD= 7.02).[16] Nearly half of the nurse practitioners (n=13, 43.33%) completed their registered nurse training in a New Zealand hospital, with six (20.00%) completing it at a New Zealand polytechnic. One (3.33%) completed it at a New Zealand University and 10 (33.33%) overseas. Nine (30.00%) nurse practitioners had completed one post registration study programme, that being a clinical Master's degree; the number of post registration study programmes completed ranged from one to nine (M=2.4, Mdn= 2, mode=2, SD=1.45). Nurse practitioners had worked within their specialty area as a registered nurse for an average of 17.03 years

[15] Multiple modes exist.

[16] Multiple modes exist

(range=5-39, *Mdn*=15.5, mode 15, *SD*=7.83) prior to registering as a nurse practitioner.

Most nurse practitioners (*n*=20, 66.70%) completed their Master's degree at a New Zealand university, seven (23.30%) completing it at a New Zealand polytechnic and three (10.00%) overseas. Nearly all of the nurse practitioners completed a clinical Master's degree (*n*=29, 96.67%).

5.1.2. Registrar demographic data

Nine female (56.25%) and seven male (43.75%) registrars participated in the study. They had an average of 3.42 years registrar experience in their current training specialty (range=0.5-7.5, *Mdn*=3.5, mode=4, *SD*=2.56) and 2.88 years house officer experience (range=1-5, *Mdn*=2.75, mode=2, *SD*=1.28). During the data collection period they practised in a variety of specialty areas, however, their specialty training areas included: general practice (*n*=5, 31.25%), cardiology (*n*=3, 18.75%), respiratory (*n*=1, 6.25%), emergency care (*n*=2, 12.50%), gerontology (*n*=1, 6.25%), and general medicine (*n*=4, 25.00%). Four (25.00%) registrars had previously worked as a registrar in another specialty training programme prior to commencing their current specialty programme. Three of these four registrars were working in the respiratory specialty; two had previously been general medicine registrars and one a public health registrar before becoming a specialist in public health. One general practice registrar had previously worked as a registrar in general medicine.

Thirteen registrars (81.25%) had completed the first part of their current specialty training, 12 (75.00%) completing it in New Zealand and one (6.25%) in the United Kingdom. The registrar group had completed a mean of 1.63 years prior to part one exams (range=0-5, *Mdn*=1.5, *SD*=1.31)[17] and a mean of 1.80 years post part one exams (range=0.50-5, *Mdn*=2, mode=2, *SD* 1.53). The need for part two exams varied with specialties; specialties, such as general practice, gerontology and cardiology, only required clinical practice time post part one exams.

5.2. Diagnostic reasoning abilities

The case scenario using think aloud protocol assessed participants' diagnostic reasoning abilities. Diagnostic reasoning abilities reflected their ability to collect and synthesise the data provided, identify diagnoses and problems and implement appropriate actions as identified by the expert panel (see Box 1 in the previous chapter).

Using the Delphi technique and achieving an expert panel consensus of 96.00%, a total of 23 items related to correct diagnoses, problem and actions were identified; as discussed in the previous chapter agreement was not reached on the need for spirometry. Recoding and computing of all the participants' correct diagnoses, problem and actions within SPSS allowed the case scenario data to be merged; this enabled comparisons between nurse practitioners' and registrars' diagnostic reasoning abilities. This analysis answered the study's first research question, how do nurse practitioner diagnostic reasoning abilities compare to those of registrars?

Registrars identified 47.30% (range=6-21, *M*=10.88 *Mdn*=10) of the correct diagnoses, problem and action items whereas nurse practitioners identified 44.78% (range=4-17, *M*=10.30, *Mdn*=10). Although nurse practitioners identified fewer of these items than registrars, analysis revealed no statistically significant difference between the two groups (U=238.5, z=-.04, p=.97).

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[17] Multiple modes exist

Figure 1 displays the frequency distribution of correct diagnoses, problem, and actions proposed by nurse practitioners plotted with the registrar mean and registrar upper and lower range. Most nurse practitioners and registrars identified between six and 15 items. A respiratory registrar who identified 21 of the 23 correct diagnoses, problem and actions achieved the highest score. In the nurse practitioner group the highest number of correct diagnoses, problem and actions (17 items) was generated by a respiratory nurse practitioner (participant 16).

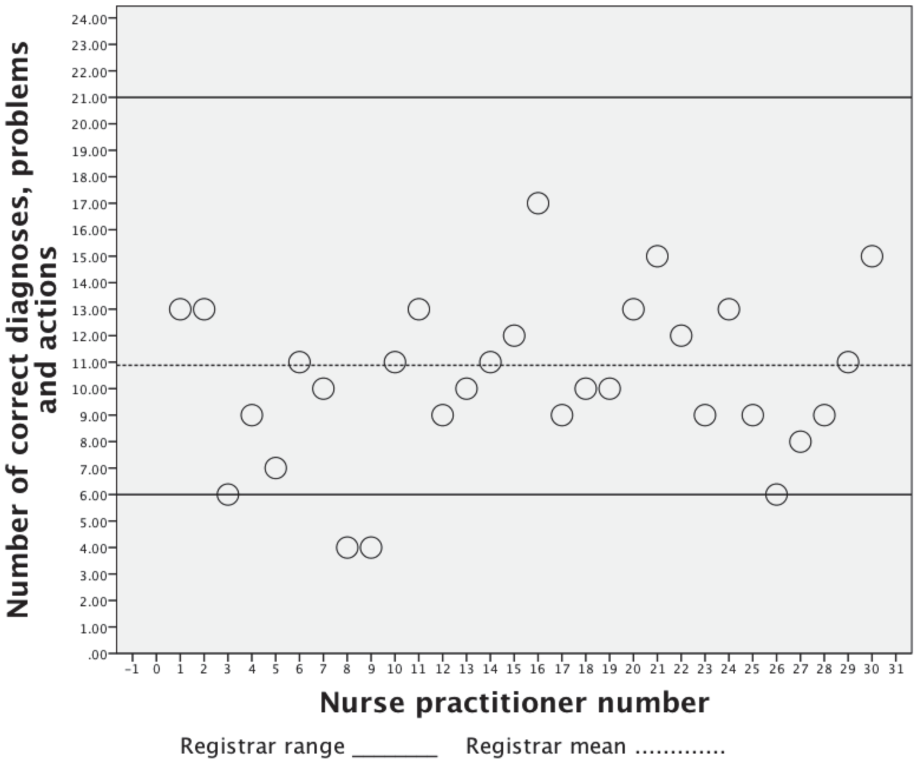

Figure 1. Frequency distribution of correct diagnoses, problem and actions proposed by nurse practitioners.

The lowest scores were generated by two nurse practitioners (participants eight and nine) who both identified four of the 23 correct diagnoses, problem and actions (see Figure 1). Participant eight completed the case scenario in the second fastest nurse practitioner time whilst participant nine completed it in the fastest nurse practitioner time. Although participants were not informed time would be measured, time to complete the case scenario was related to participants identifying the correct diagnoses, problem and actions in both the nurse practitioner (r_s=.53, n=30, p=.003) and registrar (r_s=.79, n=16, p=<.001) groups. Participants who took longer to complete the case scenario were more accurate in their diagnostic reasoning.

Participant nine did not see this type of patient presentation in his/her normal practice and was one of two participants (participant 13) who did not open data containing critical cues to diagnose gastric ulcer and gastrointestinal bleeding. These combined factors are likely to have influenced this low score.

Participants' familiarity with the type of patient presented in the scenario was assessed to determine how this might have influenced the results. Nineteen (63.33%) nurse practitioners and 11 (68.75%) registrars stated the case scenario reflected a presentation they would see regularly, χ^2 *(1, N*=46*)*=.002, p=.97. Over half of the cardiology and respiratory nurse practitioners and all of the emergency care and palliative care nurse practitioners said the case did not reflect what they would see regularly in their normal practice. Nurse practitioners working in primary health care and older persons said they would see this type of case regularly. These specialty differences were statistically significant, χ^2 (5, n=30)=14.24, p=.01.

Although these specialty differences existed, they appeared to have no influence on the number of correct diagnoses, problem, and actions nurse practitioners identified, χ^2 (5, n=30)=6.57, p=.25. As with specialty differences, no other statistically significant relationships were found between nurse practitioners' demographic factors and their diagnostic reasoning abilities (see Table 4).

Table 4

Factors influencing nurse practitioners' correct diagnoses, problem and actions

Factor	Statistical test	Result
Gender	Mann-Whitney U	U=23.5, z=-1.19, p= .24
RN training site	Kruskal-Wallis	χ^2 (6, n=30) =9.98, p=.12
Master's training site	Kruskal-Wallis	χ^2 (4, n=30)=7.02, p=14
Prescribing	Independent t-test	t(28)=-.57, p=.58
Type of master's degree	Mann-Whitney U	U=8.5, z=-.70, p=.48
Nurse practitioner specialty area	Kruskal-Wallis	χ^2 (5, n=30)= 6.57, p=.25
Years RN experience	Spearman's rho	r_S=.16, n=30, p=.41
NP years experience	Spearman's rho	r_S=.14, n=30, p=.47
Years NZ NP experience	Spearman's rho	r_S=.20, n=30, p=.30
NP years of NZ prescribing	Spearman's rho	r_S=.18, n=30, p=.34
NP years of previous prescribing	Spearman's rho	r_S=-.14, n=30, p=.48
Years of RN specialty	Spearman's rho	r_S=.08, n=30, p=.67
NZ NP years of specialty	Spearman's rho	r_S=.21, n=30, p=.30
Number of post registration programmes	Spearman's rho	r_S=.31, n=30, p=.10

Note. RN=registered nurse, NP=nurse practitioner, NZ=New Zealand.

Analysis revealed a statistically significant relationship between correct diagnoses, problem and actions and the total number of diagnoses, problems and actions (correct or incorrect) identified in both the nurse practitioner group (r_S=.75, n=30, p=<.001), registrar group (r_S=.85, n=16, p=<.001) and group as a whole (r_S=.80, N=46, p=<.001). Registrars articulated a mean of 27.50 correct or incorrect items (SD=8.01) while nurse practitioners identified a mean of 28.87 (SD=7.87). Analysis revealed no statistically significant difference in the number of identified diagnoses, problems and actions between the two groups, $t(44)=.56$, $p=.58$. The relationship between the correctly identified diagnoses, problem and actions and the total number of diagnoses, problems and actions suggests nurse practitioner and registrar diagnostic reasoning abilities are closely related to the number of differentials and working diagnoses considered and an appropriate plan to rule in or rule out these diagnoses.

Both groups identified fewer than 50.00% of the correct diagnoses, problems and actions identified by the expert panel with registrars identifying 47.30% and nurse practitioners 44.78%. To further explore these results, aspects of diagnostic reasoning including diagnoses, problems and actions will now be presented.

5.2.1. Diagnoses

The expert panel identified 10 correct diagnoses they expected registrars to identify. Of these 10 diagnoses, six were differential diagnoses. Recoding and computing of participants' correct diagnoses data within SPSS produced a correct diagnoses scale variable and enabled group comparisons. Of these 10 correct diagnoses, registrars identified 61.90% (M=6.19, SD=1.72) of them whereas nurse practitioners identified 54.70% (M=5.47, SD=1.63); both registrars and nurse practitioners generated these diagnoses by linking multiple cues found in the case presentation data. Although nurse practitioners identified fewer correct diagnoses when compared to registrars, this difference was not statistically significant, $t(44)=-1.41$, $p=.17$.

The frequency distribution of correct diagnoses proposed by nurse practitioners plotted with the registrar mean and registrar upper and lower range is displayed in Figure 2. A gerontology registrar who identified all the correct diagnoses identified by the expert panel obtained the highest registrar score. The lowest score shown in Figure 2 reflects the same nurse practitioner (participant nine) who had the low score in correct diagnoses, problem and actions (see Figure 1). The nurse practitioner who obtained the second lowest score (participant 19) did not see this type of patient presentation in her normal practice but referred the patient immediately to the general practitioner for a number of correct actions.

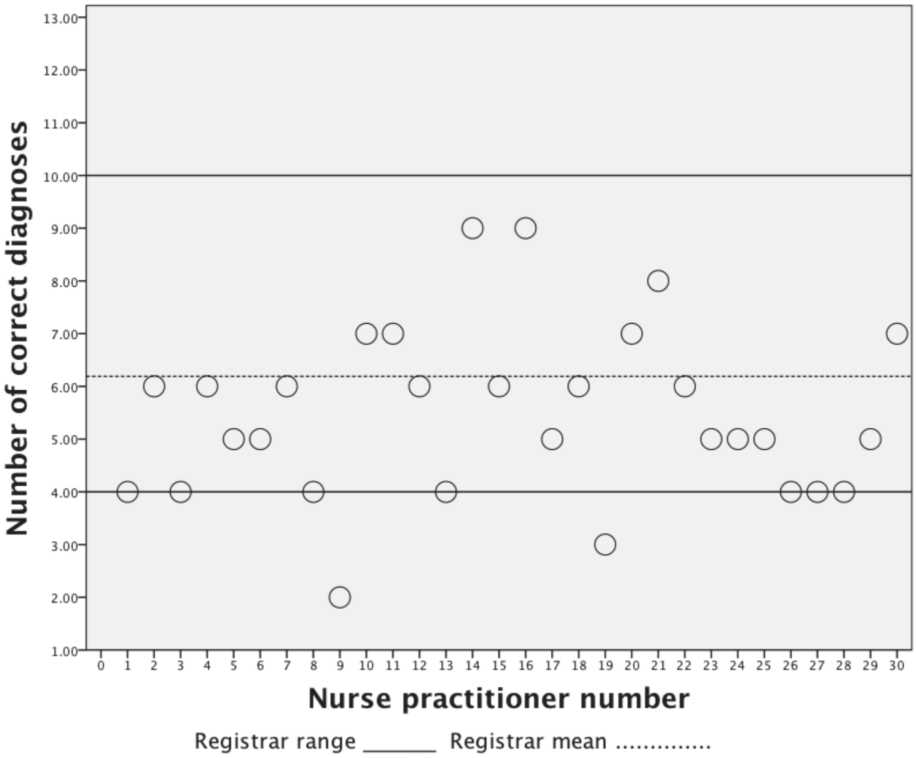

Figure 2. Frequency distribution of correct diagnoses proposed by nurse practitioners.

Differences in generating four of the correct differential diagnoses were found between the two groups (see Table 5). More registrars (*n*=12, 75.00%) correctly diagnosed lower respiratory tract infection when compared to nurse practitioners (*n*=11, 36.67%), χ^2 (1, *N*=46)=4.70, *p*=.04; more nurse practitioners (*n*=9, 30.00%) diagnosed chest infection when compared to registrars (*n*=1, 6.25%, *FET*=.13). Both of these diagnoses were treated appropriately, with no differences in how either group prescribed antibiotics, χ^2 (*N*=46)=.62, *p*=.44, or ordered a sputum culture, χ^2 (1, *N*=46,)=.01, *p*=.94, both correct actions determined by the expert panel.

Table 5

Correct diagnoses identified by participants

Diagnosis/ problem	**Nurse practitioner frequency (percent) *n*=30)**	**Registrar frequency (percent) *n*=16**	**Significance**
Hypertension	30 (100.00)	15 (93.75)	*FET* p=.35
? COPD	26 (86.67)	7 (43.75)	*FET* p=.005*
Gastric bleeding	25 (83.33)	10 (62.50)	*FET* p=.15
? gastric ulcer	21 (70.00)	10 (62.50)	χ^2 (1, N=46)=.04, p=.86
Reasonably well controlled Type II DM	18 (60.00)	6 (37.50)	χ^2 (1, N=46)=1.31, p=.26
Well controlled hyperlipidaemia	17 (56.67)	10 (62.50)	χ^2 (1, N=46)=.06, p=.94
? lower respiratory tract infection	11 (36.67)	12 (75.00)	χ^2 (1, N=46)=4.70, p=.04*
? lung cancer	8 (26.67)	9 (56.3)	χ^2 (1, N=46)=2.75, p=.10
? pleural effusion	4 (13.33)	10 (62.50)	*FET* p=.002*
? pulmonary embolus	4 (13.33)	10 (62.50)	*FET* p=.002`*

Note. *indicates statistical significance.

Fewer registrars correctly diagnosed COPD (*FET* p=.005) and fewer nurse practitioners correctly diagnosed pleural effusion (*FET* p=.002) and pulmonary embolus (*FET* p=.002). As these were differential diagnoses rather than definitive diagnoses, they required diagnostic testing to confirm or reject them. Both groups referred the patient to hospital for specialist team review and/or hospital admission, χ^2 (1, N=46)=.00, p=1.0. Other than the diagnoses already mentioned, analysis revealed no statistically significant differences in correct diagnoses between the two groups.

Relationships between nurse practitioners' ability to identify the correct diagnoses and their demographic data were examined. The ability to identify the correct diagnoses showed a statistically significant positive correlation with the number of years prescribing as a nurse practitioner in New Zealand (r_S=.37, n=30, p=.04). This may imply nurse practitioners' abilities to correctly diagnose are improved as they gain more experience as a New Zealand prescribing nurse practitioner. No further statistically significant relationships between identifying the correct diagnoses and nurse practitioner demographic data were found (see Appendix X).

Participants identified a large number of other diagnoses that the expert panel did not expect registrars to identify. Most of these were working or possible diagnoses and resulted in action plans to rule them in or out. Registrars identified a mean of 10.13 (SD=1.54) other diagnoses whereas nurse practitioners identified a mean of 10.30 (SD=1.84). Recoding and computing of these other diagnoses enabled statistical analysis and illustrated no statistically significant difference between the two groups, t(44)=.32, p=.75.

Two primary health care nurse practitioners identified the most other diagnoses. Two nurse practitioners obtained the lowest scores; one was one of the two nurse practitioners who obtained the lowest correct diagnoses, problem and actions score (see Figure 1). The other was an older health nurse practitioner who when identifying correct diagnoses, problem and actions scored higher than the registrar mean (see Figure 1). No relationship was identified between the number of correct diagnoses and the number of other diagnoses in either the registrar group (r_s=.39, n=16, p=.14), nurse practitioner group (r_s=.12, n=30, p=.54) or group as a whole (r_s=.22, N=46, p=.15).

Other diagnoses identified by participants are listed in Appendix Y. Of these diagnoses, both registrars and nurse practitioners commonly identified anaemia, hyponatraemia, bowel cancer and constipation; the expert panel considered these to be reasonable diagnoses. More registrars' diagnosed tuberculosis (n=4, 25.00%) when compared to nurse practitioners (n=0); the expert panel considered this diagnosis unlikely.

Registrars rejected a mean of 3.3 (SD =1.78) diagnoses and nurse practitioners rejected a mean of 3.1 (SD=1.74); the independent t-test confirmed no statistically significant difference between the two groups, t(44)=-.45, p=.65.

5.2.2. Identifying problems

The expert panel agreed registrars should identify one problem, that being 'poor adherence to medications.' Nine registrars (56.25%) and sixteen nurse practitioners (53.33%) identified this problem and analysis revealed no statistically significant difference between the two groups, χ^2 (1, N=46)=.00, p=1.0.

Nurse practitioners' demographic data were examined for any relationship with them identifying the problem 'poor adherence to medications.' There was a statistically significant positive relationship between identifying this problem and years of specialty practice as a registered nurse (r_s=.51, n=30, p=.004) suggesting the more experience a nurse has working in a specialty, the more likely they are to identify problems. No other statistically significant relationships were revealed (see Appendix Z).

Participants identified a total of 12 problems, 11 more than the expert panel expected registrars to identify. Recoding and computing of participants' 12 problems to a scale variable within SPSS enabled group comparisons. Of the twelve problems, registrars identified a mean of 2.31 (range=0-5, *Mdn*=2) problems whereas nurse practitioners identified a mean of 2.23 (range=0-7, *Mdn*=2); no statistically significant difference was found between the two groups (U=229.5, z=-.25, p=.80).

Two nurse practitioners working in older person's health identified more problems than the registrars. Although statistical analysis revealed specialty practice was not related to the number of problems nurse practitioners identified, χ^2 (5, n=30)=6.86, p=.23, this frequency distribution may suggest nurse practitioners working in older health identify more problems when compared to nurse practitioners working in other areas.

The types of problems identified and the difference between the two groups in identifying each of these problems are outlined in Table 6. More nurse practitioners (n=9, 30.00%) than registrars (n=0) identified patient complexity as a problem. This was a factor the expert panel considered to be a reason for the patient having a hospital specialist review and/or hospital admission.

Table 6

Problems identified by participants

Problem	**Nurse practitioner frequency (percent) *n*=30**	**Registrar frequency (percent) *n*=16**
Poor adherence to medications	16 (53.33)	9 (56.25)
Inaccurate history due to inability to speak English	11 (36.67)	4 (25.00)
Patient complexity	9 (30.00)	0
Pleuritic pain	7 (23.33)	8 (50.00)
Possible lower socio-economic factors	6 (20.00)	0
Pain (unspecified)	4 (13.30)	1 (6.25)
Cardiovascular risk factors	3 (10.00)	6 (37.50)
Extensive comorbidities	3 (10.00)	5 (31.25)
Overdue ophthalmology review	3 (10.00)	1 (6.25)
Possible care burden issues	2 (6.67)	0
Knowledge deficit of conditions	2 (6.67)	3 (18.75)
Possibility inability to self-medicate due to poor eyesight	1 (3.33)	0

5.2.3. Formulating action plans

Nurse practitioners and registrars formulated a large number of actions. Recoding and computing of participants' actions within SPSS produced a correct action items scale variable and enabled group comparisons. An expert panel consensus of 96.00% expected registrars to implement 12 actions; as mentioned earlier consensus was not reached on the need for spirometry. Registrars identified 34.42% (range=1-11, M=4.13, Mdn=4) of the correct actions whereas nurse practitioners identified 35.83% (range=0-8, M=4.3, Mdn=4). Although registrars identified fewer correct actions than nurse practitioners, this difference was not statistically significant (U=214.5, z=-.60, p=.56).

The frequency distribution of correct actions proposed by nurse practitioners plotted with the registrar mean and registrar upper and lower range is displayed in Figure 3. The registrar data showed one registrar outlier who articulated 11 of the 12 correct actions; this registrar was the same respiratory registrar who identified the most correct diagnoses, problem and actions (see Figure 1). The nurse practitioner (participant eight) who identified the least correct actions was the one who completed the case scenario in the second fastest nurse practitioner time and one of the two who identified the least correct diagnoses, problem and actions (see Figure 1).

Although analysis revealed no relationship between the correct diagnoses and correct actions for the registrar (r_s=.37, n=16, p=.16) or nurse practitioner (r_s=.29, n=30, p=.12) groups, there was a statistically significant relationship in the group as a whole (r_s=.30, N=46, p=.04). This suggests there is some relationship between identifying the correct diagnoses and implementing the correct action plan.

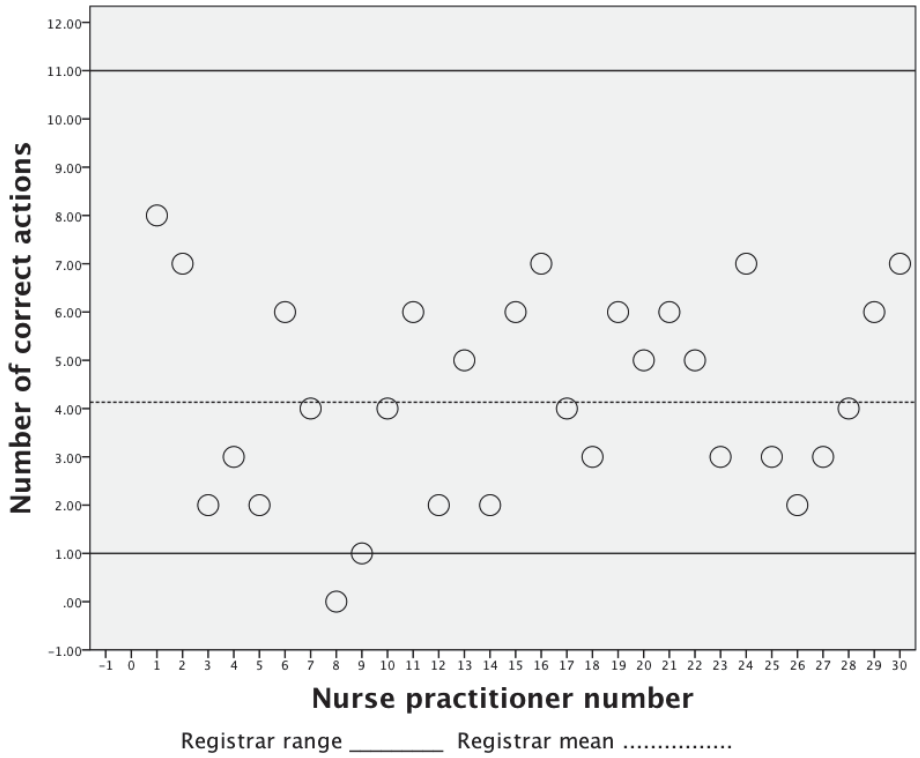

Figure 3. Frequency distribution of correct actions proposed by nurse practitioners.

Differences between the two groups' identification of the correct actions were examined. Analysis revealed a statistically significant difference between registrars and nurse practitioners planning for CT/CTPA (see Table 7). Fewer nurse practitioners (n=1, 3.33%) than registrars (n=6, 37.50%) planned for a CT/CTPA (*FET* p=.01). As more nurse practitioners discussed the patient with their consultant (n=22, 73.33%) when compared to registrars (n=1, 6.25%) and did not differ from registrars when referring the patient for hospital specialist review and/or hospital admission, χ^2 (1, N=46)=.00, p=1.0, not planning for CT/CTPA is unlikely to have resulted in substandard care. Data were examined for demographic factors influencing nurse practitioners' correct actions and identified no statistically significant relationships (Appendix AA).

Table 7

Correct actions identified by participants

Action plan	**Nurse practitioner frequency (percent) *n*=30**	**Registrar frequency (percent) *n*=16**	**Significance**
Review need for increased anti-hypertensive therapy	17 (56.67)	7 (43.8)	χ^2 (1, N=46)=.28, p=.60
Refer hospital for specialist team review and/or hospital admission	17 (56.67)	9 (56.3)	χ^2 (1, N=46)=.00, p=1.0
Diabetes referral/education	16 (53.33)	6 (37.50)	χ^2 (1, N=46)=.51, p=.48
Lung function tests	16 (53.33)	4 (25.00)	χ^2 (1, N=46)=2.68, p=.10
Stop diclofenac	13 (43.33)	4 (25.00)	χ^2 (1, N=46)=2.35, p=.12
Sputum culture	13 (43.33)	6 (37.50)	χ^2 (1, N=46)=.01, p=.94
Change antibiotic to include macrolide	10 (33.33)	8 (50.00)	χ^2 (1, N=46)=.62, p=.44
Stop aspirin	8 (26.67)	3 (18.75)	*FET* p=.72
Gastroscopy	7 (23.33)	9 (56.25)	χ^2 (1, N=46)=3.64, p=.06
Proton pump inhibitor	5 (16.67)	4 (25.00)	*FET* p=.70
Test for H-Pylori	3 (10.00)	0	*FET* p=.54
CT/CTPA	1 (3.33)	6 (37.50)	*FET* p=.01*

Note. *indicates statistical significance.

Although nurse practitioners and registrars identified a low percentage of correct actions, they formulated numerous other actions. Some of these actions were related to ruling in or ruling out diagnoses, whereas others were to rule problems in or out, or to investigate them further.

Recoding and computing of participants' more common actions within SPSS produced a common actions scale variable and enabled group comparisons. Registrars planned a mean of 2.94 (SD=2.05) common actions whereas nurse practitioners planned a mean of 4.27 (SD=1.68). This difference was statistically significant with nurse practitioners planning more of these common actions than registrars, $t(44)=2.37$, $p=.02$. The type of actions and the differences between the two groups are outlined in Appendix BB.

As already mentioned, more nurse practitioners (n=22, 73.33%) than registrars (n=1, 6.25%) planned to discuss the patient with a consultant they work with. Rationales for this are seen in excerpts from the following nurse practitioners' transcripts:

> But I think he's very complicated and beyond an easy management out here – I would be sending him through – very much so. And in fact I would get the doctor in and discuss the case with the doctor but sometimes she's not always here so I would be liaising with ED probably about this guy – he's not someone I would be sitting on I don't think at all. (Participant 7).
>
> I have to say at this stage, possibly in terms of GI bleed or suspicion of GI bleed, in my particular area of practice, I would be discussing this with one of the consultants at this stage to see what their considered thoughts are. It may well

be they want to examine the patient themselves just to elicit further information. (Participant 5).

He's got a couple of things that would be a bit worrying- he's got a low haemoglobin but he's got high blood pressure and his heart rate is not particularly racing so I am not sure if he's actively bleeding....so I would probably go and talk to somebody because this man is a story. (Participant 10).

Discussing the patient with a medical consultant was not related to nurse practitioners having prescribing authority (*FET* p=1.0), how closely the patient presentation reflected what they would normally see in their practice (*FET* p=.20), their specialty area, χ^2 (7, n=30)=8.01, p=.33, or their diagnostic reasoning abilities, t(28)=-1.44, p=.16.

More nurse practitioners (n=11, 36.76) than registrars (n=1, 6.25%) planned an endoscopy/gastroenterology referral. This difference may be explained by more registrars (n=8, 50.00%) than nurse practitioners (n=3, 10.00%) planning a colonoscopy. The groups did not differ in their diagnosis of bowel cancer (see Appendix Y), which is likely to be a reason for planning these interventions.

More nurse practitioners (n=7, 23.33%) than registrars (n=0) planned to get the chest x-ray reviewed by a medical colleague. Having the chest x-ray reviewed was not related to nurse practitioners having prescribing authority (*FET* p=1.0), how closely the patient presentation reflected what they would normally see in their practice (*FET* p=1.0) or their specialty area, χ^2 (7, n=30)=3.07, p=.88. However although not statistically significant, there was some relationship between nurse practitioners' having the chest x-ray reviewed and their diagnostic reasoning abilities, t(28)=-2.08, p=.05; nurse practitioners who planned to have the chest x-ray reviewed identified less correct diagnoses, problem and actions (M=8.29, SD=3.20) than those who did not plan a review (M=10.91, SD=2.84). More registrars (n=5, 31.25%) than nurse practitioners (n=2, 6.67%) proposed iron studies.

Participants planned a number of less common actions (see Appendix CC). Registrars planned a mean of 3.0 (range=0-9, Mdn=2.5) less common actions whereas nurse practitioners planned a mean of 4.3 (range=0-25, Mdn=3.0). No statistically significant difference was found between the two groups (U=219.5, z=-.48, p=.63). Within these less common actions there was no difference between the two groups in the actions they implemented to address the identified problems (U=190.5, z=-1.18, p=.24). Having presented the results pertaining to diagnostic reasoning abilities including diagnoses, problems and actions, the next section outlines the results pertaining to nurse practitioners' and registrars' diagnostic reasoning style.

5.3. Diagnostic reasoning style

The intuitive/analytic reasoning instrument measured participants' diagnostic reasoning style and answered the study's second subquestion, what diagnostic reasoning style do nurse practitioners use in the diagnostic reasoning process? The data assisted in answering an aspect of the study's central research question, how does nurse practitioner diagnostic reasoning compare to that of registrars?

As outlined in chapter three, *Methodology*, an intuitive/analytic diagnostic reasoning instrument was used to measure diagnostic reasoning style. Scores < 160 indicate an analytic style, scores ≥160 - ≤ 170 indicate an analytic-intuitive or intuitive-analytic style, and scores >170 indicate an intuitive style (Lauri & Salantera, 2002).

Registrars (*n*=16) revealed a mean score of 157.18 (*SD*= 6.61) indicating as a group they use an analytic diagnostic reasoning style. Nurse practitioners (*n*=30) revealed a mean score of 160.83 (*SD*=5.91) indicating as a group, they use an analytic-intuitive diagnostic reasoning style. The frequency distribution of these intuitive/analytic reasoning scores are displayed in Figure 4.

As displayed in Figure 5, eleven registrars (68.75%) scored <160 demonstrating an analytic style with no registrars scoring >170 indicative of an intuitive style. The remainder scored between 160 and 170 with three (18.75%) revealing a mostly analytic (with some intuition) style and two (12.50%) showing a mostly intuitive (with some analysis) style.

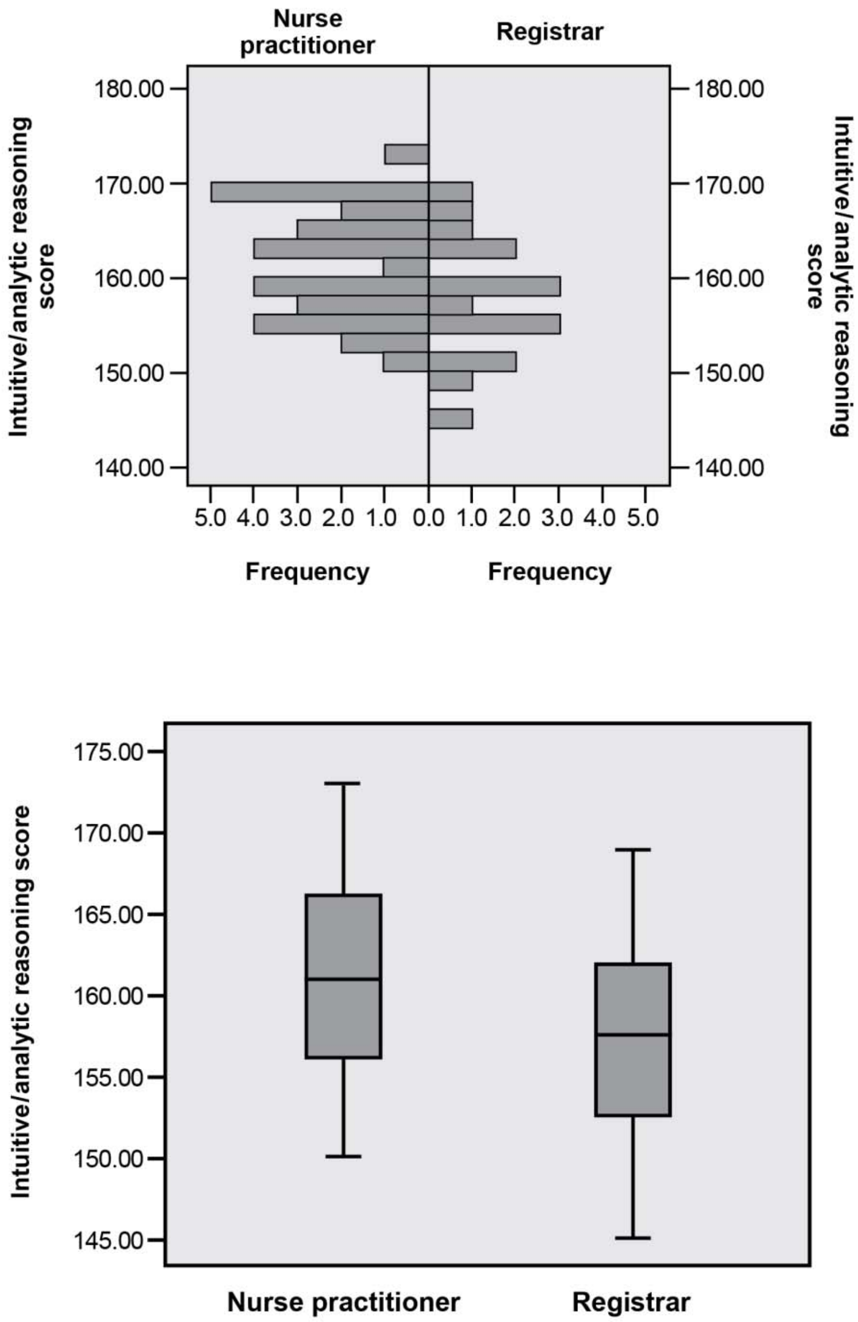

Figure 4. Frequency distribution of intuitive/analytic reasoning scores.

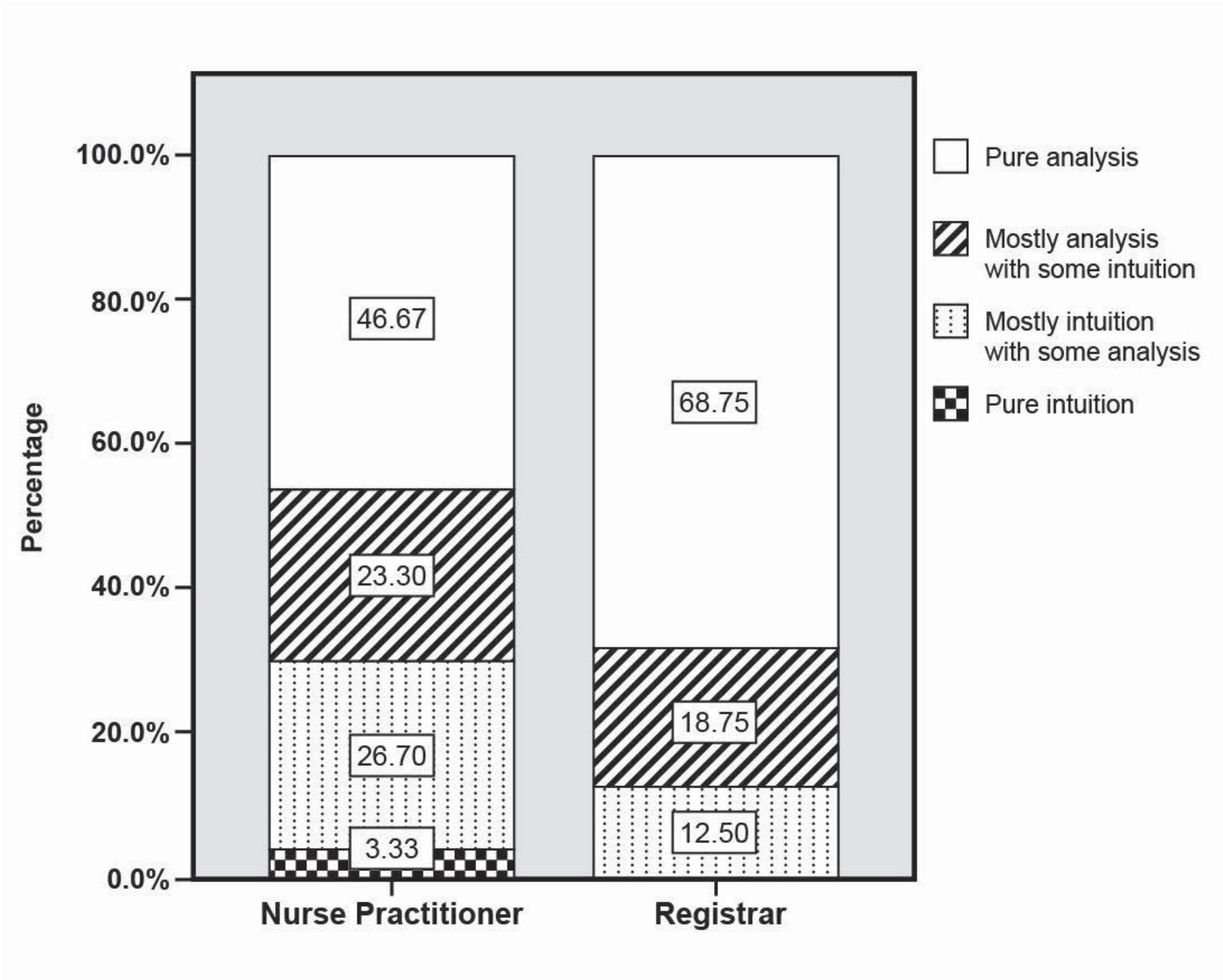

Figure 5. Participants' diagnostic reasoning style.

Figure 5 shows just under half (*n*=14, 46.67%) of nurse practitioners scored <160 demonstrating an analytic style with one (3.33%) scoring >170 showing an intuitive style. The remaining 50.00% (*n*=15) scored between 160 and 170 revealing both an analytic and intuitive style; just under half of this group (23.30%) demonstrated mostly an analytic (with some intuition) style while just over half (26.70%) reflected a mostly intuitive (with some analysis) style. The scores of nurse practitioners reflecting an analytic or mostly analytic style (scores ≤ 164) revealed an analytic diagnostic reasoning style was dominant in 70.00% (*n*=21) of nurse practitioners.

Although Figure 5 indicates nurse practitioners incorporate more System I processing in their diagnostic reasoning when compared to registrars, analysis revealed no statistically significant difference between the two groups, $t(44)=1.91$, $p=.06$. Norming studies, such as this study, often use z-scores and percentile ranks to better identify individual or group differences from the normative group. As the *t*-test indicated no statistically significant difference, z-scores and percentile ranks were calculated. Registrars' z-scores are outlined in Table 8 and nurse practitioners in Table 9. Table 10 shows how far nurse practitioners' z-scores were from the registrar mean.

Table 8

Registrars' intuitive/analytic reasoning z-scores

Score	Frequency	Percent	z-scores
145	1	6.25	-1.85
149	1	6.25	-1.24
150	1	6.25	-1.09
151	1	6.25	-0.94
154	1	6.25	-0.48
155	2	12.50	-0.33
157	1	6.25	-0.03
158	2	12.50	0.12
159	1	6.25	0.27
162	2	12.50	0.73
165	1	6.25	1.18
166	1	6.25	1.33
169	1	6.25	1.79

Table 9

Nurse practitioners' intuitive/analytic reasoning z-scores

Score	Frequency	Percent	z-score
150	1	3.33	-1.83
152	1	3.33	-1.49
153	1	3.33	-1.32
154	1	3.33	-1.16
155	3	10.00	-0.99
156	2	6.67	-0.82
157	1	3.33	-0.65
158	3	10.00	-0.48
159	1	3.33	-0.31
160	1	3.33	-0.14
162	2	6.67	0.20
163	2	6.67	0.37
164	2	6.67	0.54
165	1	3.33	0.7
166	1	3.33	0.87
167	1	3.33	1.04
168	5	16.67	1.21
173	1	3.33	2.06

Table 10

Nurse practitioners' intuitive/analytic reasoning and z-scores compared to registrar population mean

Score	Frequency	Percent	z-score
150	1	3.33	-1.09
152	1	3.33	-0.79
153	1	3.33	-0.63
154	1	3.33	-0.79
155	3	10.00	-0.33
156	2	6.67	-0.18
157	1	3.33	-0.03
158	3	10.00	0.12
159	1	3.33	0.27
160	1	3.33	0.43
162	2	6.67	0.73
163	2	6.67	0.88
164	2	6.67	1.03
165	1	3.33	1.18
166	1	3.33	1.33
167	1	3.33	1.49
168	5	16.67	1.64
173	1	3.33	2.39

As indicated in Figure 6, a zero score showed the registrar mean score to the left of the nurse practitioner normal curve, indicating most nurse practitioners' diagnostic reasoning style was less analytic than registrars. Percentile rank demonstrated 32.00% of the nurse practitioners' area of distribution is to the left of the registrar mean score (157.18) indicating 32.00% of nurse practitioners have a more analytic style of diagnostic reasoning when compared to the registrar mean. This implies 68.00% of nurse practitioners have a less analytic style when compared to the registrar mean.

Relationships between nurse practitioners' demographic data and their diagnostic reasoning style were examined. No statistically significant relationships were evident (see Appendix DD).

Spearman's rho revealed diagnostic reasoning style, whether it was intuitive, analytic or both, was not related to diagnostic reasoning abilities in either the nurse practitioner (r_s=-.14, n=30, p=.46) or registrar (r_s=.03, n=16, p=.90) groups. This answered the study's third research subquestion, does nurse practitioner diagnostic reasoning style influence their diagnostic reasoning abilities.

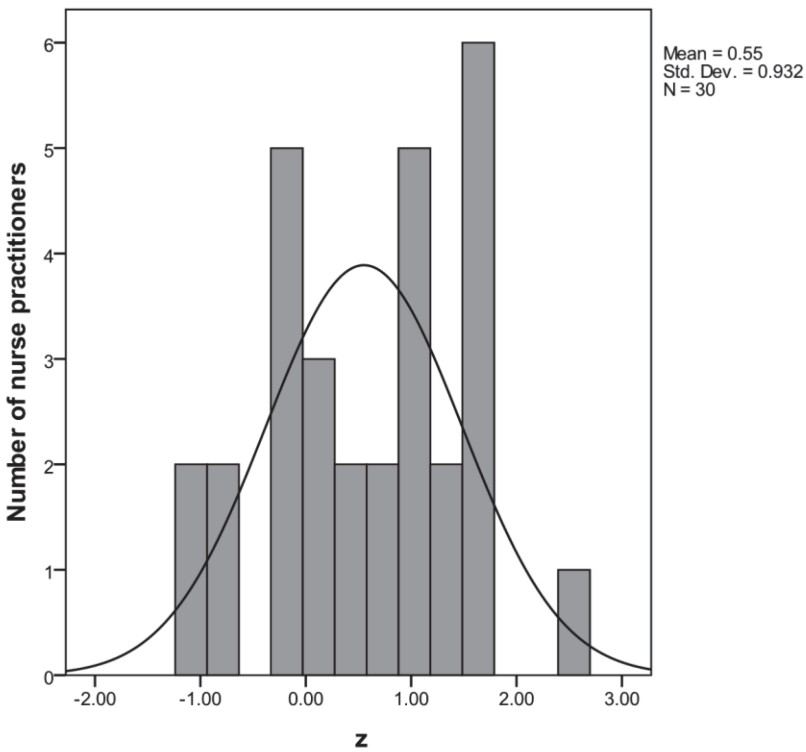

Figure 6. Distribution curve of nurse practitioners' intuitive analytic z-scores compared to registrar mean.

Maxims used to guide diagnostic reasoning

The maxims questionnaire highlighted maxims participants used to guide their diagnostic reasoning and answered the study's fourth research subquestion, what maxims guide nurse practitioner diagnostic reasoning? In answering this question, it answers a further aspect of the study's central question, how does nurse practitioner diagnostic reasoning compare to that of registrars?

Participants were questioned on their use of 13 maxims to guide their diagnostic reasoning. As discussed in the previous chapter, *Data analysis*, the study used the Delphi technique to determine the maxims the expert panel viewed as being often or always rational or irrational or often or always logical or illogical when used by registrars (see Box 6 and 7). Appendix EE presents the frequency tables outlining participants' use of individual maxims. Table 11 outlines the differences between the two groups in their use of each maxim. This table highlights statistically significant differences in how each group used five of the maxims.

When facing competing hypotheses, favour the simplest one.
Consider multiple separate diseases of a patient when the result of the history and physical examination are atypical for any one condition.
Common things occur commonly.
All drugs work by poisoning some aspect of normal physiology.
Don’t order a test unless you know what you will do with the results.
If what you are doing is working, keep doing it. If what you are doing is not working, stop doing it.
Treat the patient not the x-ray.
Never worry alone, get a consultation.
Follow-up everything.

Box 6. Maxims expert panel considered often or always logical and rational.

If you don’t know what to do, don’t do anything.
All bleeding eventually stops.

Box 7. Maxims expert panel considered often or always illogical and irrational.

Table 11

Differences between nurse practitioners' and registrars' use of maxims

Maxim	**Nurse practitioner mean rank**	**Registrar mean rank**	**Significance**
When facing competing diagnoses favour the simplest one	19.12	31.72	U=108.5, z=-3.16, p=.002*
If you don't know what to do, don't do anything	19.88	30.28	U=131.5, z=-2.77, p=.006*
Consider multiple separate diseases of a patient when the result of the history and physical examination are atypical of any one condition	26.97	17.00	U=136.0, z=-2.55, p=.01*
Common things occur commonly	19.45	31.09	U=118.5, z=-3.17, p=.002*
All bleeding eventually stops	25.70	19.38	U=174.0, z=-1.58, p=.12
All drugs work by poisoning some aspect of normal physiology	24.20	22.19	U=219.0, z=-.50, p=.62
Don't order a test unless you know what you will do with the results	22.70	25.00	U=216.0, z=-.64, p=.53
Real disease declares itself	21.15	27.91	U=169.5, z=-1.74, p=.08
Treat the patient not the x-ray	24.48	21.66	U=210.5, z=-.76, p=.45
Never worry alone, get a consultation	24.90	20.88	U=198.0, z=-1.26, p=.20
Never give two diagnoses when you can find one that explains everything	20.73	28.69	U=157.0, z=-1.98, p=.05
If what you are doing is working, keep doing it. If what you are doing is not working, stop doing it	26.33	18.19	U=155.0, z=-2.17, p=.03*

Follow up everything	25.15	20.41	U=190.5, z=-1.27, p=.20

Note. *indicates statistical significance

Analysing the maxims used often or always by nurse practitioners and registrars provided more meaningful data to illuminate their practice. Nurse practitioners used seven maxims often or always. These included:

(1) never worry alone, get a consultation
(2) If what you are doing is working, keep doing it. If what you are doing is not working, stop doing it
(3) follow-up everything
(4) consider multiple separate diseases of a patient when the result of the history and physical examination are atypical of any one condition
(5) treat the patient not the x-ray
(6) don’t order a test unless you know what you will do with the results
(7) common things occur commonly.

These seven maxims and how their use differed in the registrar group are outlined in Table 12. Registrars only used six of these maxims often or always, with only 50.00% (n=8) of registrars often or always using the maxim *consider multiple separate diseases of a patient when the result of the history and physical examination are atypical of any one condition.* Registrars were more likely to use the maxim *real disease declares itself* with 56.25% (n=9) of registrars using this maxim often or always.

Table 12

Maxims often or always/almost always used by participants

Maxim	**Nurse practitioner frequency (percent) *n*=30**		**Registrar frequency (percent) n=16**		**Significance**
	Number	Mean rank	Number	Mean rank	
Never worry alone, get a consultation	28 (93.33)	23.97	14 (87.50)	22.63	U=226.0, z=-.66, p=.51
If what you are doing is working, keep doing it. If what you are doing is not working, stop doing it	27 (90.00)	24.20	13 (81.25)	22.19	U=219.0, z=-.83, p=.41
Follow-up everything	27 (90.00)	24.70	12 (75.00)	21.25	U=204.0, z=-1.33, p=.18
Consider multiple separate diseases of a patient when the result of the history and physical examination are atypical of any one condition	25 (83.33)	26.17	8 (50.00)	18.50	U=160.0, z=-2.37, p=.02*
Treat the patient not the x-ray	25 (83.33)	23.17	14 (87.50)	24.13	U=230.0, z=-.37, p=.71
Don't order a test unless you know what you will do with the results	24 (80.00)	21.90	16 (100.00)	26.50	U=192.0, z=-1.90, p=.06
Common things occur commonly	21 (70.00)	21.10	16 (100.00)	28.00	U=168.0, z=-2.42, p=.02*

Note. * indicates statistical significance.

The expert panel considered the seven maxims used by nurse practitioners often or always logical and rational. As noted in Box 6 the expert panel did not consider the maxim *real disease declares itself* often or always logical or rational however agreed it was sometimes logical and rational.

Twenty seven (90.00%) nurse practitioners rarely or never used the maxim *if you don't know what to do, don't do anything*. The expert panel agreed this maxim was illogical and irrational (see Box 7). There were no maxims rarely or never used by most of the registrars.

Computing of participants' data within SPSS enabled maxims used often or always by participants to be calculated using a frequently used maxim single score scale variable; this score allowed group comparisons. Results demonstrated no statistically significant difference in how frequently nurse practitioners and registrars employ these maxims to guide their diagnostic reasoning, $t(44)=-.89$, $p=.38$.

Relationships between nurse practitioners' demographic data and their use of the frequently used maxims were examined. No statistically significant relationships were evident (see Appendix FF).

Analysis illustrated no relationship between the number of frequently used maxims used to guide diagnostic reasoning and diagnostic reasoning style in either the nurse practitioner ($r_S=.10$, n-30, $p=.61$) or registrar ($r_S=.38$, $n=16$, $p=.15$) groups. Nor was the number of frequently used maxims related to diagnostic reasoning abilities in the nurse practitioner ($r_S=-.17$, $n=30$, $p=37$) or registrar ($r_S=-.08$, $n=16$, $p=.77$) groups. This answered the study's fifth subquestion, do maxims used by nurse practitioners influence their diagnostic reasoning abilities.

5.4. Chapter summary

The chapter answered the central research question, how does nurse practitioner diagnostic reasoning compare to that of registrars? and in doing so answered five subquestions, which were:

1. How do nurse practitioner diagnostic reasoning abilities compare to those of registrars?
2. What diagnostic reasoning style do nurse practitioners use in the diagnostic reasoning process?
3. Does nurse practitioners' diagnostic reasoning style influence their diagnostic reasoning abilities?
4. What maxims guide nurse practitioner diagnostic reasoning?
5. Do maxims used by nurse practitioners influence their diagnostic reasoning abilities?

In answer to the first research subquestion, the findings revealed nurse practitioners' diagnostic reasoning abilities do not differ from registrars. The second research question was answered by the findings illustrating that although nurse practitioners as a group appear to use more System I processes in their diagnostic reasoning when compared to registrars, their diagnostic reasoning style did not differ from that of registrars. Analysis highlighted diagnostic reasoning style does not influence nurse practitioner or registrar diagnostic reasoning abilities; this answered the study's third subquestion.

The results revealing nurse practitioners' frequent use of seven maxims to guide their diagnostic reasoning answered the fourth research subquestion. The maxims they frequently employed were:

(1) never worry alone, get a consultation
(2) If what you are doing is working, keep doing it. If what you are doing is not working, stop doing it
(3) follow-up everything

(4) consider multiple separate diseases of a patient when the result of the history and physical examination are atypical of any one condition
(5) treat the patient not the x-ray
(6) don't order a test unless you know what you will do with the results
(7) common things occur commonly.

The use of maxims was not related to nurse practitioner or registrar diagnostic reasoning abilities and answered the fifth research subquestion. Answering the research subquestions demonstrated that nurse practitioners' diagnostic reasoning does not differ from that of registrars. This answers the central research question, how does nurse practitioner diagnostic reasoning compare to that of registrars? Having answered the study's research questions, the next chapter discusses the findings and how they relate to the wider literature and the New Zealand healthcare context.

Chapter six: Discussion

The previous chapter answered the study's central research question, how does nurse practitioner diagnostic reasoning compare to that of registrars? Through the case scenario using think aloud protocol, the study identified no difference between nurse practitioner and registrar diagnostic reasoning abilities. Exploring aspects of diagnostic reasoning showed some differences in individual diagnoses, problems and actions nurse practitioners and registrars identified but no difference overall. Nurse practitioners who had more New Zealand prescribing experience identified more accurate diagnoses than those with less prescribing experience. Nurse practitioners with more registered nurse specialty experience identified more problems than those with less specialty experience.

The intuitive/analytic instrument revealed nurse practitioners incorporate more System I processes into their diagnostic reasoning when compared to registrars but statistically there was no significant difference between the two groups. The maxims questionnaire illustrated nurse practitioners frequently used seven maxims to guide their diagnostic reasoning. Although registrars frequently used only six of these maxims there was no difference overall in how frequently nurse practitioners and registrars employed these maxims to guide their diagnostic reasoning.

The study demonstrated diagnostic reasoning style or clinicians' use of maxims did not influence their diagnostic reasoning abilities. No nurse practitioner demographic factors analysed in the study influenced their diagnostic reasoning style or their use of maxims.

This chapter discusses the study's findings and relates them to the wider literature and the New Zealand healthcare context. The discussion is presented in three parts: diagnostic reasoning abilities, diagnostic reasoning style and maxims used to guide diagnostic reasoning.

6.1. Diagnostic reasoning abilities

The thesis identified no difference between nurse practitioners' and registrars' diagnostic reasoning abilities. Nurse practitioners were introduced to provide a cost-effective way to improve access to healthcare and improve patient outcomes (Ministry of Health, 2002a). The impetus for the study pertained to criticisms over nurse practitioners' ability to perform a diagnosing role (Gorman, 2009), a role historically performed by doctors. Rather than nurse practitioners making the diagnoses at first contact, Gorman (2009) views the nurse practitioner role as focusing on interventions once the diagnosis is made and the referral initiated by the doctor (Gorman, 2009). The immense literature identifying intuition as nurses' dominant diagnostic reasoning style (Offredy et al., 2008; Thompson et al., 2007) does nothing to refute this view. This study qualifies the nurse practitioner role within the healthcare team by demonstrating no difference between New Zealand nurse practitioners' and registrars' diagnostic reasoning abilities or their diagnostic reasoning style, which like registrars, is mostly analytic. The results support nurse practitioners' ability to make diagnoses at the patient's first contact, which medicine has historically recognised as being challenging due to the indistinguishable and unorganised manner in which diagnostic cues are presented (Simpson et al., 1987).

In this thesis, the term diagnostic reasoning denoted data collection, identifying diagnoses and problems, and implementing action plans. Whereas some may argue the focus of diagnostic reasoning should be solely on the generation of diagnoses, recent research into diagnostic error has shifted the focus away from the diagnosis itself to the diagnostic reasoning process (Schiff et al., 2009; Winters et al., 2012). Diagnostic error may occur in multiple parts of the diagnostic reasoning process. This error may be related to failure in eliciting or interpreting signs and symptoms and/or diagnostic investigations to formulate correct diagnoses. Alternatively this may be related to failure to follow-up in a timely and appropriate manner and/or make a specialty referral (Schiff et al., 2009). Healthcare efficiencies in both the community and hospital setting are achieved by doing the right thing at the right time for the right reason (Ministry of Health, 2012b); hence a focus on all aspects of the diagnostic reasoning process is central to prevent diagnostic error (and the high cost associated with it) and provide high quality healthcare in an environment of lower healthcare funding (Ministry of Health, 2012a).

Nurse practitioners and registrars identified less than 50.00% of diagnoses, problems and actions identified by the expert panel. Nurse practitioners identified 44.79% and registrars identified 47.30% but there was no statistically significant difference between the two groups. This low percentage achieved is likely due to the expert panel having superior diagnostic reasoning abilities (Patel et al., 2011), the increased time frame the expert panel had to determine the correct answers, and the consensus process related to the Delphi technique used in the study. If nurse practitioners and registrars were compared to an individual expert, this percentage difference in accuracy may not be so great.

The complexity of the case scenario used in the study could further account for the low percentage of correct diagnoses, problem and actions participants identified. The thesis intentionally chose a complex scenario to ensure both System I and II processes were activated. Sherbino et al. (2012) in a study of 75 Canadian residents' ability to quickly generate accurate diagnoses removed cases that were too easy (where participants achieved 100% accuracy) or too difficult (where participants achieved 0% accuracy). Scores of <50% found in this thesis suggest the case scenario used to assess participants' diagnostic reasoning was complex enough to trigger analytic reasoning. Interestingly, Sherbino et al. (2012) reported a similar score with residents identifying 49% of diagnoses. They justify this score by their stringent scoring criteria. This thesis also used a stringent scoring system. For example nurse practitioners who actioned an endoscopy referral rather than specifically stating a gastroscopy were not given a point for being correct.

Similar scores to this research were found in a recent study of 115 US participants consisting of 51 medical students (novices), 26 first or second year residents (intermediates) and 38 third year residents (experienced) (Ilgen et al., 2011). Using 12 online vignettes that included a mixture of simple and complex cases, the researchers found participants achieved high scores in simple cases but lower scores in complex cases. In the complex cases novices scored 31%, intermediates 47% and experienced 55% (Ilgen et al., 2011). This further implies the low scores found in the thesis were related to the complexity of the case rather than poor diagnostic reasoning abilities.

The thesis illuminated time taken to complete the case scenario was positively associated with accurate diagnostic reasoning abilities. Nurse practitioners who demonstrated the poorest diagnostic reasoning abilities completed the case scenario in the fastest time. This is likely related to premature closure[18] or using System I processing when the complexity of the case required System II processing (Elstein, 2009; Lucchiari & Pravettoni, 2012; Norman & Eva, 2010; Sherbino et al., 2012).

Contrasting views exist on the effect of time on diagnostic accuracy. Most studies assessing this, however, measure participants' speed in making correct diagnoses rather than their swiftness in completing the whole diagnostic reasoning process. Mamede et al. (2008) demonstrated speed led to diagnostic error while Sherbino et al. (2012) found it improved

[18] Premature closure is the acceptance of a diagnosis before sufficient verification has occurred and failure to consider other plausible interventions once it has been reached (Levy et al., 2007).

diagnostic accuracy (Sherbino et al., 2012). Sherbino et al. aimed to assess accuracy of System I and II processing; fast times indicated System I processing while slower times signified System II processing. They only included Canadian 2nd year residents, excluding international residents with English as a second language after the pilot identified they took more time and had less diagnostic accuracy. Sherbino et al. (2012) surmise speed is not a causal variable but likely to "reflect greater knowledge and experience" (p. 790). This speed and accuracy could also be explained by diagnostic theory suggesting when hypotheses are made in the early part of the reasoning process they are more likely to be accurate (Pelaccia et al., 2011).

Although the thesis focused on all aspects of diagnostic reasoning, diagnoses, problems and actions were examined individually to provide insight into nurse practitioner diagnostic reasoning. The findings identified no difference between nurse practitioners and registrars in each of these aspects. The results demonstrating no difference in the number of problems nurse practitioners and registrars identified and addressed were unexpected. Recognition of problems is central to registered nurse practice (Baid, 2006; Paans et al., 2012) and the strength of the nurse practitioner role is seen in their combined focus, not just on diagnosis and treatment, but on problem identification and managing these problems to promote self care (Ministry of Health, 2002a). This unexpected result may reflect the type of registrars recruited into the study or mirror changes within the medical education programme, which may be training doctors to identify and manage these problems.

International literature on preventing diagnostic error highlights the importance of doctors identifying and managing problems (Pauker & Wong, 2010; Schwartz et al., 2010; Weiner et al., 2010). Doctors' perception of this being an important part of their role, however, does not resonate in the New Zealand context. New Zealand research on general practitioners' Accident Compensation Corporation (ACC) decisions identified the most important influencing factors for their decision included the patient history, followed by the examination findings and the clinicians' experience (Callaghan, 2012); patient problem management did not feature. Further New Zealand research on practising general practitioners illuminates their current disinterest in managing these problems and their desire to leave identifying and managing problems to nurses (Carryer, 2011a, 2011b). If the result of no difference between nurse practitioner and registrar problem identification and management truly reflects registrar practice, this implies the current culture of New Zealand specialist practice will refocus registrars on diagnosis and management once they achieve specialist status.

The study revealed 73.33% of nurse practitioners discussed the patient with their consultant compared to 6.25% of registrars. Discussing the patient was not related to having prescribing authority, the patient presentation reflecting their normal practice, their specialty area or their diagnostic reasoning abilities. As nurse practitioners' ability to generate diagnoses and problems and formulate an action plan did not differ from registrars, discussing the patient with their consultant may reflect nurse practitioners' use of probabilistic reasoning and their need to confirm their diagnoses before expensive tests and treatment are implemented. Arroll et al. (2012) view clinicians discussing their diagnoses and management with colleagues as a common method of improving pre-test probability of the patient having a disease and preventing "expensive, time-consuming or invasive investigations" (p. 172). Ferreira et al. (2010) in their study of 16 physicians highlighted they often suspended their judgement in complex cases until additional tests were obtained or they had further discussion with their peers. Coget and Keller (2011) claim getting a second opinion from colleagues and specialists supports rationale thinking by filling in knowledge gaps. Research illustrates more errors are detected and recovered when teams interact more (Patel et al, 2011).

This high percentage of consultation highlights the role nurse practitioners have within the healthcare team. As healthcare demands are rapidly increasing within a constrained financial environment (Ministry of Health, 2012a), maximising the expertise within the healthcare team is essential.[19] Nurse practitioners' ability to safely and independently manage patients and discuss patients with consultants in a timely and appropriate manner releases medical consultants to focus on more complex patient needs (Ministry of Health, 2011) and creates a more efficient and effective healthcare service.

The study revealed nurse practitioners with more years of New Zealand prescribing experience generated more accurate diagnoses. This suggests the academic and clinical preparation combined with prescribing experience better prepares nurse practitioners to make more accurate diagnoses. With the move to registered nurse prescribing in New Zealand and the need to clearly differentiate nurse practitioner scope of practice from registered nurse scope of practice (Nursing Council of New Zealand, 2012), this finding adds support for all nurse practitioners to be prescribers. This means appropriate further education and clinical mentorship for non-prescribing nurse practitioners is required if nurse practitioners are to be considered a consistent and effective member of the healthcare team.

The number of years registered nurse experience within nurse practitioners' specialty practice was related to the number of problems nurse practitioners identified. This factor was not related to the number of actions for these problems. As problem identification is a central part of

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[19] With an integrated clinical approach and telecommunication systems, the healthcare team focuses on the relationships healthcare professionals have rather than a physical location (Ministry of Health, 2011).

nursing practice (Baid, 2006) and contributes to patient-centred care, one can speculate registered nurses may also recognise these problems; however, they may not have incorporated all the actions identified by nurse practitioners. This may reiterate nurse practitioners' partnership role within the healthcare team in mentoring registered nurses to better address patient problems and in doing so further increase efficiency and effectiveness of healthcare delivery.

Specialty knowledge and experience improves diagnostic reasoning (Chi, Glaser, & Farr, 1998 and Johnson, 1988 as cited in Fisher & Fonteyn, 1995) yet this study found no relationship between nurse practitioners diagnostic reasoning expertise and experience or specialty knowledge. This supports the findings of Joseph and Patel (1990) who found endocrinologists' and cardiologists' assessment of an endocrine case demonstrated no difference in diagnostic accuracy. Although 36.67% of nurse practitioners in this thesis considered the case scenario not reflective of their normal practice, they did not demonstrate inferior diagnostic reasoning when compared to the remaining nurse practitioners. This may reflect the generalist academic preparation and clinical expertise necessary to register as a nurse practitioner in New Zealand or the research design. The case scenario aimed to reflect a patient presentation familiar to a wide range of specialties and intentionally excluded nurse practitioners from speciality areas where it would be unfamiliar.

No difference between nurse practitioners' and registrars' diagnostic reasoning abilities identified in this study adds to the minimal literature supporting no difference between the two disciplines. Van der Linden et al. (2010) when comparing emergency nurse practitioners and house officers in the Netherlands identified nurse practitioners and house officers missed a similar number of diagnoses, which resulted in a similar number of inappropriate actions plans. Van der Linden et al. (2010) reviewed electronic records of patients presenting with minor illnesses and injuries, which are likely to reflect the use of System I processes and environmental factors influencing diagnostic accuracy. This is in contrast to the method used in this study, which incorporated a computer case scenario using think aloud to access higher cognitive or System II processes. Both this research and van der Linden et al. used an expert panel to determine accurate diagnostic reasoning. This study, however, unlike van der Linden et al. compared nurse practitioners to an experienced group of registrars rather than house officers. Thirteen of the 16 registrars in this research had completed part one specialty exams.

An earlier study by Sakr et al. (1999) compared the care provided by United Kingdom (UK) emergency department nurse practitioners and junior doctors to patients presenting with minor injuries. In contrast to the study by Van der Linden et al. (2010), they compared nurse practitioners' and juniors doctors' assessment of these patients with that of an experienced registrar. In this study the frequency of diagnostic error made by the two groups were similar with nurse practitioners making errors in 9.2% of cases compared to 10.7% in the junior doctor group. As this study was undertaken in the emergency department while participants performed their assessment, the diagnostic reasoning of both groups are likely to reflect System I processes and environmental factors influencing the diagnostic reasoning process. As already mentioned, the weakness of this study relates to the assumption that the registrars' diagnostic reasoning was correct. As shown in this thesis, registrars also make diagnostic error.

Van der Linden et al. (2010), Sakr et al. (1999) and this study demonstrated nurse practitioners, like house officers and registrars, make diagnostic errors. In this study both nurse practitioners and registrars identified less than 50.00% of the diagnoses, problem and actions identified by the expert panel. Early research by Rosenthal et al. (1992) demonstrated nurse practitioners make diagnostic errors, however, as they excluded resident physicians working in the clinic, it prevented the nurse practitioner data being interpreted within the wider diagnostic reasoning context. Although expert doctors make fewer mistakes than registrars (Allen et al., 1998; Carrière et al., 2009, Patel et al., 2011), they still make diagnostic errors (Allen et al., 1998; Carrière et al., 2009; Coderre et al., 2003; Patel et al., 2011). Like registrars, nurse practitioners make errors and without embedding the research within the wider context, their diagnostic reasoning abilities will appear inferior to doctors, which is not the case.

Offredy (2002) identified no difference between the decision making processes of UK primary care nurse practitioners and general practitioners. Differences between the two groups in their identification of correct diagnoses and treatment were due to nurse practitioners limited knowledge and experience related to lack of familiarity with the patient presentation. These findings are in contrast to those found in this study where familiarity with the patient presentation was not related to nurse practitioners' diagnostic reasoning abilities. These contrasting results are likely due to the different nurse practitioner academic and registration requirements in the UK and New Zealand.

The study found no difference between nurse practitioner and registrar diagnostic reasoning abilities. Carryer (2011a, 2011b) asks how is "nurse practitioner scope of practice limited when compared to that of a general practitioner?" (p. 2). The results of this study provide some answers to this question. Whilst it is evident from the findings that nurse practitioners, like registrars, can appropriately diagnose and treat complex patients, they recognise when the complexity of the patient exceeds their ability to manage the patient independently and immediately discuss the patient with the medical consultant they work with. This demonstrates better, sooner more convenient healthcare [20] in

[20] Better healthcare refers to community and hospital healthcare professionals collaboratively working together to provide more effective care. Sooner healthcare

action and the importance of a team approach in providing value-added care.

6.2. Diagnostic reasoning style

The thesis identified that nurse practitioners were more likely to use an analytic-intuitive diagnostic reasoning style whereas registrars were more likely to use an analytic one. Nurse practitioners' diagnostic reasoning style reflecting both System I and II processing adds support to previous nurse practitioner studies demonstrating their use. Research has previously demonstrated nurse practitioners use System I processes that include intuition, pattern recognition (Brykczynski, 1989,1999; Burman et al., 2002; Offredy, 1998; Ritter, 2003) and maxims (Brykczynski, 1989, 1999). Burman et al. (2002) and Kosowski and Roberts (2003) illustrated intuition or gut feeling is only used by nurse practitioners as a trigger to search for red flags by gathering more objective data. Former research identified the System II processes nurse practitioners incorporate into their practice include deterministic reasoning (Offredy, 1998) and the hypothetico-deductive model (Offredy, 1998; Ritter, 2003).

Excluding Brykczynski's (1989; 1999) research identifying nurse practitioners' use the maxim *common problems occur commonly* (an heuristic based on probabilistic reasoning), prior research has not highlighted nurse practitioners' use of probabilistic reasoning. Arroll et al. (2012) suggest each question and physical examination reflects probabilistic reasoning by serving as a diagnostic test to determine the likelihood of a patient having a disease. This means generating a diagnosis and formulating a treatment option requires probabilistic reasoning. In

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reflects patients waiting less time for healthcare by providing a smoother flow between different parts of the health service. More convenient healthcare focuses on providing healthcare at a convenient setting for the patient to ensure they remain well in the community and avoid unnecessary stays in hospital (Ministry of Health, 2011).

this study nurse practitioners generated diagnoses from multiple cues indicating their use of probabilistic reasoning.

Registrars' analytic diagnostic reasoning style seen in this study may reflect their training system which, until recently considered the hypothetico-deductive model (a System II process) the predominant mode used in medical problem solving (Ritter, 2003) and the model of expert reasoning (Elstein et al., 1993; Joseph & Patel, 1990; White et al., 1992). System II processes are developed through formal training (Croskerry, 2009) thus registrars participating in formal specialist training programmes are likely to reflect the diagnostic reasoning style of their training system. It is now recognised that diagnostic reasoning requires both System I and System 11 processes (Croskerry, 2009; Elstein, 2009; Heiberg Engel, 2008). Croskerry (2009) argues clinicians in training now need a comprehensive approach to diagnostic reasoning to enable them to understand its complexity and how it affects their individual decision making.

The subtle but non-statistically significant difference in registrars and nurse practitioners' diagnostic reasoning style could also be explained by their experience. Experienced clinicians' incorporate both System I and II processes into their diagnostic reasoning (Croskerry, 2009). When compared to the nurse practitioner group, registrars had less clinical experience. Registrars averaged three years registrar experience in their current training specialty and almost three years house officer experience. This experience differs significantly from the nurse practitioner group, who although only had an average of two years nurse practitioner experience, had an average of 28 years experience as a registered nurse with 17 years registered nurse experience in their specialty.

Gender has historically been associated with intuition yet the results of this study show no association between gender and nurse practitioner diagnostic reasoning style. This is in contrast to findings by Schneider et al. (2010) who reviewed how 93 general practitioners dealt with uncertainty and illustrated intuition was more dominate in female participants. Research shows females use intuition more than males to encode and decode non-verbal communication (Lieberman, 2000, as cited in Sadler-Smith, 2011). In a recent USA study of 770 men and 1475 women, using a self reported rational-experiential inventory (REI) scale, men reported being more rational than women (Norris & Epstein, 2011). The contrasting findings in this thesis add to the literature showing mixed support for female intuition (Sadler-Smith, 2011).

Diagnostic reasoning style in this study was assessed using a validated intuitive-analytic reasoning instrument previously validated using a data set from 1460 nurses from seven different countries and five different specialties (Lauri & Salantera, 2002). As Lauri and Salantera's (2002) instrument tested problem identification and management, for this thesis the wording was altered to reflect both diagnosis and problem identification and management. Identifying diagnoses requires higher level thinking than identifying problems or nursing diagnoses (Elstein et al., 1993). Elstein et al. (1993) make this differentiation by viewing a diagnosis as "specific and precise and reflecting a higher level explanatory concept" (p. 23). They view problems on the other hand as being more "vague and global, reflecting lower level concepts more closely akin to recognising an abnormal finding or manifestation" (p. 23). This means the results of clinical decision making pertaining to problems is likely to be very different to that pertaining to diagnoses. This prevents nurse practitioner diagnostic reasoning style identified in this study being compared to registered nurse clinical decision making style illuminated in Lauri and Salantera's (2002) study.

6.3. Maxims used to guide diagnostic reasoning

Whilst there were differences in how frequently nurse practitioners and registrars used individual maxims, this thesis illuminated they had similar reliance on maxims as a whole to guide their diagnostic reasoning. Nurse practitioners regularly used seven maxims to guide their practice which were: (1) never worry alone, get a consultation; (2) if what you are doing is working, keep doing it, if what you are doing is not working, stop doing it; (3) follow-up everything; (4) consider multiple separate diseases of a patient when the result of the history and physical examination are atypical of any one condition; (5) treat the patient not the x-ray; (6) don't order a test unless you know what you will do with the results; and (7) common things occur commonly. Although registrars used six of these maxims similarly, only 50.00% of registrars regularly employed the maxim, *consider multiple separate diseases of a patient when the result of the history and physical examination are atypical of any one condition.* Instead registrars were more likely to use the maxim, *real disease declares itself*. Nurse practitioners rarely or never used the maxim, *if you don't know what to do, don't do anything.*

The lack of literature related to maxims in diagnostic reasoning creates difficulty in relating the findings of this research to the wider literature. Brykczynski (1989,1999) in one of the few studies identifying the use of maxims found nurse practitioners used pattern recognition and maxims to make both medical and nursing diagnoses. The maxims Brykczynski identified were: (1) real disease declares itself, (2) common things occur commonly and (3) follow up everything. As mentioned previously, the maxim *common things occur commonly* is a recognised heuristic in medicine based on probabilistic reasoning (Vickrey et al., 2010). The findings in this thesis bear similarity to Brykczynski (1989, 1999). Nurse practitioners in this thesis frequently used the maxims, *common things occur commonly* and *follow-up everything.* The maxim, *real disease declares itself*, was used more frequently by registrars than nurse practitioners.

Levine and Bleakley (2012) acknowledge the scarcity of literature surrounding maxims. They argue maxims aid clinical judgement by promoting memory and working as a heuristic. Maxims are regarded as clinical pearls of wisdom often reflecting the voice of past mentors (Alpert, 2009a, 2009b; Levine & Bleakley, 2012) and are often undervalued (Levine & Bleakley, 2012). Alpert (2009a) views maxims as principles based on common sense and argues three-fifths of medicine is based on common sense and the contextual factors related to knowing the patient. The results of this study illustrate nurse practitioners and registrars frequently employ maxims to guide their diagnostic reasoning yet little literature is available on their use. Whether they are used appropriately or inappropriately, their significance in diagnostic reasoning requires further investigation.

6.4. Chapter conclusion

The results of this study exploring nurse practitioners' diagnostic reasoning abilities, diagnostic reasoning style and maxims used to guide diagnostic reasoning, demonstrate nurse practitioners' cognitive and diagnostic reasoning abilities do not differ from registrars'. The triple aim in healthcare describes an approach to optimising health system performance in three areas: improving the patient experience (including quality and satisfaction), improving healthcare populations and reducing the per capita cost of healthcare (Institute for Health Care Improvement, 2012). With the need for better, sooner, more convenient care within an environment of increased healthcare need and reduced healthcare funding (Ministry of Health, 2011; Ministry of Health, 2012a) there is now a need to maximise the knowledge, expertise and value added care nurse practitioners bring to the healthcare team. The results of this study further supports nurse practitioners' abilities to perform the role they were introduced to do hence there is now a need to eradicate the "persistent legislative, custom and practice barriers" (Carryer, 2011b, p. 19) preventing nurse practitioners from being fully utilised. Having discussed the findings of the study in context to the wider literature and the New Zealand healthcare context, the next chapter summarises the thesis and outlines the limitations of the research and the implications pertaining to the research findings.

Chapter seven: Conclusion

7.1. Overview of thesis

Nurse practitioners were introduced to increase patients' access to healthcare, improve patient outcomes and provide a sustainable solution to ongoing workforce shortages. They provide a diagnostic role previously delivered by doctors. Their ability to perform this diagnostic role has been challenged by suggestions that when compared to doctors, nurse practitioners do not have the cognitive abilities to make a diagnosis at the first point of contact. This challenges nurse practitioners' ability to perform the role they were introduced to do.

This thesis used a post-positivist mixed method convergent parallel design to explore nurse practitioner diagnostic reasoning and compare it to that of registrars. The study was designed to answer the central research question, how does nurse practitioner diagnostic reasoning compare to that of registrars? To answer this question, the study had five research subquestions, which were:

1. How do nurse practitioner diagnostic reasoning abilities compare to those of registrars?
2. What diagnostic reasoning style do nurse practitioners use in the diagnostic reasoning process?
3. Does nurse practitioners' diagnostic reasoning style influence their diagnostic reasoning abilities?
4. What maxims guide nurse practitioner diagnostic reasoning?
5. Do maxims used by nurse practitioners influence their diagnostic reasoning abilities?

Methods used to answer the research questions included a complex case scenario using think aloud protocol to determine diagnostic reasoning abilities, a previously validated intuitive/analytic reasoning instrument to identify diagnostic reasoning style, a maxims questionnaire to identify maxims used to guide diagnostic reasoning and a demographic data sheet to identify variables influencing the results of all the former.

The study included 30 nurse practitioners and 16 registrars. An expert panel determined the correct diagnoses, problem and actions for the case scenario using the Delphi technique. The registrar data provided normative data and norm-referenced testing was used to compare the nurse practitioner data to the normative data.

The case scenario using think aloud protocol identified no difference between nurse practitioners' and registrars' diagnostic reasoning abilities. Exploring aspects of diagnostic reasoning, including identifying diagnoses, problems and actions, showed nurse practitioners compared favourably to registrars. Nurse practitioners who had more New Zealand prescribing experience identified more accurate diagnoses than those with less New Zealand prescribing experience. Nurse practitioners with more registered nurse specialty experience identified more problems than those with less specialty experience.

The intuitive/analytic instrument revealed nurse practitioners were more likely to incorporate System I processes into their diagnostic reasoning when compared to registrars. The maxims questionnaire illustrated nurse practitioners frequently used seven maxims to guide their diagnostic reasoning. These were:

1. Never worry alone, get a consultation
2. If what you are doing is working, keep doing it. If what you are doing is not working, stop doing it
3. Follow-up everything

4. Consider multiple separate diseases of a patient when the result of the history and physical examination are atypical of any one condition
5. Treat the patient not the x-ray
6. Don't order a test unless you know what you will do with the results
7. Common things occur commonly.

Registrars used six of these maxims frequently; only 50.00% of registrars frequently used the maxim, *consider multiple separate diseases of a patient when the result of the history and physical examination are atypical of any one condition*. Registrars were more likely to use the maxim, *real disease declares itself*. Although registrars frequently used only six of these maxims the two groups were similar in how frequently they employed maxims to guide their diagnostic reasoning.

The study demonstrated diagnostic reasoning style and how often clinicians used maxims to guide their diagnostic reasoning did not influence their diagnostic reasoning abilities. No nurse practitioner demographic factors analysed in the study influenced their diagnostic reasoning style or their use of maxims.

7.2. Limitations pertaining to the research

This thesis exploring nurse practitioner diagnostic reasoning has a number of limitations. The researcher acknowledges the limitations related to the research design. The web-based questionnaire incorporating an intuitive/analytic reasoning instrument and maxims questionnaire relied on self-reporting and may reflect perceived rather than actual diagnostic reasoning behaviours. Although the observational nature of the case scenario using think aloud (based on a real case) was incorporated to compensate for the less objective self-reports, it did not reflect participants' diagnostic reasoning in their natural settings.

Environmental factors influence diagnostic accuracy (Croskerry, 2009; Ferreira et al., 2010; Sevdalis et al., 2010) and therefore participants' diagnostic reasoning abilities when working in their normal areas of practice may differ from the findings illuminated in the study.

The complex nature of the case scenario was designed to access higher cognitive processes and trigger analytic reasoning. Many of the findings related to the number of diagnoses, problems and actions (correct or incorrect) generated, reflect findings in a complex case; analysis of a familiar and simpler case is likely to result in different findings.

The case scenario did not require participants to request information; participants acquired information passively by opening a section of the computerised case scenario. This means participants may not have obtained some of the critical and relevant cues that might have been evident in the practice setting. As the likelihood of a patient having a diagnosis is increased with critical and relevant cues gained from the health history, physical examination and diagnostic tests, failure to collect that data from the practice setting may have prevented them from generating the correct diagnoses.

Another limitation is related to the registrar sample size. Although the nurse practitioner sample was representative of nurse practitioners at the time the data were collected, the registrar group was small and may not reflect registrars as a whole. As with any normative study, another normative sample may provide quite different results.

The difficulty in recruiting registrars and the resulting unequal sample size meant there was a risk of a Type II error occurring when performing the between-group independent *t*-test. This unequal sample size, however, had little impact on the study's findings. For most of the variables measured using this test, the percent difference between the two groups was small. For example, there was less than three percent difference in nurse practitioners' and registrars' diagnostic reasoning abilities and correct problem and actions. The difference related to correct diagnoses was greater (7.2%), however, the chi-square test demonstrated this difference was related to differential diagnoses requiring further investigations. Both groups were similar in prescribing antibiotics, ordering a sputum culture and referring the patient to hospital for specialist team review and/or hospital admission. Although not statistically significant (*p*=06), there were percent differences related to the various types of diagnostic reasoning style; this was further explored using z-scores and percentage ranks.

As with any research, there is a risk of a Type I error. A Type I error occurs when the result indicates a statistically significant difference when there isn't one (Clark-Carter, 2010). Researchers often balance the risk of a Type I and a Type II error by setting the alpha at 0.05 (Clark-Carter, 2010), as was the case in this study.

7.3. Implications for future research and practice

The study did not assess the role reflective practice has on nurse practitioners' diagnostic reasoning. Reflective practice improves diagnostic reasoning by encouraging clinicians to think critically about their reasoning processes (Elstein, 2009; Mamede et al., 2008; Mamede et al., 2010). Although not measured in this study, it is a subject for future research.

The study identified individually, nurse practitioners and registrars had varying diagnostic reasoning abilities. Although this thesis analysed aspects of diagnostic reasoning style influencing diagnostic accuracy, the effect of value biases and heuristics were not fully examined. As value biases, including stereotyping, prejudice and overconfidence (Mamede et al., 2008; Norman & Eva, 2010; Standing, 2008) influence diagnostic reasoning accuracy, it is a subject for further research. Heuristics, such as framing, anchoring, availability, representativeness, confirmation bias and outcome bias, lead to diagnostic error (de Bruin et al., 2005; Vickrey et al., 2010). The effect of these heuristics on New Zealand nurse practitioners' and registrars' diagnostic reasoning warrants further investigation.

As discussed in the introduction, Gorman (2009) views the role of the doctor in the future as a health professional who has largely a cognitive function, translating patients' signs and symptoms into a diagnosis; this role, he argues, cannot be substituted by a nurse practitioner. Gorman's view of medicine having a diagnostic role and referring to nurse practitioners when required suggests doctors are better suited to diagnosis and treatment whereas nurse practitioners are better suited to ongoing interventions once the diagnosis is made. The results of this study demonstrating most nurse practitioners were likely to use an analytic or mostly analytic diagnostic reasoning style and that their diagnostic reasoning abilities compared favourably to those of registrars indicate Gorman's concerns are unwarranted.

The findings of this study suggest nurse practitioners' cognitive function developed from education and experience enables them to diagnose and manage complex patients presenting for the first time. The focus now needs to shift from questioning nurse practitioners' diagnostic reasoning abilities to how they can be better utilised within the healthcare team to improve the healthcare of the New Zealand population.

Although no difference was found between nurse practitioners and registrars in identifying correct diagnoses, problem and actions, when compared to registrars nurse practitioners were more likely to discuss the patient with their consultant. This reflects their readiness to manage patients independently but consult when needed to ensure patients are not subjected to unnecessary and often expensive, time consuming and invasive tests. With the current focus on better, sooner, more convenient healthcare in a setting of increased healthcare needs and reduced healthcare funding, there is a need to maximise nurse practitioners' expertise and value added care within the healthcare team. This can only be achieved by removing the legislative, customary and practice barriers preventing nurse practitioners from practising to their potential and patients from receiving the care to which they are entitled.

In conclusion, the rationale for this study was related to doubt over nurse practitioners' cognitive ability to perform a diagnostic role previously performed exclusively by medical doctors. This challenged nurse practitioners' ability to increase patients' access to healthcare, improve patient outcomes and provide a sustainable solution to ongoing workforce shortages. The results of this study demonstrate nurse practitioners' diagnostic reasoning abilities compare favourably to registrars.' The findings further support the use of nurse practitioners as a safe and effective professional group in the New Zealand healthcare system.

Appendices

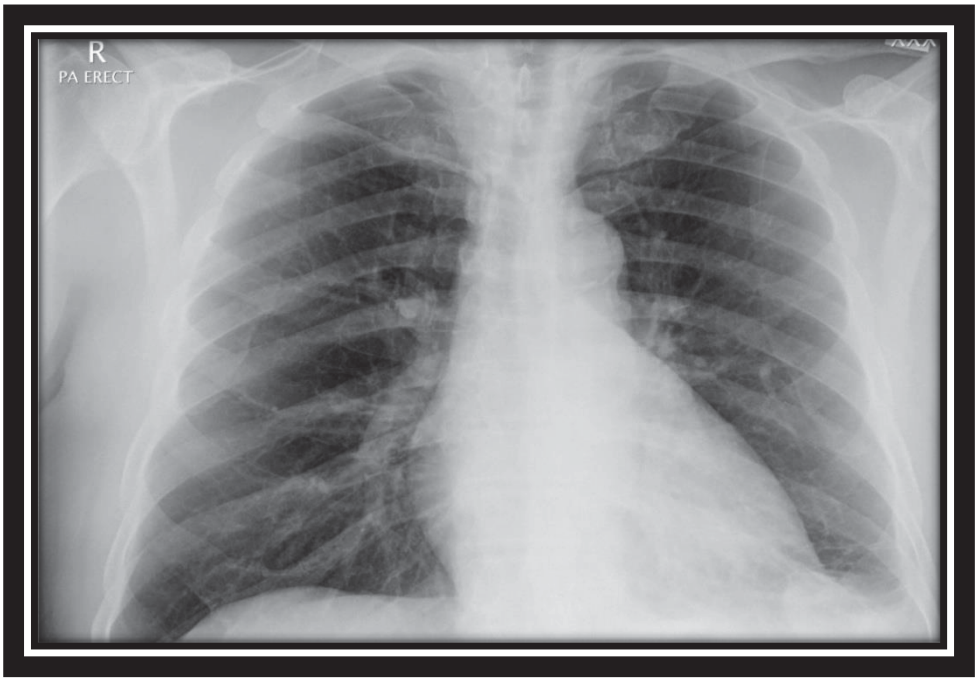
Appendix A. Case Scenario

Presenting problem	
S1	A 67 year old man who has 2 week history of flu-like illness, backache, posterior chest pain, cough. He visited his GP 1 week ago and was prescribed amoxicillin 500 mg three times daily but no improvement. Brought into out of hours medical centre by daughter with complaints of worsening cough and left sided chest pain.
HEALTH HISTORY	
Biographical	
S2	Lives locally - lower socio-economic area
S3	Retired
S4	Daughter next of kin
S5	Speaks Samoan - limited English – daughter able to translate
S6	Permanent Resident
Past medical history	
S7	Type II diabetes mellitus diagnosed 1997 Hypertension Hyperlipidaemia Previous branch occlusion left eye, persistent left macular oedema Cataract surgery right eye 2007 Ophthalmology review 2007 – no diabetic retinopathy
S8	Medications Metformin 1gm three times a day Aspirin enteric coated 100mg daily Inhibace 5mg daily Penmix 30 30 units mane and nocté Simvastatin 20 mg nocté Aspirin 150 mg daily Paracetamol 1 gm four times daily prn Diclofenac 75 mg twice daily prn Hasn’t been taking penmix as he doesn’t think he needs it.
S9	No known drug allergies
Family history	
S10	Thinks mother had a gastric ulcer otherwise not aware of any other family history

Social history	
S11	Lives with family
Health risk appraisal	
S12	Exercise is limited
S13	Walks around house and to car
S14	Able to perform activities of daily living
S15	Ex smoker – stopped 8 years ago. Smoked 20 cigarettes a day over 40 years
PHYSICAL EXAMINATION	
S16	Alert and orientated. Appears comfortable at rest
S17	Temperature 36.2 C
S18	Pulse rate 77 regular
S19	Respiration rate 22
S20	Blood pressure 194/96
S21	SpO_2 96% on air
Respiratory	
S22	No accessory muscle usage
S23	Speaking in full sentences
S24	Has noticed he gets more short of breath over past 2 weeks
S25	Productive cough with yellow sputum. Nil haemoptysis
S26	Left sided chest pain on inspiration and coughing
S27	Cough limited by pain
S28	Chest auscultation – reduced breath sound left base with a few crackles. Nil wheeze.
S29	Dullness on percussion left base
S30	Reduced vocal response left base
S31	No clubbing
S32	No CO_2 flap
Cardiovascular	
S33	Peripherally warm – feeling slightly clammy
S34	JVP not elevated
S35	Normal S1 and S2 heart sounds
S36	ECG RBBB
Gastrointestinal	
S37	Good dentition

S38	Reduced appetite
S39	5kg weight loss over past few weeks
S40	No vomiting
S41	Has been constipated. Bowels opened six days ago – black and hard
S42	Has been experiencing generalised abdominal pain
S43	Abdomen soft and non tender on palpation
S44	Active bowel sounds
S45	PR examination – no blood or mass
Genitourinary	
S46	No urinary symptoms – no frequency, normal urine volumes
General	
S47	No enlargement of cervical or axillary nodes
S48	Calves soft and non tender
S49	Nil peripheral oedema
LABORATORY INVESTIGATIONS	
S50	Sodium 134 mmol/L (135-145) Potassium 4.4 mmol/L (3.5-5.2) Chloride 102 mmol/L (95-110) Bicarbonate 26 mmol/L (22-31) Glucose 10 mmol/L (3-11) Urea 5.5 mmol/L (3.2-7.7) Creatinine 77 umol/L (60-105) Albumin 39 g/L (38-52) Bilirubin 9 umol/L (<25) GGT 16 U/L (0-60) Alkaline phosphatase 68 U/L (40-130) AST 16 U/L (<45) Lipase 31 U/L (8-78) ALT 12 U/L (<45) C-reactive protein 121 mg/L (0-5) Haemoglobin 97 g/L (130 – 175) Haematocrit 0.3 (0.4-6) Platelets 250 xE9/L (150-400)E9/L WBC 10.1 E9/L (4-11) Neutrophils 7.9 E9/L (1.9-7.5)

	Eosinophils 0.6 E9/L (0-0.5)
	Monocytes 0.9 E9/L (0.2-0.8)
	Lymphocytes 0.7 E9/L (1-4)
	HbA1c 7.6% (4-6)
	eGFR 63 ml/in/1.73m2 (>90)
	Microalbumin urine 13mg/L (<30)
	Non fasting lipids
	Cholesterol 3.7mmol/L (<5)
	Triglycerides 1.2mmol/L (<2)
	HDL cholesterol 0.98mmol/L (>1)
	LDH cholesterol 2.2mmol/L (<3)
	Chol/HDL ratio 3.8 (<4.5)
	APTT 36 seconds (25-40)
	PR 0.9 (0.8-1.2)
	Fibrinogen 9.2 g/L (1.5-4)
	Urine dip stick
	Glucose trace
	Ketones negative
	Albumin trace
	Nitrite negative
	Leucocyte esterase negative
	Haemoglobin negative
S51	Chest x-ray AP & lateral
S52	Radiological Report : CHEST PA & LEFT LATERAL No previous films are available for comparison. There is blunting of the left costophrenic recess with linear areas of density in the left lower lobe but no definite consolidation. These changes may be due to scarring from previous inflammatory disease. The right lung and pleural space are clear. The lungs appear mildly hyperinflated in keeping with a degree of COPD. Cardiac size is within normal limits. Mediastinal contours are unremarkable. IMPRESSION: COPD. Changes in the left lung base most likely represent post-inflammatory scarring. No acute abnormality is identified.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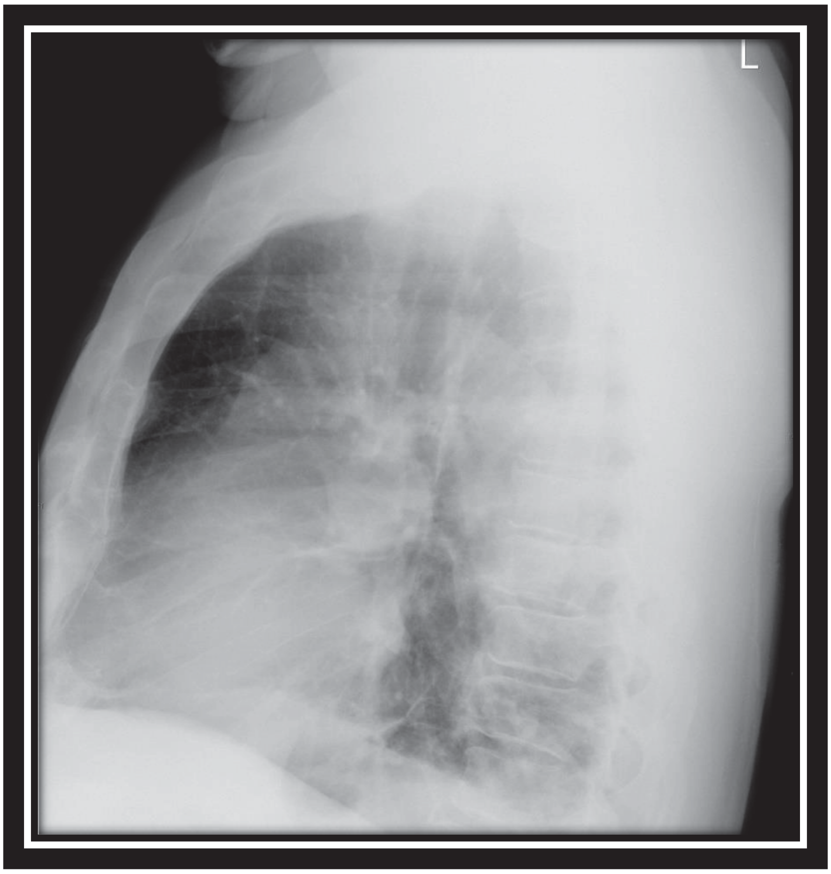
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Appendix B. Confidentiality Agreement

MASSEY UNIVERSITY
COLLEGE OF HUMANITIES
AND SOCIAL SCIENCES
TE KURA PŪKENGA TANGATA

Nurse Practitioner Diagnostic Reasoning

CONFIDENTIALITY AGREEMENT

I .... (Full Name - printed)

agree to keep confidential all information concerning the case scenario used in the think aloud of the nurse practitioner diagnostic reasoning study.

I will not retain or copy any information involving the project.

Signature: ________________________ **Date:** __________

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Appendix C. Participant Case Scenario Using Think Aloud Directions

You will have 1 hour to complete the case scenario. The case scenario is based on a real case. You are asked to complete it as you would a real case in practice. You will be audiotaped while you are working through the scenario and thinking aloud.

- The case scenario is divided into four parts: the patient's presenting problem, the patient's health history, the patient's physical examination data, and the patient's diagnostic tests.

- You can select any parts or segments in any order or at a rate acceptable to you – your selection process will be recorded by the computer programme. However, please choose the order that would best reflect your clinical practice.

- On viewing the data in each part or segment, think aloud the importance of the information in that part or segment in reaching a correct diagnoses

- As you collect data, think aloud the possible patient diagnoses

- You may go backwards and forwards to any part of segment at any time you wish.

- If you stop thinking aloud, the researcher will remind you to think aloud as you work through the scenario

- After presentation of the entire case, please provide a summary of the case and your final diagnoses, problems and action plan.

- At the end of the case scenario, you will be asked if there was any data you would have liked to collect but was not provided in any of the parts or segments

Appendix D. Web-based Questionnaire

1. Introduction to diagnostic reasoning survey

Thank you for taking time to complete this survey. This survey consists of 6 parts. Once each part is completed, please click on the next icon at the bottom of the page to go on to the next part. The survey will take 15-20 minutes to complete. Completion of this survey implies consent. However, your written consent will be obtained prior to the case scenario using think aloud. No data will be used without your written consent.

*** 1. Please write in the box below your unique identification number provided by the researcher? This needs to be provided before proceeding with the questionnaire**

2. Which group describes your practice?

- ◯ Nurse practitioner
- ◯ Registrar

2. Part Two: Collecting information for identifying diagnoses and/or problems

Listed below are some statements that describe different stages of diagnostic reasoning. Please read each statement carefully and choose the answer that best describes your own practice.

When I am collecting information about the patient and identifying his/her diagnoses and/or problems:

1. I collect as much advance information as possible from the patient's records.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

2. On the basis of my advance information, I specify all the items I intend to monitor and ask the patient about.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

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3. I assess all advance information against my own knowledge.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

4. I fill in my picture of first impressions by seeking information about the patient that deviates from the advance information.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

5. I confirm my first impressions by seeking for clear symptoms that support those impressions.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

6. I ask the patient whether I have made the right interpretations about the advance information concerning him/her.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

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7. I collect the same information for all patients on admission.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

8. I collect a lot of information about the patient's symptoms and complaints.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

9. I collect a lot of information about the patient's views of his/her condition and health.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

10. I try to keep all the advance information in my mind.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

11. I always rely on my own interpretations when it comes to identifying diagnoses and/or problems.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

12. I make assumptions about forthcoming diagnoses and/or problems during the first contact with the patient.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

13. I acquire additional information to confirm my own assumptions of the patient's situation.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

14. It is easy for me to make a distinction between important and unimportant information in identifying the patient's diagnoses and/or problems.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

3. Part three: Handling information and identifying diagnoses and/or problems

When I am handling the information I have obtained about the patient and identifying expected diagnoses and/or

1. I compare the information I have received with my earlier knowledge of similar individual patients.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

2. I compare the information I have received with my earlier knowledge of patient behavior in different life situations.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

3. I compare the information I have received with the medical or nursing model I have created on the basis of my own experience.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

4. I compare the information I have received with medical knowledge about patient's disease and its symptoms.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

5. I compare the information I have received with the medical or nursing models I have learned.

- [ ] Never/almost never
- [ ] Rarely
- [ ] Sometimes
- [ ] Often
- [ ] Always/almost always

6. I compare the information I have received with my own knowledge about diagnoses and problems.

- ○ Never/almost never
- ○ Rarely
- ○ Sometimes
- ○ Often
- ○ Always/almost always

7. I carefully analyze the information I have received before identifying the patient's diagnoses and/or problems.

- ○ Never/almost never
- ○ Rarely
- ○ Sometimes
- ○ Often
- ○ Always/almost always

8. It is easy for me to see, even without closer analysis, which pieces of information are relevant to identifying the patient's diagnoses and/or problems.

- ○ Never/almost never
- ○ Rarely
- ○ Sometimes
- ○ Often
- ○ Always/almost always

9. It is easy for me to recognize the importance of the patient's subjective experiences in identifying his/her diagnoses and/or problems.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

10. I organize the information I have received into blocks for easier identification of diagnoses and/or problems.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

11. I define the patient's diagnoses and/or problems objectively on the basis of the symptoms and complaints observed.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

12. I check with my colleagues that I have made right conclusions about the patient's diagnoses and/or problems.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

13. It is easy for me to form an overall picture of the patient's situation and major diagnoses and/or problems.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

14. I draw on diagnostic reasoning or nursing process thinking to define the patient's diagnoses and/or problems.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

4. Part four: Planning

When I am planning the care of a patient:

1. I use the plan for the patient's medical treatment as a frame of reference.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

2. I aim in my planning to resolve the current situation.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

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3. It is easy for me to get the patient to take part in the planning.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

4. I focus more on the future and on the patient's chances to pull through rather than on current medical or nursing needs.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

5. I use the patient's own views on his/her care and treatment as the frame of reference for my planning.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

6. I base my medical or nursing plans on the regimes prescribed for the patient's disease.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

7. I base my medical or nursing plans on my own experiences of the treatment of similar patients.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

8. I have no difficulty in outlining the plan of care in the patient's clinical notes.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

9. I set out targets for medicine or nursing that are easy to measure.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

10. I tend to emphasize measures of immediate treatment.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

11. I normally record in the patient's clinical notes according to a diagnostic reasoning or nursing process model.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

12. I have no difficulty in preparing individualized long-term medical or nursing plans.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

13. I anticipate the impacts of different medical or nursing measures on the patient.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

14. I rely on information about health to a greater extent than on information about illness.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

. Part five: Implementing care and monitoring and evaluating the patient's co...

/hen I am implementing medical or nursing care:

Page 11

1. I act rationally and consistently even in unexpected situations.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

2. I follow as closely as possible existing medical or nursing plans for different diseases or situations.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

3. It is easy for me to assess the impacts of my actions on the patient's condition and health.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

4. I anticipate changes in the patient's situation on the basis of individual cues even before there are any clear symptoms.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

5. I know how to motivate the patient to take care of him/herself and to take self-care responsibility.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

6. I know how to motivate the patient's family to take part in the patient's treatment.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

7. I follow the patient's individual treatment plan as closely as possible.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

8. I use specific information about the treatment of the patient's disease when making medical or nursing decisions.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

9. I flexibly change my line of action on the basis of feedback on the patient's situation.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

10. I often try to explain my own observations of changes in the patient's condition.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

11. I can see changes in the patient's condition, but I am not always able to explain how I know this.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

12. I have no difficulty in sorting out the priorities in different medical or nursing situations.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

13. I provide guidance to the patient chiefly by informing him/her about the disease and/or problem and its treatment.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

14. In providing guidance to the patient I mainly rely on package instructions that are suited to solving this patient's diagnoses and/or problems.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

6. Part six. Use of maxims

This final part of the survey is about principles you use to guide your diagnostic reasoning practice.

Please choose the answer that mostly reflects your use of these principles in your everyday practice.

1. When facing competing diagnoses, favour the simplest one.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

2. If you don't know what to do, don't do anything.

- Never/almost never
- Rarely
- Sometimes
- Often
- Always/almost always

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3. Consider multiple separate diseases of a patient when the result of the history and physical examination are atypical for any one condition.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

4. Common things occur commonly.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

5. All bleeding eventually stops.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

6. All drugs work by poisoning some aspect of normal physiology.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

7. Don't order a test unless you know what you will do with the results.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

8. If what you are doing is working, keep doing it. If what you are doing is not working, stop doing it.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

9. Real disease declares itself.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

10. Treat the patient not the x-ray.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

11. Never worry alone, get a consultation.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

12. Never give two diagnoses when you can find one that explains everything.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

13. Follow-up everything.

- ◯ Never/almost never
- ◯ Rarely
- ◯ Sometimes
- ◯ Often
- ◯ Always/almost always

-----Original Message-----
From: "Sanna Salanterä" [mailto:sansala@utu.fi]
Sent: Tuesday, 15 July 2008 7:36 a.m.
To: Pirret, Alison
Subject: Re: Decision making instrument

>Dear Alison Pierret, We are happy to share our instrument. I will send it to you by email in the near future. I don't have it with me right now. We have also made a shorter version of the instrument which has been validated in perioperative care environment and it seems to have a stronger power. This study has not been reporterd yet (just finished data collection). I will send you both instruments to look at.

>Sanna Salanterä
professor of Clinical Nursing Science
Department of Nursing Science
20014 University of Turku
FINLAND

----- Original Message -----
From: "Pirret, Alison" <A.M.Pirret@massey.ac.nz>
Date: Friday, July 11, 2008 7:02 am
Subject: Decision making instrument
To: "sanna.salantera@utu.fi" <sanna.salantera@utu.fi>

Dear Dr Salantera,

I have recently read you 1995 decision making model paper and I am
very interested in your decision making instrument that you used to identify the decision making models used by Finnish nurses and public health nurses. I am currently designing a research using multiple methods to look at Nurse Practitioner decision making and would be very keen to view your instrument to see if it could be used. Would you be willing to share your instrument with me and allow me to use it as a method in my research?

I look forward to hearing from you.

Kind Regards
Alison Pirret

Appendix F. Intuitive/analytic Items Instrument Coding

Intuitive items	Code	Analytic items	Code
Collecting data			
I assess all information collected in advance against my own knowledge.	103	I collect as much information in advance as possible from the patient's records.	101
I fill in my picture of first impressions by seeking information about the patient that deviates from the information collected in advance.	104	On the basis of my information collected in advance, I specify all the items I intend to monitor and ask the patient about.	102
I collect a lot of information about the patient's views of his/her condition and health.	109	I confirm my first impressions by looking for clear symptoms that support those impressions.	105
I try to keep all the information collected in advance in my mind.	110	I ask the patient whether I have made the right interpretations about the information collected in advance concerning him/her.	106
I always rely on my own interpretations when it comes to identifying diagnoses and/or problems.	111	I collect the same information for all patients on admission.	107
I make assumptions about forthcoming diagnoses and/or problems during the first contact with the patient.	112	I collect a lot of information about the patient's symptoms and complaints.	108
I acquire additional information to confirm my own assumptions of the patient's situation.	113		

It is easy for me to make a distinction between important and unimportant information in identifying the patient's diagnoses and/or problems.	**114**		
Identifying diagnoses and problems			
I compare the information I have received with the medical or nursing model I have created on the basis of my own experience.	203	I compare the information I have received with my earlier knowledge of similar individual patients.	201
It is easy for me to see, even without closer analysis, which pieces of information are relevant to identifying the patient's diagnoses and/or problems.	208	I compare the information I have received with my earlier knowledge of patient behavior in different life situations.	202
It is easy for me to recognize the importance of the patient's subjective experiences in identifying his/her diagnoses and/or problems.	209	I compare the information I have received with medical knowledge about patient's disease and its symptoms.	204
I organize the information I have received into blocks for easier identification of diagnoses and/or problems.	210	I compare the information I have received with the medical or nursing models I have learned.	205
It is easy for me to form an overall picture of the patient's situation and major diagnoses and/or problems.	213	I compare the information I have received with my own knowledge about diagnoses and problems.	206
		I carefully analyze the information I have received before identifying the patient's diagnoses and/or problems.	207

		I define the patient's diagnoses and/or problems objectively on the basis of the symptoms and complaints observed.	211
		I check with my colleagues that I have made right conclusions about the patient's diagnoses and/or problems.	212
		I draw on diagnostic reasoning or nursing process thinking to define the patient's diagnoses and/or problems.	214
Planning care			
It is easy for me to get the patient to take part in the planning.	303	I use the plan for the patient's medical treatment as a frame of reference.	301
I focus more on the future and on the patient's chances to pull through rather than on current medical or nursing needs.	304	I aim in my planning to resolve the current situation.	302
I use the patient's own views on his/her care and treatment as the frame of reference for my planning.	305	I base my medical or nursing plans on the regimes prescribed for the patient's disease.	306
I base my medical or nursing plans on my own experiences of the treatment of similar patients.	307	I set out targets for medicine or nursing that are easy to measure.	309
I have no difficulty in outlining the plan of care in the patient's clinical notes.	308	I tend to emphasize measures of immediate treatment.	310

I have no difficulty in preparing individualized long-term medical or nursing plans.	312	I normally record in the patient's clinical notes according to a diagnostic reasoning or nursing process model.	311
I anticipate the impacts of different medical or nursing measures on the patient.	313		
I rely on information about health to a greater extent than on information about illness.	314		
Implementing the action plan			
It is easy for me to assess the impacts of my actions on the patient's condition and health.	403	I act rationally and consistently even in unexpected situations.	401
I anticipate changes in the patient's situation on the basis of individual cues even before there are any clear symptoms.	404	I follow as closely as possible existing medical or nursing plans for different diseases or situations.	402
I know how to motivate the patient to take care of him/herself and to take self-care responsibility.	405	I follow the patient's individual treatment plan as closely as possible.	407
I know how to motivate the patient's family to take part in the patient's treatment.	406	I use specific information about the treatment of the patient's disease when making medical or nursing decisions.	408
I flexibly change my line of action on the basis of feedback on the patient's situation.	409	I often try to explain my own observations of changes in the patient's condition.	410
I can see changes in the patient's condition, but I am not always able to explain how I know this.	411	I provide guidance to the patient chiefly by informing him/her about the disease and/or problem and its treatment.	413

I have no difficulty in sorting out the priorities in different medical or nursing situations.	412	In providing guidance to the patient I mainly rely on package instructions that are suited to solving this patient's diagnoses and/or problems.	414
I flexibly change my line of action on the basis of feedback on the patient's situation.	409	I often try to explain my own observations of changes in the patient's condition.	410

Appendix G. Permission to Change Intuitive/analytic Reasoning Instrument Wording

-----Original Message-----
From: "Sanna Salanterä (sansala@utu.fi)"
[mailto:sansala@utu.fi]
Sent: Friday, 21 May 2010 5:10 p.m.
To: Pirret, Alison
Subject: Re: updated 56-ITEM INSTRUMENT.rtf

Thank you fro your Email Alison, I fully approve your changes to the 56-item instrument. Your study seems interesting. I am happy that you are getting forward. Please keep me informed about your progress.

ps. my son was an exchange student in New Zealand a few years back. He stayed at Waikanae Beach.
sanna

Sanna Salanterä
Professor of Clinical Nursing Science
Department of Nursing Science
University of Turku
20014 TURUN YLIOPISTO
FINLAND

Pirret, Alison wrote:
Dear Professor Salantera,

I will be using the intuitive/analytic reasoning instrument in phase one of the study. Participants will include nurse practitioners, clinical nurse specialists and registrars (residents). To meet the needs of the 3 groups I have changed the wording slightly in the questionnaire. I have marked the changes in red so they are easily identifiable. Would you please be able to look at the changes and see if I have not changed the intent of the instrument?

I have also attached a short outline of the research for your interest.
(The short outline still contains the original 56-item instrument
without the wording changes).

Many thanks for your time.
Kind Regards

Alison Pirret

Appendix H. Permission to Use Maxims

From: Maurice Bernstein, M.D. [mailto:doktormo@aol.com]

Sent: Sunday, 21 March 2010 5:03 a.m.

To: Pirret@xtra.co.nz

Subject: Re: Permission to use maxims

Alison, I apologize for apparently not responding to your February e-mail. I checked my Saved Mail and your e-mail was present.

I certainly give permission for you to use any of these maxims for your study and would be most interested to read your abstract.

Thanks for checking back with me. Best wishes.. ..Maurice.

Maurice Bernstein, M.D.
Associate Clinical Professor of Medicine
Keck School of Medicine
University of Southern California
"Bioethics Discussion Blog"
http://bioethicsdiscussion.blogspot.com

Appendix I. Demographic Data Sheet

NURSE PRACTITIONER		
University where RN training completed	Name	Place
Year of RN registration	Year of NP registration	
Prescribing Yes No	Year of prescribing authorisation	
Years of experience as RN	Years of experience as NP	
Specialty area		
Years of specialty practice as RN	Years of specialty practice as NP	
Post registration and Academic education levels		
University where Master's degree awarded	Country where Masters degree awards	
REGISTRAR		
Year of registration as a doctor	Years of experience as a HO	
Specialty practice area	Years of specialty practice as a registrar	
Years of experience as a registrar prior to Part 1	Year Part 1 completed	
Years of experience as a registrar post part 1 and prior to Part 2	Year Part 2 completed	
Country Part 1 awarded	Country Part 2 awarded	
Years of experience as a registrar post part 2.	Fellowship at other colleges	
Other specialty exams completed following Part 2.	Year and country completed	

Appendix J. Nurse Practitioners' Areas of Practice

Scope	Number	Authorised to prescribe	Region
Adult Cardiac Care	4	4	Taranaki, Hawkes Bay, Auckland, Manawatu
Adult Chronic Conditions	1	1	Lakes
Adult Elective Perioperative	1	1	Bay of Plenty
Adult / Older Adult	1	1	Hutt Valley
Adult / Older Adult (Renal)	1	1	Hawkes Bay
Cardiology	4	4	Auckland, Waikato
Care of the Elderly	2	1	Auckland, Otago
Child and Adolescent Health	1	1	Auckland
Child / Youth Health	3	3	Manawatu, Canterbury, Auckland
Diabetes and related conditions across the age span	1	1	Manawatu
Emergency Nursing	3	3	Auckland, Hawkes Bay
High Dependency Nursing	2	1	Auckland, Northland
Mental Health	2	0	Waikato, Bay of Plenty
Mental Health / Intellectual Disability	1	1	Otago
Neonatal Care	7	2	Bay of Plenty, Waikato (2), Auckland (4)
Older Adult	6	2	Manawatu (2) Auckland (3), Canterbury
Older Adult Mental Health	1	1	Canterbury
Organ Transplantation	1	1	Auckland
Ophthalmology	1	1	Auckland
Pain Management	2	1	Manawatu, Waikato
Palliative Care (Adult)	4	3	Auckland, Christchurch, Southland, Waikato
Paediatrics	1	1	Auckland
Paediatric, Cardiac Care	1	1	Auckland
Primary Health Care	27	22	Bay of Plenty (2), Otago, Canterbury (3), West Coast (2), Tairawhiti, Northland (2), Auckland (3), Wellington (3), Taranaki (2) Wairarapa, Hawkes Bay(3), Hutt Valley, Manawatu, Southland, Waikato.
Respiratory Nursing	3	3	Manawatu (2), Auckland
Urology	2	2	Hawkes Bay, Auckland
Whanau Ora	1	1	Manawatu
Women's Health	1	0	Auckland
Wound Care	3	0	Manawatu, Waikato, Hawkes Bay

Appendix K. Maori Health Unit Consultation

10/09/2010

Alison Pirret
Nurse Practitioner
Critical Care Complex
Middlemore Hospital

Alison.Pirret@middlemore.co.nz

Re: ***The nature of nurse practitioner diagnostic reasoning (PhD)***

Teenaa koe Alison,

I have discussed your PhD research topic with other members of the CMDHB Maaori Research Review Committee (MRRC). We commend your consultation with Maaori Health to date. We note our feedback regarding the wording used in the abstract 'Nurse practitioners reduce health inequities', has prompted a change in the terminology to 'improving access to health care'. Prior to commencing your study in the CMDHB catchment area, we have provided information required to assist in the formal CMDHB research approval process. This will include contacting the CMDHB Research office for guidance on locality assessment. We will require a completed MRRC application form, NAF, PIS and consent forms to review.

We have appreciated the opportunity to engage with you regarding your research topic for PhD and we look forward to further consultation when you are ready to submit your application.

Kia piki te ora,

Karla Rika-Heke.
(Committee member – CMDHB Maaori Research Review Committee)

NPAC-NZ
The Nurse Practitioner Advisory Committee of New Zealand

C/o P O Box 2128
Wellington

11 June 2010

Alison Pirret
Nurse Practitioner – Critical Care Complex
Middlemore Hospital
Private Bag 93311
Otahuhu
Auckland 1640

Dear Alison

Thank you for your PhD outline. The Nurse Practitioner Advisory Committee of New Zealand has critiqued your outline and would like to commend you on a well written proposal that has tremendous merit in improving the understanding of the Nurse Practitioner diagnostic reasoning process.

We wholeheartedly endorse this project moving forward and are happy to help in any way that is possible. We have no comments with regards to your research methodology or methods and believe these to be sound and appropriate for the topic under study.

We wish you well with your project and as I mentioned, if there is any further assistance or support we can provide please do not hesitate to get back to us.

Yours sincerely

HELEN SNELL
Nurse Practitioner – Diabetes/
Chair of the Nurse Practitioner Advisory Committee

From: Liz Manning [mailto:Liz.Manning@dhbnz.org.nz]
Sent: Tuesday, 25 May 2010 1:26 p.m.
To: 'Alison Pirret'
Subject: RE: Research

Thanks for making contact Alison, its very good to hear about your research and certainly it is an area which will be of interest to the Workforce groups.
At this stage the Workforce group would like to offer support, through me, if you need to access any health networks or groups- the network links across workforce are extensive

In the meantime, I hope your research goes well.

Regards
Liz

Liz Manning
Project Manager *WORKFORCE*
DHBNZ
PO Box 5535

Appendix N. NZNO Consultation

The New Zealand
Nursing Education and Research Foundation
Incorporated under the Charitable Trusts Act 1957

THE NEW ZEALAND NURSING EDUCATION AND RESEARCH FOUNDATION

NEW ZEALAND NURSES ORGANISATION

10913966

Ref: H211.02

14 May 2010

Alison Pirret
3 JILL PLACE
MANUREWA
MANUKAU
2102

Dear Alison

NERF CENTENNIAL SCHOLARSHIP

Your Centennial Scholarship has been reviewed by NERF Centennial review committee. The reviewers were over-whelmed with the calibre of applications.

The NERF Trustees have great pleasure in approving a grant of $10,000 which will contribute towards your cost. The reviewers commented on the importance of your research and felt that your study proposal has the potential to benefit both nurses and the future health of New Zealanders.

The NERF Trustees request that you keep your success confidential until you are presented with this award at the NZNO Annual Conference on the 15 September 2010 in Wellington. Your Travel costs and one nights accommodation will be covered by NERF and Tessa Cate, NERF Administrator, will be contacting you about these arrangements.

Finally may I offer you congratulations on a successful application, we do hope you find this grant of help. Please would you acknowledge NERF in your written work and if you present, we can supply you with the NERF logo to use in your presentation.

It is also requested that a bound copy of your study is lodged in the NZNO library. Your research abstract will be entered onto the NZNO Nursing Research Section, Research database website.

Yours sincerely

pp. Nano Tunnicliffe
Chair of NERF
President NZNO

Head Office
PO Box 2128, Wellington 6140. Phone (04) 499 9533, Fax (04) 382 9993, Website www.nzno.org.nz

From: Susanne Trim [mailto:SusanneT@nzno.org.nz]

Sent: Friday, 11 June 2010 1:36 p.m.

To: Pirret, Alison

Subject: RE: PhD research

That is good to hear and will certainly pave the way.

Enjoy

Susanne

From: Pirret, Alison [mailto:A.M.Pirret@massey.ac.nz]

Sent: Friday, 11 June 2010 1:15 p.m.

To: Susanne Trim

Subject: RE: PhD research

Thanks for your feedback Susanne. Yes I expect the registrars will be the most difficult group but I am going to ask the NPs recruited to recruit a CNS and registrar they work with which may help. Also I am putting together an expert panel that will have 2 professors/associate professors of medicine on it so I am hoping that will provide some assistance. Workforce DHB have also offered assistance into their contact lists so I may need that.

I will wait and see!!!

Regards

Alison

From: Susanne Trim [mailto:SusanneT@nzno.org.nz]

Sent: Friday, 11 June 2010 12:59 p.m.

To: Pirret, Alison

Subject: RE: PhD research

How interesting, Alison. What a wonderful piece of research to be embarking on. Interestingly, in an informal, off the record discussion I had with NCNZ re NP applications which are declined (NZNO has been called on to advise a number of these nurses who have appealed and I have provided that advice) they indicated to me that it often occurred because, during the interview process, the applicants cannot demonstrate a systematic approach to differential diagnosis and clinical reasoning. I am not the best person to comment on research design. The only concern that I see is the ability to recruit 75 registrars.

This may take some time as a number may be unwilling to participate due to collegial views of the NP role encroaching on medicine and an unwillingness to pop their head above the parapet. However, I may be quite erroneous about this.

My very best wishes Alison. An important piece of work.

Warm regards

Susanne

Susanne Trim
Professional Services Manager
New Zealand Nurses' Organisation
PO Box 4102
Christchurch
03 366 0186

From: Pirret, Alison [mailto:A.M.Pirret@massey.ac.nz]

Sent: Friday, 11 June 2010 12:44 p.m.

To: Susanne Trim

Subject: PhD research

Hi Susanne,

Hope all is well with you. You may have already heard but I am doing my PhD research on the nature of nurse practitioner diagnostic reasoning. I am currently engaging with different groups to ensure the study is suitably designed and to gain support for the study. I have received a letter of support from NPAC-NZ and a support email from Liz Manning WORKFORCE DHBNZ. I submitted a successful funding application to NERF so they have reviewed my proposal. However, I know you have historically done a lot of work around NP development in NZ and in your role as Professional Services Manager I wanted to make sure you were aware of the research and give you an opportunity to comment on my design. I have attached an abstract of the research and would be really interested in your comments. If you would like any further information please let me know.

Regards

Alison Pirret

Massey University

Private Bag 102 904

North Shore Mail Centre

Auckland 0745

Phone 09 414 0800 extn 9067

Appendix O. Massey University Ethics Committee Approval

MASSEY UNIVERSITY
ALBANY

10 December 2010

Alison Pirret
c/- Dr S Neville
College of Humanities & Social Sciences
Massey University
Albany

Dear Alison

HUMAN ETHICS APPROVAL APPLICATION – MUHECN 10/079
"Nurse practitioner diagnostic reasoning"

Thank you for your application. It has been fully considered, and approved by the Massey University Human Ethics Committee: Northern.

Approval is for three years. If this project has not been completed within three years from the date of this letter, a reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

Dr Ralph Bathurst
Chair
Human Ethics Committee: Northern

Dr S Neville
College of Humanities & Social Sciences

Te Kunenga ki Pūrehuroa

Research Ethics Office
Private Bag 102 904, Auckland, 0745, New Zealand Telephone +64 9 414 0800 ex 9539 humanethicsnorth@massey.ac.nz

From: Claire_Lindsay@moh.govt.nz
[mailto:Claire_Lindsay@moh.govt.nz]
Sent: Monday, 13 September 2010 10:12
To: Alison Pirret (CMDHB)
Subject: Query

Good morning

Thank you for your phone call.

Your study does not require ethical approval from the Health and Disability Ethics Committees as it meets the exception of clause 11.10, in which ethical approval is not required, this is detailed below. I have also attached the pdf of the guidance document, this clause is found on page 24.

11.10 Extra data collected within a health
or disability support service setting
Exception
Investigator collection of extra data (that is, data
that are not already generated or monitored)
normally triggers a requirement for ethics
committee review.
Ethics committee review is not required for the
collection of non-sensitive data, or an observation
in which participants remain anonymous, when
undertaken by those employed or contracted by
the health or disability support service provider.

Should you have any more queries please do not hesitate to contact me

Kind regards

Claire Lindsay
Ethics Committees
Health and Disability Services Policy
Population Health Directorate

Appendix Q. Participant Information Sheet

MASSEY UNIVERSITY
COLLEGE OF HUMANITIES
AND SOCIAL SCIENCES
TE KURA PŪKENGA TANGATA

Nurse Practitioner Diagnostic Reasoning

NURSE PRACTITIONER INFORMATION SHEET

Hello, my name is Alison Pirret. I am currently completing PhD research at Massey University. My research explores nurse practitioner diagnostic reasoning and compares it to that of registrars. The results of the study will illustrate nurse practitioners' diagnostic reasoning abilities and illuminate their role in future workforce initiatives aimed at best meeting New Zealand's healthcare needs. I would like to invite you to participate in this study.

I am inviting 40 New Zealand registered nurse practitioners (**excluding** neonatal, child, youth health, mental health, and wound, organ transplantation, oncology and urology) and 40 registrars to participate. To enable the results to reflect rural, provincial, metropolitan and multiple specialty areas, I will be asking nurse practitioners willing to participate in the study to invite a registrar they work with to also participate.

The numbers of participants required for this study has been determined following statistical analysis. Excluding the time taken for data collection, there will be no financial costs incurred by you. As a participant you will not receive any payment or reimbursement of expenses. A $20 petrol or book voucher will be given to participants as a thank you gift for participating in the study. There are no expected discomforts or risks to you as a result of participating in this study.

If you agree to take part in the study, there are two aspects to the study. The first part is a web-based questionnaire that can be completed at a time convenient to you. This questionnaire will take approximately 15-20 minutes to complete. The second aspect requires you to complete a demographic data sheet and a computerised case-scenario using think aloud which is expected to take 1.5 – 2 hours to complete. Clear directions on how to do this think aloud case scenario will be provided and you will be offered a "practice run" prior to completing the case scenario for the study. Your verbalisations during the think aloud will be audio-taped. As the same case scenario will be used for all participants, you will be required to sign a confidentiality agreement.

Every endeavor will be made to preserve confidentiality and anonymity. All information collected will be safely stored until completion of both the research and publications pertaining to the research. Once the research and publications are completed, I will take responsibility for destroying all the information.

Once all information has been analysed, an electronic summary of the study will be available and sent to the email address you have provided. There may be a delay between data collection and the publication of the results.

You are under no obligation to accept this invitation. Participation in this research is entirely voluntary. If you decide to participate, you will be required to complete a consent form. You have the right to ask any questions about the study at any time during participation and to decline to answer

Te Kunenga
ki Pūrehuroa

School of Health and Social Services
Private Bag 102904, North Shore City 0745, Auckland, New Zealand
Health Enquiries +64 9 441 8166 **Social Work/Policy Enquiries** +64 9 441 8164 **Fax** +64 9 441 8165 **www.massey.ac.nz**

any particular question. You may ask for the recorder to be turned off at any time during the think aloud case scenario. You may withdraw from the study up until the time of data analysis.

My contact details are

Phone: 09 2677323
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Please contact me or my supervisors if you have any questions about this study.

Conflict of Interest: I am a prescribing nurse practitioner employed by Counties Manukau District Health Board and secretary of Nurse Practitioner New Zealand. To minimise this conflict. the study design has been reviewed and supported by New Zealand Nurse Practitioner Advisory Committee-New Zealand (NPAC-NZ), WORKFORCE DHBNZ, and the study's expert panel. If you have concerns regarding this conflict, please discuss these with me or my supervisors.

This project has been reviewed and approved by the Massey University Human Ethics Committee: Northern, Application 10/079. If you have any concerns about the conduct of this research, please contact Dr Ralph Bathurst, Chair, Massey University Human Ethics Committee: Northern, telephone 09 414 0800 x 9570, email humanethicsnorth@massey.ac.nz.

MASSEY UNIVERSITY
COLLEGE OF HUMANITIES
AND SOCIAL SCIENCES
TE KURA PŪKENGA TANGATA

Nurse Practitioner Diagnostic Reasoning

REGISTRAR INFORMATION SHEET

Hello, my name is Alison Pirret. I am currently completing PhD research at Massey University. My research explores nurse practitioner diagnostic reasoning and compares it to that of registrars. The results of the study will illustrate nurse practitioners' diagnostic reasoning abilities and illuminate their role in future workforce initiatives aimed at best meeting New Zealand's healthcare needs. I would like to invite you to participate in this study.

I am inviting 40 New Zealand registered nurse practitioners (**excluding** neonatal, child, youth health, mental health, and wound, organ transplantation, oncology and urology) and 40 registrars to participate. To enable the results to reflect rural, provincial, metropolitan and multiple specialty areas, I will be asking nurse practitioners willing to participate in the study to invite a registrar they work with to also participate. The registrar data will be used to provide a standard (normative data) against which the performance of nurse practitioners diagnostic reasoning will be compared.

The numbers of participants required for this study has been determined following statistical analysis. Excluding the time taken for data collection, there will be no financial costs incurred by you. As a participant you will not receive any payment or reimbursement of expenses. A $20 petrol or book voucher will be given to participants as a thank you gift for participating in the study. There are no expected discomforts or risks to you as a result of participating in this study.

If you agree to take part in the study, there are two aspects to the study. The first part is a web-based questionnaire that can be completed at a time convenient to you. This questionnaire will take approximately 15-20 minutes to complete. The second aspect requires you to complete a demographic data sheet and a computerised case-scenario using think aloud which is expected to take 1.5 – 2 hours to complete. Clear directions on how to do this think aloud case scenario will be provided and you will be offered a "practice run" prior to completing the case scenario for the study. Your verbalisations during the think aloud will be audio-taped. As the same case scenario will be used for all participants, you will be required to sign a confidentiality agreement.

Every endeavor will be made to preserve confidentiality and anonymity. All information collected will be safely stored until completion of both the research and publications pertaining to the research. Once the research and publications are completed, I will take responsibility for destroying all the information.

Once all information has been analysed, an electronic summary of the study will be available and sent to the email address you have provided. There may be a delay between data collection and the publication of the results.

You are under no obligation to accept this invitation. Participation in this research is entirely voluntary. If you decide to participate, you will be required to complete a consent form. You have the right to ask any questions about the study at any time during participation and to decline to answer

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any particular question. You may ask for the recorder to be turned off at any time during the think aloud case scenario. You may withdraw from the study up until the time of data analysis.

My contact details are

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Appendix R. Participant Consent Form

MASSEY UNIVERSITY
COLLEGE OF HUMANITIES
AND SOCIAL SCIENCES
TE KURA PŪKENGA TANGATA

Nurse Practitioner Diagnostic Reasoning

PARTICIPANT CONSENT FORM

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree/do not agree to the case scenario using think aloud being sound recorded.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signature: ____________________ **Date:** ________

Full Name - printed ____________________

Page 1 of 1

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Appendix S. Elstein et al's. (1993) Coding Schemes

Rules for Coding Process Constructs

1. *Formulates working diagnostic hypothesis.*
   Subject arrives at a diagnostic hypothesis involving a disease entity of medical condition. This construct is scored for every unique diagnostic hypothesis that is given. Do not score if a subject repeats a diagnostic hypothesis given in a previous section.
2. *Confirms or strengthens diagnostic hypothesis using new information.*
   Score when subject retains, confirms, or strengthens hypothesis using vignette information. Simply repeating a previously mentioned diagnostic hypothesis is not enough to score here. The subject must say why or clearly be using vignette material to retain or confirm the hypothesis.
3. *Rejects or weakens diagnostic hypothesis using new information.*
   Score if subject rejects or weakens a hypothesis using find or rules out a diagnosis based on finding presents in a segment. A subject may reject a hypothesis without explicitly proposing it. When this happens, go back and score it as a diagnostic hypothesis and indicate that it was never explicitly hypothesized by writing "rejects" by it. A subject also may reject a proposed hypothesis in the same segment and may prose and reject virtually at the same time.
4. *Multiple-cue inference.*
   Score when the subject draws conclusions about diagnosis, prognosis, or treatment on the basis of multiple cues. These cues may be information given in the vignette or information generated by the subject. The cue must be fairly explicit. An exception to the explicit-cues rule occurs when the subject says this is a “classic” case or example. When a subject gives multiple inferences embedded in one sentence, score each instance
5. *Single cue inference.*
   Score when the subject draws conclusion about diagnosis, prognosis, or treatment on the basis of a single cue. This cue may be information given in the vignette or information generated by the subject.

Score also when the subject adds one more piece of information to a clinical picture and makes an inference. That is, the clinical picture may contain numerous cues, but the subject explicitly picks one piece of information and adds it, resulting in the subject's final inference.

Rules for Coding Knowledge Utilization

1. *Do not draw inference across sentences*
   If a diagnosis is drawn on the basis of symptoms mentioned in an immediately preceding separate sentence, it should be coded "diagnosis" not "finding to diagnosis." But if such sentences begin with connectives such as "therefore" they should get relational codings.
2. *Draw inferences across segments within the same sentence.*
   That is, if, for example, a diagnosis is drawn on the basis of a symptom mentioned in a preceding segment of the same sentence, it should be coded "symptom to diagnosis." This holds even when there is no tell-tale word such as "so" or "therefore," so long as the diagnosis seems clearly to have been elicited by the symptoms mentioned.
3. *Use "Context" to code statements about nonmedical facts about the patient.*
   E.g. the patient's age, job history, living conditions, normal bodily statistics, daily activities and nonmedical events prior to admission. Normal bodily statistics of any every day sort are context; abnormal are findings. E.g. weight is context, overweight is a finding.
4. *Use "Finding" to code statements about medical history and direct physical examination.*
   Include testimony of the patient or the patient's friends, family, etc.
5. *Use "Test" to code statement based on laboratory tests or special diagnostic procedures.*
   E.g. x-rays, blood cultures, sputum culture, CT scan. "Test" refers only to direct test results; code inference from test results as "diagnosis" (see rule 6).
6. *Use "Diagnosis" to code any statement about the possible underlying pathophysiology or cause of the problem.*
   Not just for statements about diseases.
7. *Use "Treatment" to code statements about therapy and management.*

When treatment information is used to make diagnostic inference, code as “Treatment to Diagnosis”

8. *Use “Other” to code “Same” and “I don’t know,” as well as the following:*
    a. General programmatic or procedure statements.
    b. B. Nonmedical or metacognitive statements

9. *Follow relational order given in the sentence syntax to determine code order unless the reasoning goes clearly the other way*.

10. *Procedural or goal statements that name categories with filling them should be codes as though the categories were filled.*

11. *Assign two codings to segments that seem to combine more than two basic categories in a way that cannot be resolved by further segmentation.*

12. *Use relational category of the for “C” to “C” in two ways:*
    a. To code segments in which information in one basic category leads to other information from the same category, as when one symptom leads to consideration of another
    b. To code segments in which information in one basic category leads to an elaboration of that information, as when a diagnosis leads to consideration of a complication that could result from that diagnosis.

Appendix T. Observation Protocol

- PARTICIPANT APPRECIATION GIFT
- Sign informed consent
- Sign confidentiality agreement
- Test each participant in a private office.
- Practice session
- One hour allocated for think aloud (excluding practice run)
- Data is presented in segments
- Participants can choose segments and may go backwards and forwards
- Turn audiotape on
- Participants are asked to choose segments in order reflecting their normal practice – order of segment choice is recorded by SBL programme
- Ask participant to think aloud as they open each segment - request participant to verbalise their thoughts about the role and importance of information in each segment in reaching a correct diagnosis.
- If the participant is quiet, prompt the participant to think aloud- verbalise as above.
- Provide a summary of the case and articulate final diagnosis and problems and action plan.
- Ask if there was any data participant liked to collect but was not provided in any of the segments.
- Ask how did this case scenario reflect participant's normal daily practice?

Appendix U. Case Scenario Coding Sheet

DIAGNOSES			
(WD)	**Working Diagnoses (WD)**		
1	a) Pneumonia b) LRTI c) bronchitis	35	TB
2	LLL consolidation	36	Pneumothorax
3	Pleural effusion	37	Musculo-skeletal pain
4	a) Exacerbation COPD b) infective exacerbation of COPD	38	Bronchiectasis
5	COPD	39	Asthma
6	Ca lung	40	OSA
7	PE	41	Gall stones
8	CHF	42	Bowel obstruction
9	MI/Ischaemic event	43	Dehydration
10	Poorly controlled HTN	44	Fractured rib
11	a) AAA b) aortic dissection/rupture	45	Gastro paresis secondary to diabetes
12	Gastric ulcer	46	DVT
13	Gastric bleeding	47	Gastrointestinal lesion
14	Gastritis	48	Empyema
15	Ca bowel/gut	49	DIC
16	Poorly controlled diabetes	50	Bowel perforation
18	Renal failure/impairment	51	Hypoglycaemia
19	UTI	52	Haemophilus influenza
20	Anaemia	53	Pericarditis
21	Constipation	54	Viral type illness
22	Controlled hyperlipidaemia	55	Acute abdomen
23	Chest infection	56	Hypoglycaemia

24	Reasonably controlled Type II diabetes	57	Discitis/osteomylelitis
25	Mild hyponatraemia		
26	Poorly controlled hyperlipidaemia		
28	Atelectasis		
29	Iron deficiency anaemia		
30	Pleurisy		
31	Cardiomegaly		
32	Right sided heart failure		
33	IHD		
34	LVF		
PLAN OF CARE			
(P)	**PLAN (P)**		
1	Arrange translator		
2	Sputum spec a) culture b) AFB		
3	D/w GP/consultant	33	Monitor BSLs/Diet
4	a) Change antibiotic b) macrolide c) augmentin d) macrolide & augmentin e)macrolide and cefuroxime f) add macrolide to amoxicillin g) continue same AB	34	Bronchodilators/ COPD inhalers
5	Iron studies	35	Review/increase simvastatin
6	a) Educate pt around diabetes b) Diabetes referral c) both	39	Analgesia
7	Educate family	40	Ask does he do BSLs & results
8	a)Stop aspirin X2 b) stop 1 aspirin non enteric c) stop one aspirin	41	Omeprazole/PPI
9	Stop diclofenac		

10	D/w pharmacist what he's getting	43	Laxatives/suppositories/enema
11	Test H-pylori	44	Investigate pain
		45	Repeat CXR 6 weeks
13	Admit/refer hospital/specialist review	46	Explore hx of taking meds with pt
14	Iron replacement	47	Refer GP
15	a)spirometry b) resp service review c) both d) Investigate COPD	48	
16	Endoscopy/gastro referral	49	Steroids
17	Gastroscopy	50	Explore presenting symptoms and each system in more depth
18	Colonoscopy	51	Ask previous occupation
19	Blood product replacement	52	a)review 1-2 days b)F/U 2 wks
20	Faeces occult blood	53	
21	Abdominal x-ray	54	D-dimer
22	Get x-ray reviewed	55	a) Check abdominal bruits b) carotid bruits
23	a) Antihypertensive b) monitor BP c) both	56	Assess fullness rectum
24	BNP	57	IV/xmatch
		58	CT gut/colonography
26	Troponin	59	a) CT chest b) CTPA
27	a)ECG single b) serial c)review	60	Walk test
28	More past medical hx/blood test hx etc, previous weight, previous BP, ECGs, CXRs, previous service involvement on file	61	Sleep screening/snoring
29	Actual weight	62	Review dietary intake

31	D/W pt why not taking insulin	63	Pulmonary rehab/physio referral
32	Restart insulin	64	D/w radiologist CXR
		65	TFTs
68	Ask if taken paracetamol recently	66	Explore constipation
69	Check dental health	67	a) Investigate understanding of diabetes b) investigate families understanding
70	a) Repeat bloods daily b) repeat bloods 1 week		
71	Prednisone		
72	Explore resp symptoms more fully		
73	ENT assessment		
74	Opthalmology/retinal screening review		
75	Echworth scale		
76	Encourage mobilisation		
77	Teaching coughing, expectorating techniques		
78			
79	Explore social need, social support requirements, financial assistance		
80	Explore housing/overcrowding		
81	Investigate hx of fall/elder abuse		
82	Encourage fluids		
83	Check for faecal impaction		
84	Check affordability for new		

	script		
85	Educate pt re medications		
86	Fasting lipids		
88	Educate to achieve compliance	109	U/S a)chest b) abdomen
89	O/T physio assessment for home	110	Fasting glucose
91	Review mobility	111	ECHO
92	Nutritional advice	112	Blood culture
93	O2 sats on exercise	113	FBC-MCV
94	Lying/standing BP	114	Anal tone
96	Home visit/environment assessment	115	DVT prophylaxis
97	Monitor weight	116	Pleural tap cytology/culture
98	Check feet	118	WELL score
99	Medopac		
100	Ask if been overseas recently		
101	Cultural support		
102	Blood cultures		
103	NPM		
104	Check BSL		
105	ABG		
106	If fresh bleeding, educate re seeking medical advice/hospital		
107	Check radial pulses equal		
108	Bilateral BP		

Problem (Pr)			
1	? Care burden	9	Pleuritic pain
3	Disease knowledge deficit/self management	10	? Inability to self medicate 2° to eyesight
4	Inaccurate hx secondary to language and daughter translating		N.B. C1 and P4 same
5	Pain		
6	Respiratory problem		
7	Gastrointestinal problem		
8	Non compliant with meds		
3	Disease knowledge deficit		

Appendix V. Case Scenario Coding Sheet for Quantitised Data

Comfortable with xray
Rejects resp diagnosis for COPD after CXR report

Reflects practice

Part No

D	Time to D (mins)	Wd	Time to WD (mins)	RD	Time to RD (mins)	C/S D	Time to C/S D	MCI	SCI	F -D	S-D	Probs	Nos WD on expert panel list	Nos problems on expert panel list	Plan	Nos plan on expert panel list	Tests	Findings	Treatment to Diagnoses	O statements	Context	Extra info
		total																				

Time to completion of diagnoses plan of care

Appendix W. Intuitive/analytic Instrument Coding

Collecting	Almost/ Always	Often	Sometimes	Rarely	Never/almost never
q3 - 1 - 101	5 = 1	4=2	3=3	2 = 4	1 = 5
q4 - 2 - 102	5 = 1	4=2	3=3	2 = 4	1 = 5
q5 - 3 - 103	5	4	3	2	1
q6 - 4 -104	5	4	3	2	1
q7 - 5 - 105	5 = 1	4=2	3=3	2 = 4	1 = 5
q8 - 6 -106	5 = 1	4=2	3=3	2 = 4	1 = 5
q9 - 7 -107	5 = 1	4=2	3=3	2 = 4	1 = 5
q10 - 8 - 108	5 = 1	4=2	3=3	2 = 4	1 = 5
q11 - 9 - 109	5	4	3	2	1
q12 - 10 -110	5	4	3	2	1
q13 -11 - 111	5	4	3	2	1
q14 - 12 - 112	5	4	3	2	1
q15 - 13 - 113	5	4	3	2	1
q 16 - 14 - 114	5	4	3	2	1

Handling	Almost/always	Often	Sometimes	Rarely	Never/almost never
q17 - 1 - 201	5	4	3	2	1
q18 - 2 - 202	5 = 1	4=2	3=3	2 = 4	1 = 5
q19 - 3 - 203	5 = 1	4=2	3=3	2 = 4	1 = 5
q20 - 4 - 204	5	4	3	2	1
q21 - 5 - 205	5 = 1	4=2	3=3	2 = 4	1 = 5
q22 - 6 - 206	5 = 1	4=2	3=3	2 = 4	1 = 5
q23 - 7 - 207	5 = 1	4=2	3=3	2 = 4	1 = 5
q24 - 8 - 208	5 = 1	4=2	3=3	2 = 4	1 = 5
q25 - 9 - 209	5	4	3	2	1
q26 - 10 - 210	5	4	3	2	1
q27 -11 - 211	5	4	3	2	1
q28 - 12 -212	5 = 1	4=2	3=3	2 = 4	1 = 5

q29 - 13 - 213	5 = 1	4=2	3=3	2 = 4	1 = 5
q 30 - 14 - 214	5	4	3	2	1

Planning	**Almost/always**	**Often**	**Sometimes**	**Rarely**	**Never/almost never**
q31 - 1 - 301	5 = 1	4=2	3=3	2 = 4	1 = 5
q32 - 2 - 302	5 = 1	4=2	3=3	2 = 4	1 = 5
q33 - 3 - 303	5 = 1	4=2	3=3	2 = 4	1 = 5
q34 - 4 - 304	5	4	3	2	1
q35 - 5 - 305	5	4	3	2	1
q36 - 6 - 306	5	4	3	2	1
q37 - 7 - 307	5 = 1	4=2	3=3	2 = 4	1 = 5
q38 - 8 - 308	5	4	3	2	1
q39 - 9 - 309	5	4	3	2	1
q40 - 10 - 310	5 = 1	4=2	3=3	2 = 4	1 = 5
q41 -11 - 311	5 = 1	4=2	3=3	2 = 4	1 = 5
q42 - 12 - 312	5 = 1	4=2	3=3	2 = 4	1 = 5
q43 - 13 -313	5	4	3	2	1
q 44 - 14 - 314	5	4	3	2	1

Implementing	**Almost/always**	**Often**	**Sometimes**	**Rarely**	**Never/almost never**
q45 - 1 - 401	5 = 1	4=2	3=3	2 = 4	1 = 5
q46 - 2 - 402	5 = 1	4=2	3=3	2 = 4	1 = 5
q47 - 3 - 403	5	4	3	2	1
q48 - 4 - 404	5	4	3	2	1
q49 - 5 0 405	5	4	3	2	1
q50 - 6 - 406	5	4	3	2	1
q51 - 7 - 407	5 = 1	4=2	3=3	2 = 4	1 = 5
q52 - 8 - 408	5	4	3	2	1
q53 - 9 - 409	5	4	3	2	1
q54 - 10 - 410	5 = 1	4=2	3=3	2 = 4	1 = 5

q55 -11 - 411	5	4	3	2	1
q56 - 12 - 412	5	4	3	2	1
q57 - 13 - 413	5 = 1	4=2	3=3	2 = 4	1 = 5
q 58 - 14 - 414	5 = 1	4=2	3=3	2 = 4	1 = 5

Appendix X. Factors Influencing Nurse Practitioners' Ability to Identify Correct Diagnoses

Factor	Statistical test	Significance
Gender	Independent *t*-test	$t(28)=.15$, $p=.89$
RN training site	Kruskal-Wallis	χ^2 (6, n=30)=7.99, p=.24
Master's training site	Kruskal-Wallis	χ^2 (4, n=30)=4.02, p=.40
Prescribing	Mann-Whitney U	U=19, z=-1.52, p=.13
Type of master's degree	Mann-Whitney U	U=10, z=-.53, p=.60
Specialty area	Kruskal-Wallis	χ^2 (5, n=30)=7.5, p=.19
Types of post-registration programmes	Kruskal-Wallis	χ^2 (15, n=30)=12.60, p=.63
Years RN experience	Spearman's rho	r_s=-.19, n=30, p=.30
NP years experience	Spearman's rho	r_s=.25, n=30, p=.19
Years NZ NP experience	Spearman's rho	r_s=.33, n=30, p=.08
NP years of NZ prescribing	Spearman's rho	r_s=.37, n=30, p=.04*
NP years of previous prescribing	Spearman's rho	r_s=-.09, n=30, p=.65
Years of RN specialty	Spearman's rho	r_s=-.09, n=30, p=.66
NZ NP years of specialty	Spearman's rho	r_s=.28, n=30, p=.13
Number of post registration programmes	Spearman's rho	r_s=.22, n=30, p=.25

Note. RN=registered nurse, NP=nurse practitioner, NZ=New Zealand, *indicates statistical significance.

Appendix Y. Other Diagnoses Identified by Participants

	Nurse practitioner frequency (percent) *n*=30	**Registrar frequency (percent) *n*=16**
Anaemia	29 (96.67)	16 (100.00)
Hyponatraemia	13 (43.33)	7 (43.75)
Bowel cancer	13 (43.33)	7 (43.75)
Constipation	14 (46.67)	7 (43.75)
Poorly controlled type II diabetes	12 (40.00)	8 (50.00)
Cardiomegaly	10 (33.33)	1 (6.25)
Chest infection	9 (30.00)	1 (6.25)
Renal failure	9 (30.00)	3 (18.75)
Exacerbation of COPD	8 (26.67)	2 (12.50)
Consolidation	8 (26.67)	9 (56.25)
Myocardial infarction	7 (23.33)	5 (31.25)
Gastritis	3 (10.00)	0
Pleurisy	4 (13.33)	0
Musculoskeletal pain	4 (13.33)	2 (12.50)
Congestive heart failure	3 (10.00)	1 (6.25)
Iron deficiency anaemia	3 (10.00)	5 (31.25)
Atelectasis	3 (10.00)	1 (6.25)
Fractured ribs from fall or elder abuse	2 (6.67)	0
Obstructive sleep apnoea	2 (6.67)	0
Bowel obstruction	2 (6.67)	3 (18.75)
Poor lipid control	2 (6.67)	2 (12.50)
Abdominal aortic aneurysm	2 (6.67)	2 (12.50)
Urinary tract infection	1 (3.33)	0
Gastrointestinal lesion	1 (3.33)	0
Right sided heart failure	1 (3.33)	0
Left ventricular failure	1 (3.33)	0
Infective exacerbation of COPD	1 (3.33)	3 (18.75)
Dehydration	1 (3.33)	0
Gastroparesis	1 (3.33)	0
Hypoglycaemia	1 (3.33)	0
Gall stones	1 (3.33)	0
Empyema	0	1 (6.25)
Bowel perforation	0	1 (6.25)
Discitis/osteomylelitis	0	1 (6.25)
Tuberculosis	0	4 (25.00)

Appendix Z Factors Influencing Nurse Practitioners' Identification of the Patient Problem Identified by the Expert Panel

Factor	**Statistical test**	**Significance**
Gender	Fisher's exact test	*FET* p=.59
RN training site	Kruskal-Wallis	χ^2 (6, n=30)=5.21, p=.52
Master's training site	Kruskal-Wallis	χ^2 (4, n=30)=3.12, p=.54
Prescribing	Fisher's exact test	*FET* p=1.0
Type of master's degree	Fisher's exact test	*FET* p=1.0
Specialty area	Kruskal-Wallis	χ^2 (5, n=30)=2.93, p=.71
Types of post-registration programmes	Kruskal-Wallis	χ^2 (15, n=30)=13.90, p=.53
Years RN experience	Spearman's rho	r_s=.21, n=30, p=.26
NP years experience	Spearman's rho	r_s=.08, n=30, p=.69
Years NZ NP experience	Spearman's rho	r_s=.04, n=30, p=.82
NP years of NZ prescribing	Spearman's rho	r_s=-.02, n=30, p=.92
NP years of previous prescribing	Spearman's rho	r_s=-.03, n=30, p=.89
Years of RN specialty	Spearman's rho	r_s=.51, n=30, p=.004*
NZ NP years of specialty	Spearman's rho	r_s=.07, n=30, p=.70
Number of post registration programmes	Spearman's rho	r_s=.37, n=30, p=.05

Note. RN=registered nurse, NP=nurse practitioner, NZ=New Zealand.

Appendix AA. Factors Influencing Nurse Practitioners' Correct Actions

Factor	**Statistical test**	**Significance**
Gender	Mann-Whitney U	U=23.5, z=-1.19, p=.24
RN training site	Kruskal-Wallis	χ^2 (6, n=30)=10.46, p=.11
Master's training site	Kruskal-Wallis	χ^2 (4, n=30)=4.11, p=.39
Prescribing	Mann-Whitney U	U=39.0, z=-.11, p=.92
Type of master's degree	Kruskal-Wallis	χ^2 (1, n=30)=.09, p=.77
Nurse practitioner specialty area	Kruskal-Wallis	χ^2 (5, n=30)=6.11, p=.30
Years RN experience	Spearman's rho	r_s=.33, n=30, p=.08
NP years experience	Spearman's rho	r_s=-.05, n=30, p=.79
Years NZ NP experience	Spearman's rho	r_s=.01, n=30, p=.94
NP years of NZ prescribing	Spearman's rho	r_s=-.01, n=30, p=.97
NP years of previous prescribing	Spearman's rho	r_s=-.2, n=30, p=.30
Years of RN specialty	Spearman's rho	r_s=.14, n=30, p=.47
NZ NP years of specialty	Spearman's rho	r_s=.05, n=30, p=.78
Number of post registration programmes	Spearman's rho	r_s=.24, n=30, p=.20

Note. RN=registered nurse, NP=nurse practitioner, NZ=New Zealand.

Appendix BB. More Common Actions Identified by Participants

Action plan	**Nurse practitioner frequency (percent) *n*=30**	**Registrar frequency (percent) *n*=16**
Discuss patient with consultant	22 (73.33)	1 (6.25)
Investigate pain and why on analgesics †	16 (53.33)	4 (25.0)
Obtain more history	14 (46.67)	6 (37.50)
Endoscopy/ gastroenterology referral	11 (36.67)	1 (6.25)
Explore history of taking medications with patient †	10 (33.33)	5 (31.25)
Faecal occult bloods	9 (30.00)	2 (12.50)
Bronchodilators/COPD inhalers	9 (30.00)	3 (18.75)
Discuss/refer patient back to GP	9 (30.00)	1 (6.25)
Arrange translator †	7 (23.33)	2 (12.50)
Get x-ray reviewed by medical colleague	7 (23.33)	0
Abdominal x-ray	7 (23.33)	5 (31.25)
Serum troponin	6 (20.00)	3 (18.75)
Get x-ray reviewed	7 (23.33)	0
Colonoscopy	3 (10.00)	8 (50.00)
Iron studies	2 (6.67)	5 (31.25)

Note. † indicates actions to address problems

Appendix CC. Less Common Actions Identified by Participants

Action plans	**Nurse practitioner frequency (percent) *n*=30**	**Registrar frequency (percent) *n*=16**
Analgesia †	5 (16.67)	3 (18.75)
Repeat ECG	4 (13.33)	4 (25.00)
Discuss with patient why not taking insulin †	4 (13.33)	2 (12.50)
Monitor BSLs and diet	4 (13.33)	2 (12.50)
Explore respiratory symptoms in more depth	4 (13.33)	0
Investigate patient's and family's understanding of DM †	4 (13.33)	1 (6.25)
Explore social/financial need †	3 (10.00)	1 (6.25)
Review patient again in 24-48 hours	3 (10.00)	3 (18.75)
Discuss with pharmacist what medications patient is getting †	3 (10.00)	0
Repeat chest x-ray 6 weeks	3 (10.00)	5 (31.25)
Ask patient if takes BSLs and check results	3 (10.00)	0
Explore constipation	3 (10.00)	1 (6.25)
Review dietary intake	3 (10.00)	0
Serum brain natriuretic peptide	3 (10.00)	0
Actual patient weight	2 (6.67)	0
Iron replacement	2 (6.67)	1 (6.25)
Restart insulin	2 (6.67)	0
Rectal digital examination	2 (6.67)	0
Sleep screening/snoring review	2 (6.67)	0
Pulmonary rehab/physio	2 (6.67)	1 (6.25)
Ophthalmology screening	2 (6.67)	1 (6.25)
Encourage mobilisation	2 (6.67)	0
Explore housing/overcrowding †	2 (6.67)	0
Explore history of fall/elder abuse	2 (6.67)	0
Review mobility †	2 (6.67)	0

Explore each symptom in more depth	2 (6.67)	0
Check abdominal bruits	1 (3.33)	0
Repeat bloods	1 (3.33)	2 (12.50)
Blood transfusion	1 (3.33)	0
Review/increase simvastatin	1 (3.33)	0
Check affordability of prescription †	1 (3.33)	0
Previous occupation	1 (3.33)	0
Discuss x-ray with radiologist	1 (3.33)	1 (6.25)
Ask if taken paracetamol recently	1 (3.33)	0
Prednisone	1 (3.33)	1 (6.25)
ENT assessment	1 (3.33)	0
Check affordability of prescription †	1 (3.33)	0
Ask if taken paracetamol recently	1 (3.33)	0
Previous occupation	1 (3.33)	0
Encourage fluids	1 (3.33)	0
Fasting lipids	1 (3.33)	0
Educate to achieve compliance †	1 (3.33)	0
OT/home assessment †	1 (3.33)	0
Nutritional advice	1 (3.33)	0
Oxygen saturations on exercise	1 (3.33)	0
Lying & standing BP	1 (3.33)	0
Home visit assessment †	1 (3.33)	0
Monitor weight	1 (3.33)	0
Assess feet	1 (3.33)	0
Medopac †	1 (3.33)	0
Ask if been overseas recently	1 (3.33)	1 (6.25)
Check blood sugar glucose	1 (3.33)	1 (6.25)
Repeat bloods in 24-48hrs	1 (3.33)	2 (12.50)
Assess carotid bruits	0	1 (6.25)
Cultural support †	0	1 (6.25)
Blood culture	0	2 (12.50)
Nil per mouth	0	1 (6.25)
Arterial blood gas	0	2 (12.50)

Note. †indicates actions to address problems.

Appendix DD. Factors Influencing Nurse Practitioners' Intuitive/analytic Reasoning Scores

Factor	**Statistical test**	**Significance**
Gender	Mann-Whitney U	U=40, z=-.04, p=.97
RN training site	Kruskal-Wallis	χ^2 (6, n=30)=3.11, p=.80
Master's training site	Kruskal-Wallis	χ^2 (4, n=30)=1.01, p=.91
Prescribing	Mann-Whitney U	U=23, z=-1.21, p=.23
Type of master's degree	Independent *t*-test	U=7.5, z=-.81, p=.42
Specialty area	Kruskal-Wallis	χ^2 (5, n=30)=3.27, p=.66
Types of post-registration programmes	Kruskal-Wallis	χ^2 (15, n=30)=21.37, p=.13
Years RN experience	Spearman's rho	r_s=-.22, n=30, p=.24
NP years experience	Spearman's rho	r_s=.04, n=30, p=.82
Years NZ NP experience	Spearman's rho	r_s=.06, n=30, p=.75
Years of NZ NP prescribing	Spearman's rho	r_s=.19, n=30, p=.33
NP years of previous prescribing	Spearman's rho	r_s=-.13, n=30, p=.50
Years RN specialty	Spearman's rho	r_s=-.09, n=30, p=.64
NZ NP years of specialty	Spearman's rho	r_s=.12, n=30, p=.54
Number of post registration programmes	Spearman's rho	r_s=-.25, n=30, p=.18

Note. RN=registered nurse, NP=nurse practitioner, NZ=New Zealand.

Appendix EE. Frequency of Maxims Participants Use to Guide Diagnostic Reasoning

When facing competing diagnoses, favour the simplest one	**Nurse practitioner Frequency (percent)**	**Registrar Frequency (percent)**
Never/almost never	8 (26.77)	2 (12.50)
Rarely	9 (30.00)	1 (6.25)
Sometimes	12 (40.00)	5 (31.25)
Often	1 (3.33)	8 (50.00)
Always/almost always	0	0

If you don't know what to do, don't do anything.	**Nurse practitioner Frequency (percent)**	**Registrar Frequency (percent)**
Never/almost never	21 (70.00)	4 (25.00)
Rarely	6 (20.00)	7 (43.75)
Sometimes	0	3 (18.75)
Often	2 (6.67)	1 (6.25)
Always/almost always	1 (3.33)	1 (6.25)

Consider multiple separate diseases of a patient when the result of the history and physical examination are atypical for any one condition.	Nurse practitioner Frequency (percent)	Registrar Frequency (percent)
Never/almost never	0	0
Rarely	0	2 (12.50)
Sometimes	5 (16.67)	6 (37.50)
Often	14 (46.67)	6 (37.50)
Always/almost always	11(36.67)	2 (12.50)

Common things occur commonly	Nurse practitioner Frequency (percent)	Registrar Frequency (percent)
Never/almost never	0	0
Rarely	1 (3.33)	0
Sometimes	8 (26.67)	0
Often	18 (60.00)	9 (56.25)
Always/almost always	3 (10.00)	7 (43.75)

All bleeding eventually stops	Nurse practitioner Frequency (percent)	Registrar Frequency (percent)
Never/almost never	8 (26.67)	6 (37.50)
Rarely	3 (10.00)	5 (31.25)
Sometimes	11 (36.67)	3 (18.75)
Often	1 (3.33)	0
Always/almost always	7 (23.33)	2 (12.50)

All drugs work by poisoning some aspect of normal physiology	Nurse practitioner Frequency (percent)	Registrar Frequency (percent)
Never/almost never	5 (16.67)	3 (18.75)
Rarely	6 (20.00)	4 (25.00)
Sometimes	8 (26.67)	5 (31.25)
Often	6 (20.00)	1 (6.25)
Always/almost always	5 (16.67)	3 (18.75)

Don’t order a test unless you know what you will do with the results	Nurse practitioner Frequency (percent)	Registrar Frequency (percent)
Never/almost never	3 (10.00)	0
Rarely	0	0
Sometimes	3 (10.00)	0
Often	6 (20.00)	6 (37.50)
Always/almost always	18 (60.00)	10 (62.50)

If what you are doing is working, keep doing it. If what you are doing is not working, stop doing it	Nurse practitioner Frequency (percent)	Registrar Frequency (percent)
Never/almost never	0	0
Rarely	0	0
Sometimes	3 (10.00)	3 (18.75)
Often	13 (43.33)	11 (68.75)
Always/almost always	14 (46.67)	2 (12.50)

Real disease declares itself	Nurse practitioner Frequency (percent)	Registrar Frequency (percent)
Never/almost never	0	1 (6.25)
Rarely	6 (20.00)	0
Sometimes	15 (50.00)	6 (37.50)
Often	7 (23.33)	7 (43.75)
Always/almost always	2 (6.67)	2 (12.50)

Treat the patient not the x-ray	Nurse practitioner Frequency (percent)	Registrar Frequency (percent)
Never/almost never	1 (3.33)	0
Rarely	0	1 (6.25)
Sometimes	4 (13.33)	1 (6.25)
Often	7 (23.33)	7 (43.75)
Always/almost always	18 (60.00)	7 (43.75)

Never worry alone, get a consultation	Nurse practitioner Frequency (percent)	Registrar Frequency (percent)
Never/almost never	0	0
Rarely	0	0
Sometimes	2 (6.67)	2 (12.50)
Often	4 (13.33)	4 (25.00)
Always/almost always	24 (80.00)	10 (62.50)

Never give two diagnoses when you can find one that explains everything	Nurse practitioner Frequency (percent)	Registrar Frequency (percent)
Never/almost never	4 (13.33)	0
Rarely	10 (33.33)	1 (6.26)
Sometimes	6 (20.00)	8 (50.00)
Often	8 (26.67)	5 (31.25)
Always/almost always	2 (6.67)	2 (12.50)

Follow-up everything	Nurse practitioner Frequency (percent)	Registrar Frequency (percent)
Never/almost never	0	1 (6.25)
Rarely	1 (3.33)	0
Sometimes	2 (6.67)	3 (18.75)
Often	9 (30.00)	5 (31.25)
Always/almost always	18 (60.00)	7 (43.75)

Appendix FF. Factors Influencing Nurse Practitioners' Frequently Used Maxims

Factor	**Statistical test**	**Significance**
RN training site	Kruskal-Wallis	χ^2 (6, n=30)=4.86, p=.56
Master's training site	Kruskal-Wallis	χ^2 (4, n=30)=3.67, p=.45
Prescribing	Mann-Whitney U	U=36.5, z=-.28, p=.78
Type of master's degree	Independent t-test	U=6.5, z=-.95, p=.34
Specialty area	Kruskal-Wallis	χ^2 (5, n=30)=4.93, p=.43
Types of post-registration programmes	Kruskal-Wallis	χ^2 (15, n=30)=14.37, p=.50
Years RN experience	Spearman's rho	r_s=.15, n=30, p=.44
NP years experience	Spearman's rho	r_s=.24, n=30, p=.20
Years NZ NP experience	Spearman's rho	r_s=.32, n=30, p=.08
NP years of NZ prescribing	Spearman's rho	r_s=.14, n=30, p=.46
NP years of previous prescribing	Spearman's rho	r_s=-.12, n=30, p=.52
Years of RN specialty	Spearman's rho	r_s=-.17, n=30, p=.36
NZ NP years of specialty	Spearman's rho	r_s=.33, n=30, p=.07
Number of post registration programmes	Spearman's rho	r_s=-.16, n=30, p=.41

Note. RN=registered nurse, NP=nurse practitioner, NZ=New Zealand.

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