Title: An International Comparison of Student Nurse Practitioner Diagnostic Reasoning Skills

Introduction

There is a worldwide shortage of healthcare providers including a significant lack of trained personnel to provide healthcare to the population (Maier et al., 2017). While explanations differ by country, some of the reasons for these shortages include an aging population and increasing rates of chronic diseases (Laurant et al., 2018; Maier et al., 2017). Advanced nursing roles including that of the Nurse Practitioner (NP) have been developed to meet the increasing demands in healthcare and fill gaps in healthcare systems (Heale & Buckley, 2015). It is well recognized that NPs provide equivalent, or superior levels of care to physicians with improved outcomes and patient satisfaction (Martínez-González et al., 2014; Horrocks et al., 2002; Laurant et al., 2018; Martin-Misener et al. 2015; Poghosyan et al., 2017).

Nurse Practitioners are "educated to diagnose and treat conditions based on evidence-informed guidelines that include nursing principles'" with a focus on holistic care (International Council of Nurses, 2020, p. 18). They are registered nurses with advanced clinical skills who should be educated to a master's degree level (International Council of Nurses 2020, Ljungbeck et al., 2021). NPs practice at an advanced and expanded level which is shaped by the context and/or country in which they are credentialed to practice (International Council of Nurses, 2020).

Diagnostic reasoning is an important competency for NPs to develop during their education program (Burt & Corbridge, 2018; Lawson, 2018; National Organization of Nurse Practitioner Faculties, 2017). There is a lack of consensus in the literature defining diagnostic reasoning with many studies using the term informally, without providing a definition (Brentnall et al., 2022; Lawson, 2018). There are also multiple terms used within the literature including

diagnostic reasoning, critical thinking, decision making, clinical judgment and diagnostic reasoning (Brentnall et al., 2022). However, Young et al. (2018 p 990) described the clinical process of diagnostic reasoning where the "professional engages in clinical reasoning—by gathering and synthesizing information; generating hypotheses; and formulating a clinical impression, prognosis, diagnosis, treatment, care, and/or management plan" which is the approach taught to most NP students globally. There is also little information identifying how student NPs develop diagnostic reasoning (Lawson, 2018). Diagnostic reasoning is a key skill used by all clinicians, including NPs, to accurately diagnose and treat patients, improving patient outcomes and reducing errors (Balogh et al., 2015; Burt & Corbridge, 2018). We use the term diagnostic reasoning within this paper, based on the Youngs definition.

NP education often includes an emphasis on the NP clinical role and becoming an autonomous provider (Ljungbeck et al., 2021). The autonomous role requires scientific and clinical knowledge, which the NP uses during diagnostic reasoning (de Bruin et al., 2005; Golabchi et al., 2022). The scientific knowledge required by an NP includes physiology, pharmacology, and pathophysiology (Burman et al., 2009; Gardner et al., 2006; Ljungbeck et al., 2021). The clinical knowledge is gained during simulated clinical encounters and precepted clinical experiences, enabling the NP to use the advanced knowledge in diagnostic reasoning (de Bruin et al., 2005; Golabchi et al., 2022; Sharrock et al., 2013). According to Ljungbeck et al. (2021) being able to independently manage patients includes a focus on health promotion and disease prevention integrating medically oriented content. Competency in research, evidence-based practice, and leadership are also considered important topics for NP students to develop skill in throughout their education and when working as an NP post-graduation (AACN, 2021, Health Education England 2017).

One way of assessing the student's diagnostic reasoning skills is by using simulation (Lafleur et al., 2015). Objective Structured Clinical Exams (OSCE) have been used in medical programs since the 1970s, and increasingly in NP programs (Hickey, 2021; May et al., 2009). The use of OSCE generally involves the use of a standardized or simulated patient (SP) who is a person trained to portray a patient in realistic and reliable ways (Kowitlawakul et al., 2015; Lewis et al., 2017). The SP may be a paid actor, theatre major, faculty member or fellow student who has been trained to present a specific scenario to the student (Hart & Chilcote, 2016; Phillippi et al., 2013). OSCEs have been used to evaluate competency in both formative and summative evaluations, focused on communication, physical exam skills, diagnostic reasoning and disease management (Lafleur et al., 2015; Lavery, 2022; May et al., 2009).

Aim and Objectives:

The aim of this study was to compare the diagnostic reasoning skills of NP students and NP Program Curricula in 12 countries.

The objectives of the study were:

1) To compare diagnostic reasoning skills of a sample of international NP students.
2) To identify variability of clinical teaching components of a sample of international NP curricula.

Methods:

A mixed methods online survey collected data from NP students and NP Program faculty during year one of their education in twelve countries between 2020 and 2021. Data collection dates varied depending on when the NP program started. The STROBE criteria were applied and followed for this study.

Ethical Considerations

Ethical approval was given by the University of Huddersfield ethics panel in January 2020 SREIC/2019/079. Study information was sent to both students and faculty, consent was obtained prior to completion of the survey via accepting consent in Qualtrics®. The information also included a sentence regarding protection of survey data that would be collected and stored securely with password protection on a server in the UK.

Data Collection:

Emails were sent out to 20 NP program leads or faculty representative of the 6 World Health Organization regions (Africa, the Americas, South-East Asia, Europe, Eastern Mediterranean and Western Pacific) by the research team through the international council of Nursing, Advanced Practice Network (ICN NP/APN network) with an invitation to participate in the study. Nurse practitioner program faculty from 12 countries including Australia, Canada, Chile, England, Eswatini, Finland, Hungary, New Zealand, Saudi Arabia, Singapore, the Netherlands, and USA agreed to participate in this study. A single program participated from each country. The survey was launched online using the Qualtrics® (2022) online survey tool, a cloud-based survey tool. Program leads or faculty received links to both the faculty and student surveys. The program faculty circulated the invitation to participate in this study to their first year NP students. The student invitation included an anonymous link to access the survey in English, Spanish or Hungarian. The student surveys included the Diagnostic Thinking Inventory (DTI) and demographic data about the student. Once the survey was accessed, the person could not re-enter it or send it to someone else. The survey was distributed in 2020 and 2021. Response rate varied with the lowest being from Singapore (5) and the highest being from the Netherlands (42) with no student participants in Hungary. Participation was voluntary.

The program faculty or a course lead completed the survey which asked for data regarding the NP program, clinical placements, number of students, education requirements on entry, graduation degree, curriculum, and use of simulation in assessments. Qualitative data regarding the program curriculum were obtained.

Diagnostic Thinking Inventory

This international study utilized the validated Diagnostic Thinking Inventory to evaluate diagnostic reasoning skills of student NPs during the first year of their studies in twelve countries. Students often utilize hypothetico-deductive reasoning (HDR), while experienced health care clinicians use case pattern recognition (CPR) when assessing patients (Bordage et al., 1990; Kicklighter et al., 2016), but there is a dearth of studies evaluating the performance diagnostic reasoning skills in Nurse Practitioner The validated Diagnostic Thinking Inventory (DTI) was used with permission to assess NP students' diagnostic reasoning skills (Bordage et al., 1990, email correspondence November 11, 2020). The DTI has been found to be a valid and reliable tool in research with medical residents, physicians, physiotherapists, athletic training, dental and NP students to identify their level of diagnostic reasoning (Bordage et al., 1990; Jones, 1997; (LaBreacht King, 2006); Kicklighter et al., 2016; Keshmeri et al., 202; Rogers & Steinke, 2022).

The students completed the Diagnostic Thinking Inventory (DTI), which is designed to measure the “degree of flexibility in thinking and the degree of knowledge structure in memory”, two aspects of diagnostic thinking (Bordage et al., 1990, p. 413). Flexibility uses the clinician’s knowledge, based on prior memorization, while at the same time the clinician remains responsive to the patient's answers, setting aside the predetermined questions and instead following up on the information provided, even when it differs from the expected (Bordage et al.,

1990). Structure in knowledge "refers to the availability of knowledge, stored in memory, during the diagnostic process." (Bordage et al., 1990, p. 416).

This DTI survey (Appendix 1) consists of 41 questions, each with a stem, and a 6-point semantic-differential type scale (Bordage et al 1990). The marking schedule for scoring the answers was detailed as 23 of the items were reversed, meaning that 23 of the items were weighted from left to right (6 points - 1 point), and 18 weighted from right to left, (1point - 6 points) (Bordage et al 1990; Open University Centre for Education in Medicine 1991). Twenty-one items reflected flexibility in thinking (FT), and twenty items reflected knowledge structure in memory (KSM). For example, question number two is considered a 'flexibility' question (scored left to right on the likert scale): "in considering each diagnosis, I try to evaluate their relative importance" versus "I try to give them equal importance or weighting." An example of a 'structure in memory' item is question number 7 (scored right to left on the likert scale): "Once the patient has clearly presented his symptoms and signs, I think about them in my mind in the patient's own words" versus I translate them in my mind into medical terms (e.g. 'numbness' becomes 'paraesthesia' or 'paralysis'). Overall reliability of the survey was 0.83; and 0.72 and 0.74 for the flexibility and structure categories respectively (Bordage et al.1990).

Appendix 1 Diagnostic Thinking Inventory: Here please

Data Analysis

Quantitative data obtained from the DTI were analyzed using Qualtrics® (2022) analysis tools and Bordage's et al scoring criteria (Open University Centre for Education in Medicine 1991).

Analysis of 162 completed surveys included means, ranges and reliability for total DTI scores, flexibility in thinking scores and structure of memory scores. Faculty data were analyzed manually.

Results:

Student DTI data was obtained from 11 countries and NP curriculum data was obtained from 12 countries during year 1 of the NP education. The survey was also sent to students from a program in Hungary, but no responses were returned. Faculty said that the reason for this was that Hungarian students currently do not have a clinical practicum and no NP jobs are available on qualification, the students therefore felt they did not have the clinical knowledge to respond to the survey. Core curricula and the timing and type of clinical practicums and assessments were examined in each NP program.

Student Responses:

162 survey respondents from 11 schools completed the DTI survey from an online survey. 27 faculty responses were collected. The number of responses from student participants of each country varied widely (Table 1). 3 student responses were removed as they had responded using the same number for each of the questions. The overall reliability of the survey was 0.77; and FT subscale of 0.65 and KSM subscale of 0.57. Reliability has previously been 0.82 overall with KSM 0.76 and FT 0.65 previously found in NP students and practicing NPs (LaBreacht King, 2006). Bordage et al. (1990) original alpha was 0.83 for the overall DTI, with a KSM 0.74 and 0.72 for FT subscale. The maximum score for the DTI is 246, the NP students (n=152) obtained a mean of 142, a mean FIT subscale score of 73 and KSM score of 69.

Table 1 Range of Responses from the NP Student Survey: Here please

Forty-four percent of respondents were under the age of 35, 33% were between the ages of 35 to 44 years old, 21% were between the ages of 45 to 54 years old, and 2% were between the ages of 55 to 64 years old. Eighty-five percent identified as female. Seventy-four percent had a bachelor's degree, and 18% had a masters when they entered their APRN program. The duration of the NP program averaged 2.29 years with the longest program lasting up to 5 years. Over 94% of the graduates completed a master's degree, with US respondents graduating with a Doctor of Nursing practice.

The number of NP student responses on the DTI varied widely from country to country with 0 responses (Hungary) to 42 (the Netherlands). Figure 1 illustrates the breakdown between scores of flexibility in learning and structure of memory for each country, as well as total mean distributions.

Figure 1 Mean DTI, FIT and MSK subscale scores based on country here please

F*aculty Responses:*

There were 27 faculty responses. Multiple responses from several countries were received as some faculty had responsibility for the full program curricula and some for the clinical teaching. All responses were reviewed to identify the similarities and differences. Three responses were removed as they were incomplete. The faculty respondents had been teaching for between 2 and 20 years, most had a nursing background and on average had worked for 11 years in clinical practice (range 1-22 years of experience). Two thirds of the respondents indicated they are required to maintain clinical practice to teach.

Of the countries who responded, the majority (66%) of NP programs were generic, allowing graduates to care for patients across the lifespan in both acute and primary care settings. Eswatini and Singapore include both pediatrics and adult education but did not mention specific clinical placements for their students. Canada and the United States provide focused education with graduates being restricted by their certification, for example Family NP providing care across the lifespan in a primary care setting, or Psychiatric Mental Health NP graduates, who focus on patients with a mental health presentation, across the lifespan, in both acute and primary care settings. Most of the countries surveyed, apart from New Zealand and Australia, require students to have a bachelor's degree to apply for the NP program. All responding students finish the NP program with a master's degree, apart from the respondents from the United States where students graduated with a Doctor of Nursing Practice. Master's degree NP programs remain available in the 50 states and D.C, in 2021 there were nearly 400 DNP programs in the U.S (AACN, 2022). NP students in New Zealand and Australia are required to have an additional graduate certificate, beyond their bachelor's degree, to enter the NP program. A different approach to advanced practice education occurs in England where allied health professionals with a bachelor's degree can apply to join advanced practice programs (which have the same curricula as NPs programs) and graduate with the title "Advanced Clinical Practitioner" for example, pharmacists, paramedics and occupational therapists.

Seven (58%) of the country's programs lasted between 18-24 months, 3 (27%) were over 24 months. Four (25%) of the programs, allowed students to enter on either a part or full-time basis. However, programs in Hungary, Singapore and Saudi Arabia are full-time programs, with New Zealand, England, Eswatini, Finland and the Netherlands offering part-time programs. Seven (58%) of the programs enrolled at least 50 students.

From the course information provided classes appear to be similar in content within the countries surveyed for example health assessment, pathophysiology, pharmacology, diagnosis and management, research, evidence- based practice, and education were common to all NP programs. Additional classes offered in some programs included epidemiology and population health, advanced diagnostic reasoning, business of Advanced Practice Nursing, ethics, family and community assessment, health promotion, innovation of NP practice, internationalization, introduction to advanced practice concepts, evidence-based practice, capstone and final year dissertations (Figure 2).

Figure 2: Classes offered in NP Programs here please

Other*: Epidemiology and population health, advanced diagnostic reasoning, business of Advanced Practice Nursing, ethics, family and community assessment, health promotion, innovation of NP practice, internationalization, introduction to advanced practice concepts

Clinical hours vary widely with Finland not requiring students to complete any additional clinical hours. Most programs, however, required between 500 to 950 clinical hours during the program. In contrast the Netherlands required over 2,000 hours. New Zealand requires 4 years of experience, with 500 advanced practice hours and Australia 300 supernumerary hours, and a total of 5000 hours prior to endorsement by the regulatory body.

Over 90% of the programs utilized objective structured clinical exams with their students, 40% use paid actors, the rest use a mixture of family and/or friends, students, or mannequins for the student experience.

Discussion:

Diagnostic Reasoning

The Diagnostic Thinking Inventory developed by Bordage et al (1990 p 413) was designed to "measure two aspects of diagnostic thinking: the degree of flexibility in thinking and the degree of knowledge structure in memory" whilst comparing medical students with more experienced physicians. They found that there was "a clear demarcation in the mean scores of the clinical students and those of the remaining seven groups of subjects" (Bordage et al 1990 p. 419). The more experienced participants in the study had higher scores reflected in their diagnostic thinking scores as well as the KSM and FIT subscales. The higher scores reflect the participants level of experience and expertise in diagnostic thinking. The DTI has previously been used with athletic training, physiotherapists, NP students and with practicing NPs (Jones, 1997; Kicklighter et al., 2016; LaBreacht King, 2006; Rogers & Steinke, 2022).

In Bordage et al (1990) original study groups had thirty subjects. In this global study of 12 countries' NP programs, student numbers varied, however England, New Zealand, The Netherlands, and the USA had over 20 participating students each. However, most of the countries had less than 15 participants. This limits comparison between the obtained scores as the highest result for the DTI was from Finland with a single participant, with the lower total DTI scores from countries with higher participant levels.

Table 2 An overview of DTI mean scores of students and providers progression in ascending order

The NP students' scores when compared to Bordage et al. (1990) group comparisons fell below that of the first-year medical of 153 (total), 79 (FIT) and 74 (KSM). They mean scores are similar to the findings of Rogers and Steinke (2022). The KSM reflects the student's ability to

use available knowledge during the diagnostic process. The majority of participants in this study are nurses, they are beginning their graduate program and lack advanced knowledge required to practice as an APRN, which may be reflected in their low scores. A strong foundation in the sciences including biomedical knowledge may benefit the students diagnostic reasoning (Diemers et al., 2015). Similar to medical students, research shows the progression of an NPs knowledge structure in memory as they gain further education and progress through their program (see table 2). Flexibility in thinking was consistent amongst the NP students and first year medical residents (Bordage et al., 1990; LaBreacht King, 2006; Rogers & Steinke, 2022). FIT reflects the student's knowledge and ability to follow a patient's lead during the interview process. The students in this study had not completed clinical hours at this time, which may be reflected in their low scores as clinical hours have been found to be an important aspect in the development of diagnostic reasoning (Goss et al., 2011).

Courses

The countries participating in this study met the standard for education identified by the International Council of Nursing (ICN) (International Council of Nurses, 2020), entry requirements were a bachelor's degree and on completion most (94%) of the students obtained a master's degree. The ICN (2020) advanced practice nurse guidelines stipulate that master's level programs need to be specifically geared towards developing NP skills. While NPs education has expanded their scope-of-practice, each country regulates clinical practice and role autonomy (Maier et al., 2017).

A strong biomedical science knowledge is an important foundation for diagnostic reasoning (Dickinson et al., 2020) to provide understanding of pathophysiological processes

linking patient presenting symptoms to patterns of disease and the formulation of differential diagnoses in the diagnostic process. The NP programs in this study included biomedical science courses advanced physiology, pharmacology and pathophysiology within their curriculum, which is concordant with other studies (Bergström & Lindh, 2018; International Council of Nurses, 2020; Ljungbeck et al., 2021). Several programs identified anatomy although this does not appear consistent across programs.

Building on a biomedical science foundation is done with clinical courses including diagnosis and management, clinical practice, physical assessment, and advanced diagnostic reasoning. These courses included in NP education may prepare students for clinical practice. Clinical encounters provide students with the opportunity to develop their flexibility in thinking skills as they respond to a patient rather than follow a preidentified plan (Bordage et al., 1990). Clinical encounters with standardized patients or during clinical rotations provide an opportunity to strengthen diagnostic thinking skills.

Clinical hours

Nurse practitioner student clinical observation for instruction and evaluation, can be achieved using workplace-based assessment, which for NP students is achieved while completing their clinical hours (Norcini & Burch, 2007), or during OSCE (Hickey, 2021). As proposed by Durning et al. (2013, 2016), the integration of practice factors into the decision-making process should be considered in the evaluation of diagnostic reasoning amongst clinicians. Clinical hours and supervision are key components for NP students to gain 'real world' experience to develop competence and develop their professional identity as a qualified NP. The use of a clinical supervisor provides an opportunity for students' to "reflect on and

review their practice, discuss individual cases in depth, change or modify their practice … and review professional standards" (Care Quality Commission, 2013, p. 3), hence developing their diagnostic reasoning skills. Clinical supervision has been found to be a valuable tool for NP students (Gloster et al., 2020; Wilson & Taylor, 2019).

Clinical hour requirements in this study are very similar to the findings of Beauchesne et al. (2020). For instance, Finland did not require any clinical hours, while the majority of programs required 500-950 hours. All of the programs required students to work with a clinical supervisor or preceptor. All of the respondents with the exception of Saudi Arabia and Singapore indicated that the students were supervised individually. Clinical education for NPs usually involves working alongside a preceptor who provides direct supervision (Fitzgerald et al., 2012). Two respondents from Saudi Arabia and Singapore, indicated that clinical supervision is completed in groups, while this is uncommon in graduate nursing education, it is more commonly used in undergraduate programs (Ownby et al., 2012). The use of groups provides support for the students; however, they may spend more time waiting for the supervisor in contrast to precepted students who were more likely to be required to plan or evaluate patient care, important skills in a graduate program (Sadeh, 2018). There is a paucity of research on the potential use of group supervision to facilitate diagnostic reasoning in graduate education, a vital skill for the NP role.

Education

Graduation with a master's degree is associated with increased leadership skills, confidence providing a solid educational and professional foundation for advanced practice (Chau et al., 2022). The programs in this study had similar courses to Ljungbeck et al. (2021)

scoping review of NP education. This apparent consistency in education level amongst countries may alleviate some of the confusion experienced by health care team members as they begin working with NPs, by reassuring them about the current standards of NP education. Two thirds (66%) of the countries surveyed provided a generic education allowing graduates to provide care for patients across the lifespan in both acute and primary care settings. Canada and the United States, in contrast, restrict graduates based on education and certification. To reduce confusion, protect the public and standardize the Advanced Practice Registered Nurse (APRN) role in the United States, the *Consensus Model* was developed in 2008. The *Consensus Model* is a single regulatory framework that "defines the APRN in terms of graduate level preparation and successful completion of a national certification exam" (Rounds et al., 2013. p. 181). An NP in the United States may take any one of a number of certification exams based on their education track e.g. Family, Pediatric, or Psychiatric-Mental Health Nurse Practitioner. Certification exams are required to be legally defensible, based on national competencies that are focused on the APRN role and population focus and be accredited by a national certification accrediting organization (Rounds et al., 2013.). The International Council of Nurses (2020) guidelines call for a common understanding of the advanced practice nurse education, regulation and nursing practice, while recognizing the dynamic nature of the role within a global community seeking to promote consistency and clarity within the advanced practice nurse role and education (ICN, 2020). Consistency across education is an important factor in ensuring that NPs are able to provide the assessment, diagnosis and management of patients in all settings and all countries.

Limitations

For the DTI analysis we were unable to perform any correlational or causative analysis due to the varied number of responses from each country. Only one country, The Netherlands, had more

than 30 responses from students, whilst New Zealand, England and USA had 23, 24, and 28 responses respectively and the rest were 15 or less. Overall, the means of each country for flexibility and memory on the DTI were similar with the exception for two countries: Saudi Arabia and Singapore. The difference could be due to the timing of some of the core classes prior to the clinical rotation, language, or cultural interpretation of the questions. According to Bordage et al. (1990, p 416), "the inventory could be used in two contexts, either in reference to one's general mode of diagnostic thinking or in reference to a particular patient interview". However, Dr. Bordage (email correspondence November 11, 2021) recommends the DTI should be used as an assessment of the individual student's diagnostic reasoning skills at different points of the clinical experience. Therefore, use of this tool would be most appropriate immediately after and in direct relation to specific cases for debriefing purposes and perhaps in conjunction with a simulation tool such as the OSCE and/or standardized patients. This study presents the findings of NP diagnostic reasoning in semester one of their NP programs. One could argue that the DTI tool focuses mainly on measuring developmental components of diagnostic reasoning such as critical thinking and memory structures. For practitioners, like NP students, it may be of value to develop a DTI subscale or tool to measure applied diagnostic reasoning, perhaps in a vignette or case study style.

The majority of programs enrolled over 50 students, responses to the survey may have been limited due to the Covid-19 pandemic which caused widespread global chaos and demands on all health care clinicians, including NP students. The study was to have students complete the survey at the end of their program, due to the poor response and COVID-19 pandemic only a single survey took place.

Conclusions

We reported in this paper our international study which examined NP students' diagnostic reasoning skills. The findings suggest that most pedagogical structures for NP programs from the countries surveyed were similar and included the use of patient simulation in teaching and assessment by experienced educators with a clinical background Overall, the Nurse Practitioner courses prepared students for future roles as competent healthcare providers and critical thinkers. However, some aspects including topics taught, clinical practicums, mandated clinical hours and clinical supervision varied between countries which may have impacted the Diagnostic Thinking Inventory scores. There is a scarcity of tools to assess NP student's diagnostic reasoning skills, and these may need to be developed to further strengthen this study's findings.

Implications

Diagnostic reasoning skills are core to NP practice and key to ensuring patient safety. The findings of this study imply that particular attention needs to be paid to the provision of dedicated clinical hours, including supervised clinical practice experiences and OCSEs to assess NP students' development of diagnostic reasoning throughout the program. Core topics should be covered prior to clinical in order to maximize the students' learning experience. Further research is recommended to understand the development of diagnostic reasoning skills.

Figure 1 Mean DTI, FIT and MSK subscale scores based on country

Figure 2: Classes included in the NP course/program

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