INTRODUCTION

The International Council of Nurses (ICN) define Nurse Practitioners (NPs) as "autonomous clinicians who are able to diagnose and treat conditions based on evidence-informed guidelines" (ICN 2019, 2002; Schober et al., 2020, p26). They are registered nurses who have attained a full master's degree in advanced practice. Their clinical practice is "determined by, and sensitive to the context of the country or setting and the regulatory policies in which the NP practices" (Schober et al 2020, p18). The United Kingdom and United States of America both have established Nurse Practitioner curricula, training NP students to work at high levels of advanced practice (Maier, Aiken & Busse, 2017). Both countries promote the optimal scope of the role and recognise the value to the healthcare workforce. NPs continue to transform healthcare provision in the UK and USA with comparable diagnostic reasoning skills and similar patient outcomes to colleagues in the medical profession (Horrocks, Anderson & Salisbury, 2002; Laurant et al., 2005; McCleery et al., 2014; Pirret et al., 2015). They have also received positive feedback from the community in the form of increased patient satisfaction (Mundinger, Kane & Lenz, 2000; Stanik-Hutt et al., 2013).

Advanced Practice Nurse (APN) roles, especially NP roles continue to develop globally with the majority of developed countries offering education at master's level (Schober, 2016; Schober et al., 2020), though in the USA the move is towards doctoral studies. There is variability of curricula due to country context, although the core elements are often consistent with a focus on theory and clinical practice application. One important component of advanced practice programme outcomes is the development of the

student's diagnostic reasoning skills. Diagnostic reasoning is a critically important aspect of the NP role, though there is a paucity of literature on this topic relative to advanced nursing practice (Burt & Corbridge, 2018; Lawson, 2018). Kicklighter, et al. (2016) identify that this cognitive process involves clinical decision-making based upon hypothetico-deductive reasoning and pattern recognition. They suggest experts rely more on pattern recognition, whilst novices tend to practice within the hypothetico-deductive reasoning approach. For instance, an experienced nurse practitioner may quickly and subconsciously diagnose appendicitis based on his or her biomedical knowledge and experience whilst a novice will be more systematic, using a symptom-to-symptom approach and display less flexibility in thinking by ignoring signs he or she is not familiar with, or do not fit with the preconceived diagnosis (Kicklighter et al., 2016).

Pattern recognition is an element of critical thinking taught in nursing programmes and is considered an important component of nursing intuitive judgement (Benner & Tanner 1987, p. 24). These authors built upon Dreyfus & Dreyfus' (1986) work of intuitive judgement characteristics: pattern recognition, similarity recognition, commonsense understanding, skilled know-how, sense of salience, and deliberative rationality. They examined how nurses make a complex assessment of a patient's response to illness. For instance, they posited that pattern recognition is more than an analytical reasoning skill such as a feature-detection system or a template-matching scheme, but the combination of experience and knowledge that an expert nurse develops over the course of time. It is the recognition of "whole patterns" and a sense of salience, knowing what aspects of a situation are more important than others. Bordage et al. (1990, p413-414) maintain that "the variables associated with the hypothetico-deductive

model include data acquisition, hypothesis generation, data interpretation and hypothesis evaluation [while] the knowledge-based model...focuses on the organization and availability of medical knowledge stored in memory as the prime determinant of diagnostic thinking". The novice nurse learned content and skills in nursing school and with experience, clinical judgment. A more experienced and astute nurse is able to communicate effectively with the physician regarding subtle changes in the patient's condition and then efficiently carry out any orders given. Utilising previous knowledge and experiences as a nurse, the NP student learns to recognise patterns, sort out meaningful information, think abstractly and make a good clinical diagnosis.

The ability to develop cognitive skills in diagnostic decision-making is key to preventing diagnostic errors (Walsh, Knight & Lee, 2018). There are several known factors which negatively impact safe and effective diagnostic reasoning which include making a diagnosis without considering the salient cues and making a diagnosis on the basis of being exposed to a condition recently (Mamede et al., 2014). Additionally, minimising information that does not fit the diagnosis, not taking into account epidemiology and accepting a diagnosis if already made by another clinician all impact diagnostic accuracy (Ilgen, Eva & Regehr, 2016; Thammasitboon & Cutrer, 2013; Thompson, 2003). Taking a comprehensive clinical history is paramount to making a diagnosis and having a diagnostic checklist can help improve diagnostic accuracy (Shimizu et al., 2013).

Bordage, Grant & Marsden (1990) developed the Diagnostic Thinking Inventory (DTI) based on previous work on diagnostic thinking and clinical reasoning. They suggested

that the knowledge-based model had replaced the hypothetico-deductive model of medical diagnosis and “focuses on the organisation and availability of medical knowledge stored in memory as the prime determinant of diagnostic thinking” (Bordage, Grant & Marsden,1990, p.414). They used the term ‘forceful features’ to explain relevant pieces of information about the patient that act as a key to certain memory structures which then influence the interpretations made. Flexibility in thinking occurs when the clinician shifts thinking based on new information given by the patient. They suggest that the more astute clinicians have a network of medical knowledge that has developed into abstract relationships in their memory while the weaker diagnosticians function from a simpler model based on signs and symptoms, proceeding symptom-by-symptom to determine the diagnosis. In other words, the experienced diagnostician builds a “global representation” of the patient’s case based on the relational structure of his or her medical knowledge in long-term memory (Bordage, Grant & Marsden,1990). Astute clinicians through translating the signs and symptoms into more abstract relationships further clarify diagnoses. The DTI is grouped into two categories to test flexibility in thinking and evidence for structure in memory. In the Bordage, Grant and Marsden (1990) study, the authors compared the scores of 270 participants who completed the diagnostic reasoning inventory. The participants included medical students from year 1 and year 3 of their studies, hospital Doctors in their first and second posts, senior specialist hospital doctors and General Practitioners and trainees. Comparisons were made between medical students and the more experienced clinicians, and junior and senior clinicians. The intent of their work was to design ways to improve the diagnostic thinking of the weaker or inexperienced diagnosticians and to

incorporate the findings into the medical students' training. The results showed a gradual improvement in scores from medical students to specialists which could reflect the participants' years of training and experience. However, Bordage, Grant & Marsden (1990, p 419) advised that "it would be premature to use the mean scores for each subject group as standards from which to compare individual respondents". They recommended larger numbers of subjects per group to set reference values.

Research related to student NPs is still in its infancy. Few studies have investigated diagnostic reasoning skills of NPs and none have investigated diagnostic reasoning skills of NP students. This study arose after discussion by two members of the core steering group from the International Council of Nurses (ICN) Nurse Practitioner/Advanced Practice Nursing Network (ICN NP/APNN) to facilitate a global exchange and undertake a study of the students' diagnostic reasoning skills.

METHODS

Aim

The aim of the study was to examine and compare diagnostic reasoning skills of two cohorts of students, one from the United Kingdom and one from the United States of America, in their first-year of clinical placement and then again after their final clinical placement. A validated Diagnostic Thinking Inventory was used to ascertain diagnostic reasoning skills for this quantitative study (Bordage, Grant & Marsden,1990).

Design

This study utilised quantitative methodology via the Bristol on-line survey (BSOS, 2018) examining diagnostic reasoning skills between two cohorts of NP students in the United Kingdom (UK) and United States of America (USA) during their first and last clinical placements.

Sample/Participants

Convenience sampling occurred through invitations to participate in the study sent to all students in both student NP cohorts. A total of 22 surveys were accurately completed by NP students at the start of the clinical placement and a total of 19 surveys were accurately completed at the end of the clinical placements. Both sets of surveys were sent to the same group of students. (1 survey was a duplicate in part 1, and 1 survey was only partially completed in part 2). Those 2 surveys were discarded. The recruited student NPs were enrolled in their universities at master's level with the expectation to work as an NP in clinical practice upon graduation. Each of the NP programmes had similar entry criteria and curricula, as well as clinical hours requirements.

Data Collection

The Diagnostic Thinking Inventory by Bordage, Grant & Marsden (Table 1) was "designed to measure two aspects of diagnostic thinking: the degree of flexibility in thinking and the degree of knowledge structure in memory" (Bordage, Grant & Marsden, 1990, p. 413). Overall reliability of their survey was 0.83 (α coefficient for internal consistency) and 0.72 for flexibility in thinking and 0.74 for structural memory (Bordage,

Grant & Marsden,1990, p416). The subjects of the DTI ranged from first-year medical students to post-graduate clinicians.

The DTI is a useful tool to evaluate diagnostic reasoning skills at the early point in training as it can identify weaker clinicians in need of further training (Bordage, Grant & Marsden,1990). In this study, the DTI was used to compare the difference in the Nurse Practitioner students' diagnostic decision-making skills as a novice student clinician just beginning clinical rotations to an advanced student clinician who is at the end of the NP programme. Permission to use the DTI was provided by John Wiley and Sons, publisher, through the Copyright Clearance Center.

The DTI consists of 41 questions, each with a stem, and a 6-point, semantic-differential type scale (Table 1). The scales for half of the items were reversed in terms of the right half answers to reduce a possible right-handed response bias. Twenty-one items reflected flexibility, and twenty items reflected structural memory.

Both the first and second surveys consisted of five demographic questions including age, gender, professional background, years of experience and specialty experience and the 41 questions from the Bordage, Grant & Marsden (1990) DTI. It was launched online using the Bristol Online survey tool (BSOS, 2018), a cloud-based survey tool. The language was English only. All students were sent an anonymous link. Once the survey was accessed, the person could not re-enter it or send it to someone else. The survey (Part 1) was distributed over three months in 2018 and the same survey (Part 2) was distributed over three months a year later in 2019.

Ethical Considerations

Ethical approval was obtained from both university ethics panels. First year students on the MSc Advanced Clinical Practice (ACP) course in a northern town in the United Kingdom and first year students on the MS Family Nurse Practitioner course in a mid-west town in the USA volunteered to participate in the study. The informed consent and study information was sent to both student cohorts with the caveat that if the survey was completed and returned that would constitute agreement to participate. The information also included a sentence regarding the survey data that would be collected and stored securely with password protection on a server in the UK.

Data Analysis

Continuous data and categorical data were summarised using descriptive frequencies and percentages. The Diagnostic Thinking Inventory was scored in accordance with the criteria used by Bordage, Grant & Marsden (1990). Mean scores were compared with Bordage, Grant & Marsden's mean scores of nine groups of subjects (n=270) who varied from medical student to experienced clinician. A paired sample 2-tailed t-test was performed on the flexibility and structural components and the combined scores of the UK students to the USA students between part 1 and part 2 surveys, as well as a comparison of the UK and USA students combined scores between part 1 (the beginning of clinical placements) and part 2 (the last semester of clinical placements). A 95% confidence level was set. Also, a comparison was made between the mean distribution of each individual student of the flexibility and knowledge structure of memory between part 1 and part 2 surveys.

Results

Demographics of the sample

Twenty-three students responded to the survey, 95.5% were nurses. One student was a paramedic undertaking the MSc Advanced Clinical Practitioner course. The majority (87%) were female, most (73.7%) of the respondents were between 34 years old and 41 years old. Approximately 34% had 5-10 years of clinical practice and 43% had 12-15 years of experience post-initial qualification respectively.

NP students placements included: 4 general practice/family practice students (17.4%), 3 (13.04%) students in the emergency department, 2 (8.69%) each in general surgery and medicine, 1 (4.34%) in orthopaedics, and 11 (47.82%) in areas such as women's health, intensive care, ICU, critical care, acute dialysis, cardiology, labour and delivery and care of the elderly.

Survey results

The mean distribution of the NP students were similar to those of the first year medical students in the Bordage, Grant & Marsden (1990) study at the first and final semester clinical marks (Table 2). The mean distributions between the UK & USA students were not significantly different (Table 3). There were no statistically significant differences between scores of the UK and USA students in either the flexibility, structure, or combined scores. There was no significant difference in the mean distributions of the individual student's scores, but the raw scores did indicate some improvements in the second survey of structure of memory.

When comparing the student's individual scores from each country, only the results of the students who completed both surveys accurately were compared. Eight students' scores from the UK and 7 students' scores from the USA were analysed. Since the size of each sample was small, a comparison of mean scores was used. Both the UK (68%) (Figure 1) and USA (71%) (Figure 2) demonstrated an improvement in knowledge structure of memory, but not in flexibility.

DISCUSSION

The role of the Nurse Practitioner/Advanced Practice Nurse exists in over 33 countries in the world (Maier, Aiken & Busse, 2017). Diagnostic reasoning is critical to the role and also to patient safety (Burt & Corbridge, 2018). NP students have had experience in making intuitive judgements of a patient's response to illness as nurses, but not in analytical clinical reasoning with the intent of making an appropriate diagnosis and developing a comprehensive treatment and holistic management plan. Bordage's (2007, 2009) concept of prototypes and semantic qualifiers explains how the clinician thinks in terms of determining diagnoses. He maintains that the concept of prototypes includes learning certain aspects of a disease that the student commits to long-term memory and then recalls when determining a diagnosis.

The results of this study suggest that there was similarity in diagnostic thinking in both the flexibility and knowledge structure of memory categories in the two cohorts of NP students who were educated at the master's level in their own country-specific curricula. Additionally, there was evidence that all the students improved in structure of memory from their first year to their final semester, which could reflect their pedagogy and

clinical experiences. However, the students did not improve in flexibility of thinking. This may be due to lack of clinical experience in internalising their past nursing intuitive experiences and knowledge with the relatively unfamiliar way of analysing disease states clinically through diagnostic thinking and discourse. Benner (1982) studied the progression of nurses' skill set from novice to expert and documented examplars of expert nurses in their ability to holistically understand a patient's response to disease based on experience. Benner & Tanner (1987) include excerpts of conversations with experienced nurses in their phenomenological descriptions of nursing intuition. They suggest that "the better the nurse knows the patient, the greater the possibility of a rich and appropriate sense of salience" (Benner & Tanner, 1987, p. 27).

Between the time of the first survey and the second, the students continued in their studies and clinical placements. In both the UK and USA NP students are expected to attain a minimum of 500 hours of clinical practice at the advanced level (National Organization of Nurse Practitioner Faculty, 2020 & Royal College of Nursing, 2018). By the second survey, each group of students were in their final semester of clinical placements and nearing the required 500 clinical hours. They had gained an additional year's worth of pedagogy as well as more experience with patient consultations taking a history, physically examining their patients and developing management plans under supervision. During this time, they learned to generate hypotheses based on cues and retrieval of knowledge from memory in a safe environment where they could receive feedback from an experienced clinician. The ability to retain knowledge presumably from their studies and experience is reflected in the structure of knowledge in memory high correlation scores, and the lack of improvement in flexibility of thinking may show a

deficit of experience as was seen by Jones' (1997) comparison of scores between student physiotherapists and qualified physiotherapists. Jones (1997, p.8) suggested that "student physiotherapists, although possessing good structure of knowledge in memory, lack flexibility in thinking which may come through experience of managing many patient problems". Whilst the results of this survey indicate that diagnostic reasoning skills for year 1 and final year NP students from two universities in different countries with similar programmes overall were good, it would be more appropriate to use the DTI to evaluate each individual student's response to the tool based on a case the student had encountered. Bordage, Grant & Marden (1990) suggested the DTI could be used individually by students and clinicians to identify their strengths and weaknesses. In an email conversation, Dr. Bordage indicated that "the DTI is an excellent tool for assessing case-specific reasoning and feedback, but not meant as a generic measure of diagnostic reasoning…" (M. Rogers, personal communication 13 June 2020). This tool could be integrated into NP programme curricula as a learning instrument and used in both summative and formative assessments.

Whilst Kicklighter, et al. (2016) suggested that diagnostic reasoning be based upon hypothetico-deductive reasoning and pattern recognition it is clear that NPs need more than data acquisition to safely diagnose their patients. The knowledge-based model which experienced NPs should draw upon relies on the knowledge and experience of the NP to be stored in their memory and utilised as the primary determinant of diagnostic reasoning (Bordage, Grant & Marden, 1990). Students may cling to the idea that pattern recognition will lead to a diagnosis, which could lead to diagnostic error. A combination of pattern recognition and flexibility in thinking may support what Bordage,

Grant & Marsden (1990) identified as the deterministic and responsive modes. This relates to the concept of ‘forceful features’, which triggers the memory structures of a clinician towards their diagnosis. In order to develop flexibility in thinking an NP should be able to listen to the patient, absorb any new information and constantly shift their thoughts regarding a diagnosis. Bordage, Grant & Marsden (1990) suggested that this shift in thinking is shown in the presence of both the deterministic and responsive modes. In the deterministic mode, the NP would ask questions based upon memorised knowledge. Bordage, Grant & Marsden (1990) warn against the clinician being committed to one diagnosis as this inhibits flexibility in thinking and diagnostic reasoning. We propose that a combination of hypothetic-deductive reasoning, clinical experience and the knowledge-based model will develop a more rounded and competent NP. We know that NPs can perform well as clinicians. Several studies have compared diagnostic reasoning skills of NPs and Physicians and found little difference in accurate diagnostic reasoning (Chiffi & Zanotti, 2015; Pirret et al., 2015; Walsh, Knight & Lee, 2018). NPs are often underutilised and undervalued in their jobs (Steinke et al., 2016). Continually improving our knowledge and understanding of the core areas of NPs’ foundation of learning may lead to more recognition of the role and impact on patient care. Diagnostic reasoning is one of these core areas which has a major impact on patient care and safety. Several studies have compared diagnostic reasoning skills of NPs and Physicians and found little difference in accurate diagnostic reasoning (Chiffi & Zanotti, 2015; Pirret et al., 2015; Walsh, Knight & Lee, 2018), but there are few tools available to measure those skills. It is the educator’s task to ensure the NP student learns those skills. Nurse P ractitioners have had many diverse patient-nurse intuitive

experiences as nurses (Benner & Tanner, 1987) and should have the ability to learn to combine those experiences with the analytical aspects of pattern recognition and key features to form holistic and accurate diagnoses.

Study limitations

Limitations of this study include the small number of participants and variability in settings, response bias as the researchers were also the NP programme leaders who taught the students, familiarity with the test questions despite the length of time between tests and the simple form of analysis employed.

CONCLUSION

The use and the evaluation of the DTI tool in regard to the NP students brought to light valuable information regarding what other types of instruments we were using and how we were using them to gauge the student's progress from the beginning to the end of clinical experiences. The students in this study voiced their agreement that simulation was also very helpful in their learning process. We know that for NP students, standardised patient simulation and case studies have been shown to support NPs in developing diagnostic reasoning skills (Burke 2017; Duff, Miller, & Bruce, 2016; Mason & Schuessler, 2018). These approaches enable NP students to hone their critical thinking skills in a supportive environment, which will augment their clinical experiences.

Recommendations from Bordage, Grant & Marsden (1990) research suggested more studies to be done in other clinical areas. Establishing the validity and reliability of the

tool for Nurse Practitioner students is needed. Utlilising the results of the survey could aid in tailoring advanced practice pedagogy to incorporate this tool for evaluation of diagnostic skills. It is not easy to capture how students develop a deeper understanding of the complexities of human discomforts and diseases and how they determine which concern is pertinent to the situation and which is not. The findings in this study were not intended to identify specifically weaker and stronger students, rather to ascertain whether the current pedagogy for NP students in these two countries helped develop their diagnostic reasoning skills. It would be anticipated if we went back a year post qualification to survey the participants with more experience working with different types of clinical presentations and diagnoses that their flexibility in thinking would have improved.

Implications for Advanced Practice Nursing and Health policy

The role of the Nurse Practitioner/Advanced Practice Nurse exists in over 33 countries in the world (Maier, Aiken & Busse, 2017) and numbers of NPs are growing. We know that diagnostic reasoning is a core element of the NP role and without significant skills in this area patient care may be put at risk. The results of this survey indicate that diagnostic reasoning skills for year one and the final year NP students from two universities in different countries with similar programs showed an improvement in score on the DTI at the end of their clinical placements. The findings suggest that the pedagogy for the Nurse Practitioner programmes from the UK and the USA were similar in preparing the students for future roles as competent healthcare providers and critical thinkers. In addition, further exploration into utilising the individual outcomes of the DTI

as an important summative and formative feedback assessment would be helpful for the student and faculty. In addition, when used as a debriefing tool following specific cases, it could strengthen the development of NP students' diagnostic thinking skills.

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