

NURSING KNOWLEDGE OF CATHETER SELECTION

Investigation of Nursing Knowledge of Catheter Selection following the Introduction of a Catheter Decision Support Tool

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Abstract

People living with spinal cord injury or multiple sclerosis are often dependent on some form of catheterisation to manage their urinary incontinence, and this is accompanied by the risk of urinary complications. Nurses' expertise, based on contemporary evidence about catheter types, purposes and risks, is fundamental to the role nurses play in urinary catheter selection, insertion and care with this client group, and more broadly. Catheter selection choice integrity is influenced by clinical nursing expertise and experience, research evidence, client preference, the availability of appropriate equipment and the capacity of both nurses and clients to use the equipment.

Using a quasi-experimental design, this research investigates the extent to which nurses in a speciality context take up and retain complex and technical catheter information to use during catheter selection for clients with neurogenic bladders caused by spinal injury or multiple sclerosis. An education intervention involving a decision support tool is used with pre- and post-intervention testing to determine participant uptake and retention of information. The findings indicate that participants learnt and retained technical information on catheter selection in their practice. However, the findings also indicate that catheter selection knowledge of the registered nurse in this practice context remains a concern, despite improvements detected in catheter selection knowledge following the implementation of tailored education and a decision support tool. Strong correlation was found between uptake and retention of catheter selection knowledge, and overall years of experience as a registered nurse. The evidence also indicates that clinical reasoning and expertise in catheter selection can be quickly learned. The knowledge survey was tested to reveal an intra-class correlation coefficient of 0.89 and a 95% confidence interval of 0.46 to 0.98, thereby indicating extremely

robust test–retest reliability, and establishing the survey as a useful component of future research in this field.

This research is significant because it builds on earlier work by Dobson, Naidu and Johnson (1996) and Fleming, Day and Glanfield (2000), and extends understanding of the support required by nurses in this context for speciality education delivered in ways that meet their learning needs and support practice development. By revealing the effects of knowledge translation on the use of evidence in everyday practice, this study highlights the need for effective assessment and training to aid clinical reasoning and assist in the use of decision support tools and guidelines to facilitate knowledge translation. This is particularly the case in primary care contexts, where specialist nurses provide both episodic and long-term care and practice in relative isolation from other professionals.

Statement of Authorship and Sources

This thesis contains no material published elsewhere or extracted in whole or in part from a thesis by which I have qualified for or been awarded another degree or diploma.

No parts of this thesis have been submitted towards the award of any other degree or diploma in any other tertiary institution.

No other person's work has been used without due acknowledgment in the main text of the thesis.

All research procedures reported in the thesis received the approval of the relevant Ethics/Safety Committees.

Statistical analysis guidance was provided Dr Belinda Butcher and Mr Dale Morrell.

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Contents

Abstract	i
Statement of Authorship and Sources	iii
Acknowledgements	iv
Contents	v
List of Figures	ix
List of Tables	x
Chapter 1: Introduction	1
1.1 Background	1
1.2 Purpose	4
1.3 Context	5
1.3.1 Participant and service overview.	5
1.3.2 Urinary catheter complexities.	7
1.3.3 Knowledge translation.	10
1.4 Study Design	11
1.5 Diagnostic and Descriptive Terms Used in This Research	12
1.5.1 Voiding dysfunction	12
1.5.2 Urinary tract infection.	12
1.5.3 Catheter-associated bacteriuria, asymptomatic bacteriuria and urinary tract infection.	12
1.5.4 Detrusor sphincter dyssynergia.	13
1.5.5 Residual urine.	13
1.5.6 Vesicoureteral reflux.	13
1.5.7 Autonomic dysreflexia.	13
1.5.8 The novice nurse.	14
1.5.9 The advanced beginner nurse.	14
1.5.10 The competent nurse.	14
1.5.11 The proficient nurse.	14
1.5.12 The expert nurse.	14
1.6 Thesis Structure	14
Chapter 2: Literature Review	16
2.1 Introduction	16
2.2 Clinical Reasoning	18
2.3 Clinical Reasoning by Experienced Nurses	20
2.4 Knowledge Translation in Clinical Practice	24
2.5 Decision Support Tools	32
2.6 Catheter-associated Problems among Target Client Group	35
2.6.1 Spinal cord injury.	35
2.6.2 Urinary complications from catheter use by people with a spinal cord injury.	35
2.6.3 Multiple sclerosis.	41
2.6.4 Urinary complications associated with multiple sclerosis.	42

2.7 Urinary Catheter Considerations.....	45
2.8 Role of the Registered Nurse in Catheter Selection.....	49
2.9 Catheter Selection Knowledge of Nurses	52
2.10 Summary of Literature Review.....	57
2.11 Purpose of This Study.....	57
2.12 Aims of This Study	58
2.13 Research Questions	58
2.13.1 Research Question 1—Current knowledge.....	58
2.13.2 Research Question 2—Knowledge translation.	58
2.13.3 Research Question 3—Knowledge retention.....	58
Chapter 3: Methodology	60
3.1 Research Design.....	60
3.2 Rationale for Investigative Approach to Research Questions	63
3.2.1 Research Question 1.....	63
3.2.2 Research Question 2.....	67
3.2.3 Research Question 3.....	68
3.3 Educational Intervention.....	69
3.3.1 Decision support tool.	71
3.3.2 Educational intervention structure and content.....	73
3.4 Knowledge Measurement	76
3.4.1 Knowledge assessment instrument availability.	76
3.4.2 Assessment survey item development.	76
3.4.2.1 Catheter suitability in terms of size and purpose.....	78
3.4.2.2 Commonly occurring problems experienced by patients.	79
3.4.2.3 Issues for nurses performing or teaching catheterisation in this context.	81
3.5 Participant Demographic Data.....	83
3.6 Participant Recruitment	83
3.6.1 Inclusion and exclusion criteria.	84
3.6.2 Ethical considerations.	85
3.7 Analysis Plan	86
3.7.1 Statistic and other analytical assistance.	86
3.7.2 Descriptive statistics.	86
3.7.3 Statistical techniques.....	86
3.7.4 Research Question 1—Current knowledge.....	87
3.7.4.1 ‘By participant’ hypotheses.....	90
3.7.4.2 ‘By question’ hypotheses.	91
3.7.5 Research Question 2— knowledge translation.	94
3.7.5.1 ‘By participant’ analysis.....	94

3.7.5.2 ‘By question’ analysis.	95
3.7.6 Research Question 3—Knowledge retention.	95
3.7.7 Test–retest validation.	96
Chapter 4: Findings.....	98
4.1 Guide to Presentation of Findings.....	98
4.2 Outliers.....	98
4.2.1 Question 13.	98
4.2.2 Question 12.	100
4.3 Descriptive Statistics.....	101
4.3.1 Descriptive statistics by participant.	101
4.3.2 Descriptive statistics by question.	104
4.4 Research Question 1—Current Knowledge.....	107
4.4.1 Current knowledge by participant.	108
4.4.2 Current knowledge by question.	108
4.5 Research Question 2— Knowledge translation	109
4.5.1 Knowledge translation by participant.	109
4.5.2 Knowledge translation by question.	110
4.6 Research Question 3—Knowledge Retention	111
4.6.1 Knowledge retention by participant.	111
4.6.2 Knowledge retention by question.	111
4.7 Qualitative Question in Six-month Follow-up.....	112
4.8 Test–retest Validation of Knowledge Questionnaire	112
4.9 Participant Demographic Findings	114
4.9.1 The effect of years of nursing experience on knowledge gain.....	117
Chapter 5: Discussion.....	123
5.1 Introduction.....	123
5.2 Current Catheter Selection Knowledge	124
5.3 Knowledge Uptake.....	130
5.4 Knowledge Retention.....	137
5.5 Summary	149
Chapter 6: Conclusions.....	152
6.1 Background	152
6.2 Major Findings, Limitations and Recommendations.....	153
6.2.1 Current catheter selection knowledge.	153
6.2.2 Uptake of catheter selection knowledge.	154
6.2.3 Catheter selection knowledge retention.	156
6.2.4 Validity testing of the knowledge survey.	158
6.3 Implications of This Research	159

References.....	160
Appendix A: Catheter Features and Catheter Table	172
Appendix B: Literature Review Flowchart.....	176
Appendix C: Nursing Practice Decision Summary Guide.....	178
Appendix D: Catheter Compass™.....	179
Appendix E: Knowledge Survey	186
Appendix F: Demographic Survey	188
Appendix G: University Ethics Approval	189
Appendix H: Participant Information Pack	190
Appendix I: Calculations—Knowledge translation by Participnt	195
Appendix J: Calculations—knowledge translation by Question	199
Appendix K: Calculations—Knowledge Retention by Participant	204
Appendix L: Calculations—Knowledge Retention by Question.....	208

List of Figures

<i>Figure 1.</i> ‘By participant’ hypotheses probability distributions.	90
<i>Figure 2.</i> ‘By question’ hypotheses probability distributions for Question 1.	92
<i>Figure 3.</i> ‘By question’ hypotheses probability distributions for Question 11.	93
<i>Figure 4.</i> ‘By question’ hypotheses probability distributions for all other questions. ...	93
<i>Figure 5.</i> Graph of participant responses to Question 13.	99
<i>Figure 6.</i> Histogram of participant responses to Question 13.	99
<i>Figure 7.</i> Correct responses to individual questions by number of participants.	101
<i>Figure 8.</i> Superimposed histogram of the total scores of each by number of participants.	102
<i>Figure 9.</i> Box-whisker plot of participant responses to the three data collection points.	103
<i>Figure 10.</i> Correct responses by question.	104
<i>Figure 11.</i> Superimposed histogram of correct responses by question of the three data collection points.	106
<i>Figure 12.</i> Box-whisker plot of question responses to the three data collection points.	107
<i>Figure 13.</i> Test–retest scores.	113
<i>Figure 14.</i> Experience v. knowledge change pre- to post-intervention.	118
<i>Figure 15.</i> Standardised residuals.	118

List of Tables

Table 1 Design and Methodology	62
Table 2 Probability of Correctly Answering a Question Under Each Hypothesis	89
Table 3 Critical Ranges and Type I and II Error Probabilities by Participant.....	91
Table 4 Critical Ranges and Type I and II Error Probabilities for Question 1	92
Table 5 Critical Ranges and Type I and II Error Probabilities for Question 11	93
Table 6 Critical Ranges and Type I and II Error Probabilities for All Other Questions	94
Table 7 Critical Ranges and Type I and II Error Probabilities by Participant.....	100
Table 8 Summary Statistics by Participant.....	102
Table 9 Summary Statistics by Question.....	105
Table 10 Participants' Current Knowledge	108
Table 11 Current Knowledge—Questions Supporting Each Hypothesis.....	109
Table 12 Evidence against Null Hypothesis—Research Question 2.....	110
Table 13 Questions Supporting Each Hypothesis: Research Question 3— Knowledge Retention	111
Table 14 Demographic Responses	115
Table 15 Summary Regression Statistics	119
Table 16 Linear Regression Coefficients	121
Table 17 Analysis of Variance	121
Table 18 Research Question 2—Wilcoxon Signed Rank Test for Null Hypothesis	196
Table 19 Research Question 2—Wilcoxon Signed Rank Test for Alternative Hypothesis	197
Table 20 Research Question 2—Wilcoxon Signed Rank Test for Null Hypothesis, Excluding Question 13	197

Table 21 Research Question 2—Wilcoxon Signed Rank Test for Alternative Hypothesis, Excluding Question 13	198
Table 22 Research Question 2—Exact McNemer Test for Question 1.....	199
Table 23 Research Question 2—Exact McNemer Test for Question 2.....	200
Table 24 Research Question 2—Exact McNemer Test for Question 3.....	200
Table 25 Research Question 2—Exact McNemer Test for Question 4.....	200
Table 26 Research Question 2—Exact McNemer Test for Question 5.....	200
Table 27 Research Question 2—Exact McNemer Test for Question 6.....	201
Table 28 Research Question 2—Exact McNemer Test for Question 7.....	201
Table 29 Research Question 2—Exact McNemer Test for Question 8.....	201
Table 30 Research Question 2—Exact McNemer Test for Question 9.....	201
Table 31 Research Question 2—Exact McNemer Test for Question 10.....	202
Table 32 Research Question 2—Exact McNemer Test for Question 11.....	202
Table 33 Research Question 2—Exact McNemer Test for Question 12.....	202
Table 34 Research Question 2—Exact McNemer Test for Question 13.....	202
Table 35 Research Question 2—Exact McNemer Test for Question 14.....	203
Table 36 Research Question 2—Exact McNemer Test for Question 15.....	203
Table 37 Research Question 3—Wilcoxon Signed Rank Test for Null Hypothesis	205
Table 38 Research Question 3—Wilcoxon Signed Rank Test for Alternative Hypothesis	206
Table 39 Research Question 3—Wilcoxon Signed Rank Test for Null Hypothesis, Excluding Question 13	206
Table 40 Research Question 3—Wilcoxon Signed Rank Test for Alternative Hypothesis, Excluding Question 13	207
Table 41 Research Question 3—Exact McNemer Test for Question 1.....	208

Table 42 Research Question 3—Exact McNemer Test for Question 2.....	209
Table 43 Research Question 3—Exact McNemer Test for Question 3.....	209
Table 44 Research Question 3—Exact McNemer Test for Question 4.....	209
Table 45 Research Question 3—Exact McNemer Test for Question 5.....	209
Table 46 Research Question 3—Exact McNemer Test for Question 6.....	210
Table 47 Research Question 3—Exact McNemer Test for Question 7.....	210
Table 48 Research Question 3—Exact McNemer Test for Question 8.....	210
Table 49 Research Question 3—Exact McNemer Test for Question 9.....	210
Table 50 Research Question 3—Exact McNemer Test for Question 10.....	211
Table 51 Research Question 3—Exact McNemer Test for Question 11.....	211
Table 52 Research Question 3—Exact McNemer Test for Question 12.....	211
Table 53 Research Question 3—Exact McNemer Test for Question 13.....	211
Table 54 Research Question 3—Exact McNemer Test for Question 14.....	212
Table 55 Research Question 3—Exact McNemer Test for Question 15.....	212

Chapter 1: Introduction

1.1 Background

Neurogenic bladder dysfunction is associated with disruption to the central or peripheral nerves, associated with micturition from either disease or trauma, which essentially results in a problem with bladder storage and emptying. Management plans for neurogenic incontinence that are designed to overcome retention and distension are often dependent on some form of catheterisation.

The lower urinary system is regulated by three structures: the brain, spinal cord and peripheral nervous system. Neural control of voiding is achieved by the brain communicating with the sacral portion of the spinal cord, which contains the reflex voiding centre. The T11 to L1 nerves provide sympathetic stimulation that allows the bladder to fill by simultaneously relaxing the bladder and stimulating contraction of the internal bladder neck sphincter. The S2 to S4 (reflex voiding centre) nerves provide parasympathetic stimulation and a pathway for voluntary motor control (pelvic nerves). Micturition centres in the pons provide ultimate cerebral control (Nelson, Zejdlik, & Love, 2001). Nelson et al. (2001) stated that “The Wein classification describes voiding dysfunction as a storage problem, emptying problem, and/or combination of storage and emptying problems” (p. 165). That is, for a dysfunctional bladder, there is reflux or leakage, the release of urine is inhibited or exaggerated, or both.

Catheter-associated urinary tract infections (CAUTIs) are reduced by minimising the use of an indwelling catheter, and minimising the duration for which the catheter is left *in situ* (Hooton et al., 2010). Alternatives that should be assessed for use prior to an indwelling catheter include intermittent catheterisation for men and women, or using a male sheath for men with low residuals (Hooton et al., 2010). However, some

people require long-term catheterisation and are unable to use a penile sheath (condom catheterisation). Penile sheaths use is limited in people with neurogenic incontinence due to the incidence of detrusor sphincter dyssynergia. The alternative of intermittent catheterisation is not always possible given the limited client dexterity and lack of regulation and competency framework in relation to catheterisation within the carer workforce in Australia. Causes of neurogenic incontinence include, but are not limited to, spinal cord injury, multiple sclerosis, Parkinson's disease, spina bifida, cerebral palsy and acquired brain injury.

In the advancing world of technology the original Foley catheter and intermittent catheter have evolved into many different designs that need to be considered when selecting a catheter for indwelling or intermittent use. Catheterisation is sometimes performed by a medical practitioner; however, it is generally acknowledged as a nursing skill (Fleming et al., 2000; Turner & Dickens, 2011). The nurse needs to have a good up to date working knowledge of the clinical features of catheters both indwelling and intermittent catheter. However, the majority of existing guidelines do not provide specific advice on catheter selection, necessitating nurses to choose a catheter based on the manufacturer's specifications and their own understanding of the client's individual needs. When a nurse is considering catheterisation, either indwelling or intermittent, catheter selection choice should be influenced by clinical expertise, research evidence and patient preference, while also being further guided by the available resources.

Dobson et al.'s (1996) early Australian cross-sectional descriptive survey of 709 registered nurses and enrolled nurses concluded that there was a lack of knowledge regarding catheter selection, and advocated the need for continence advisor input and ongoing education. Fleming et al. (2000) also conducted an Australian study with 39 registered nurses, set in a long-term rehabilitation setting, in order to identify

knowledge and management practices related to urinary catheters. Fleming et al. (2000) claimed that, “[o]f particular note is the lack of knowledge pertaining to selection of catheters” (p. 243) and advocated for education that “addressed the issues of unchallenged traditional knowledge and support the nurse in changing clinical practice to embrace evidence base knowledge” (p. 245). Whether this situation has improved in Australia during the past 15 years has not been reported. Research into the effects of education in relation to change of clinical practice pertaining to catheter selection has also not been reported in Australia.

Clinical decision making involves nurses evaluating the relevance and application of evidence-based research in relation to individual client needs. The use of evidence in practice was defined by Aarons, Hurlburt and Horwitz (2011), who stated that, “the connection between research and practice is the translation of evidence based practices into broader application and impact” (p. 5), while Graham et al. (2006) defined knowledge translation as “turning knowledge into action and encompassing the process of both knowledge creation and knowledge application” (p. 22). Waters, Crisp, Rychetnik and Barratt (2009) undertook an Australian study investigating the level of nursing preparedness for evidence-based practice by surveying 386 registered nurses from across New South Wales (NSW). They claimed that nurses encouraged the use of evidence-based practice, yet lacked competence and were apprehensive regarding evidence-based practice techniques. In addition, Chapman (2007) acknowledged the difficulty that some clinicians have in using evidence to inform everyday practice, and advocated the use of clinical decision support tools to overcome barriers to implementing evidence-based practice during daily clinical care.

1.2 Purpose

The process of choosing catheter types has a great influence on both clients' clinical outcomes and the cost of care. In the case of people with a spinal cord injury or multiple sclerosis, incorrect or inappropriate selection of catheter products may increase the likelihood of autonomic dysreflexia. Clinical reasoning by nurses is required during catheter selection to determine the needs of the client with respect to bladder management and urination, and to match these with the characteristics of the catheter. While earlier studies by Dobson et al. (1996) and Fleming et al. (2000) advocated the need for education in catheter selection, neither study investigated the effects of education pertaining to catheter selection. Thus, the current study addresses this shortcoming by assessing catheter selection knowledge in a specialised context, and determining the effect of education on catheter selection knowledge.

The aim of this research is threefold:

1. to establish registered nurses' current knowledge level
2. to confirm knowledge translation that is, whether education and the use of a decision support tool in catheter selection improve the level of registered nurses' knowledge in catheter selection
3. to determine whether nurses retain knowledge regarding catheter selection.

These aims are addressed through the following research questions

- What do registered nurses know and understand about urinary catheters and the difference between catheter types?
- To what extent do the participant nurses take up and apply new information on catheter types and catheter selection for defined client groups?

- To what extent can registered nurses' knowledge about assessment and catheter selection and use for multiple sclerosis and spinal cord injury patients be retained by the participants following an education intervention?

To answer these questions, this study undertook an assessment of specialist registered nurses' current catheter selection knowledge, prior to the delivery of an education intervention that was designed to highlight current best practice and unique catheter features. During the intervention, each participant also received a decision support tool. Following the intervention, a post-test (at three months) and follow-up knowledge test (at six months) enabled the researcher to ascertain the participants' catheter knowledge translation and retention of contemporary clinical information.

1.3 Context

1.3.1 Participant and service overview. Nurses who provide care to either spinal cord injured or multiple sclerosis clients need specific skills in continence management that must incorporate catheter management and a deep understanding of the physiology and pathophysiology of patient conditions that affect catheter selection, according to the aetiology of the incontinence. The Dreyfus five-stage skill acquisition model (Dreyfus & Dreyfus, 1980) was adapted to a nursing context by Benner (1982)—a well-published American nursing theorist on practice development. The five skill stages, as renamed by Benner (1982), are novice, advanced beginner, competent, proficient and expert. Building on Benner's early research, Benner, Hughes and Sutphen (2008) claimed that, over time, the experiences of nurses in a speciality group will result in increased expertise of those nurses in that speciality group context. This finding contrasts with the work of Ericsson, Whyte and Ward (2007), who highlighted that, while experience is necessary to become an expert, it does not necessarily lead to expertise. Given that the participant nurses in the current study work in the highly

specialised context of spinal cord injury and multiple sclerosis, the demographic data collected in this study will reveal any relationship that may exist between experience and expertise during catheter selection in this speciality setting.

Residential care facilities provide long-term care, as opposed to that given in the hospital setting, where the standard care for spinal cord injury or disease involves management of critical care or rehabilitation. In these settings, bladder management varies from acute care to long-term care and management. In contrast, the care provided by nurses to people in residential care facilities focuses on assisting them to maintain the activities of daily living, and manage their bladder issues in the presence of established daily routines. Only two long-term residential care facilities were identified in NSW that specifically care for people with either spinal cord injury or multiple sclerosis: Ferguson Lodge and the Studdy MS Centre–Residential Unit. An Australian study by Winkler, Farnworth and Sloan (2006) exploring young people with disabilities in residential care claimed that, even when domain-specific residential care facilities are available, scant evaluation has occurred of the services provided by these facilities, whose core purpose is to provide care to people with complex, high-care needs. Thus, part of the current study explores the knowledge and expertise of the registered nurses who manage and direct the continence care pertaining to catheter selection for people with spinal cord injury or multiple sclerosis in residential care facilities.

Ferguson Lodge is owned and operated by ParaQuad NSW (2015)—a not-for-profit charity organisation. Ferguson Lodge is funded partly by the government and partly via charity. Registered nurses provide the majority of care and are rostered on for each shift to provide professional nursing for catheter management, medications and wound management. A senior clinical nurse is present during the day shift from Monday to Friday to provide clinical supervision to the registered nurses. A total of nine

registered nurses are employed at Ferguson Lodge, who provide services to the residents of Ferguson Lodge only—they do not provide care to ParaQuad NSW clients living in the community.

The Studdy MS Centre—Residential Unit is operated by MS Australia (2015)—a not-for-profit charity organisation. Funding for the Studdy MS Centre—Residential Unit is also provided partly by the government and partly via charity. In this facility, the majority of care is provided by families or carers, who have access to registered nurses' advice and assistance. Registered nurse care at the Studdy MS Centre—Residential Unit is provided by three registered nurses, who service both the residents of the unit and patients in the community living with multiple sclerosis.

Preparatory observation of the practices at Ferguson Lodge and the Studdy MS Centre—Residential Unit suggested that their registered nurse practice approach aligns with the Dorothea Orem Self-Care Deficit Nursing Theory: “Self-care activities are what people do on their own behalf to maintain health and wellbeing; the goal of nursing is to help people meet their own therapeutic self-care demands” (Polit & Beck, 2012, p. 134). Catheter management is regarded by these nurses as a therapeutic self-care demand of people with neurogenic incontinence, who are at risk of retention and distension. The Self-Care Deficit Nursing Theory (Polit & Beck, 2012) recognises the self-care needs of the individual; thus, catheter selection by registered nurses needs to meet the unique and complex needs of individuals with neurogenic incontinence.

1.3.2 Urinary catheter complexities. Catheters have a number of different features from which to choose, including French gauge (Fg) size; length; balloon capacity; material (silicon, latex or glass); coating (hydrogel coated or silver coated); registered reusable or disposable; polished or hole-punched eyelets; different tips (straight tipped, coude tipped, olive tipped coude/olive tipped, or tieman tipped); and

whether they are hydrophilic, pre-lubricated, enclosed (also known as sets) or non-touch. When seeking to make a correct choice in each circumstance, the goal is to minimise trauma with the smallest lumen size that provides the best drainage (H. P. Loveday et al., 2013). However, factors other than catheter size must also be considered. The European Association of Urology Nurses (EAUN) provides practice guidelines for both indwelling catheters (Geng et al., 2012) and intermittent catheters (Vahr et al., 2013), and outlines the many features that are available to consider during catheter selection.

When investigating catheter features, Biering-Sørensen, Hansen, Nielsen and Looms (2007); De Ridder et al. (2005); and Spinu et al. (2012) all compared hydrophilic intermittent coated catheters to standard non-coated intermittent catheters. They found that a variety of brands all resulted in changes in clinical outcomes with the use of hydrophilic-coated catheters (Appendix A). Further, Biering-Sørensen et al. (2007) and Spinu et al. (2012) also reported finding greater client satisfaction with the use of hydrophilic-coated catheters, while ease of use may have influenced adherence issues (Biering-Sørensen et al., 2007). Fader et al. (2001) earlier examined adherence to urethral mucosal at the end of catheterisation, using hydrophilic catheters. They found that different brands had different effects on the urethral mucosa. Later, Stensballe, Looms, Nielsen and Tvede (2005) studied the withdrawal force of hydrophilic catheters, and demonstrated a reduction of the level of micro trauma to patients when the correct catheter was used.

Closed-system intermittent catheters are sometimes referred to as ‘sets’ or ‘enclosed catheters’ in Australia. Day, Moore and Albers (2003) compared a closed-system intermittent catheter (O’Neill type) with a traditional open-system intermittent catheter and found some evidence (although not strong) that less urinary tract infection

occurred when using the closed-system intermittent catheter. In that study, the intermittent catheterisation was performed by the nurse, rather than the patient, which may have implications for the results. A larger *in vitro* study by Hudson and Murahata (2005) also suggested that a closed non-touch system may result in less urinary tract infection; however, they suggested that a larger study was needed for conclusive results.

Much clinical controversy exists regarding the use of silver-coated catheters, and there are many studies published on this issue. Some studies—such as those by Gentry and Cope (2005) and Karchmer, Giannetta, Muto, Strain and Farr (2000)—claimed a reduction in urinary tract infections with the use of silver-coated catheters. However, Hooton et al. (2010) claim that there is a lack of evidence supporting the routine use of these catheters, and call for more research on their use. Controversy also exists over which catheter material should be used, both for intermittent and indwelling use, and further evidence is needed to determine whether one type of material is better than another in reducing CAUTI (Mitchell et al., 2011).

However, the clinical goals of catheter selection extend beyond reducing CAUTI. They also involve safe insertion and removal considerations, such as those recommended by Parkin et al. (2002), who examined cuff deflation and found that all silicon catheters (BARD, Simpla and Rusch) are plagued by increased resistance to suprapubic withdrawal due to balloon cuffing on deflation. The choice is further complicated when balancing the individual needs of clients. For example, some clients have urine that is high in sediment (Singh et al., 2011), which needs to be considered if using a coated catheter because the internal drainage diameter of the catheter is narrower than a non-coated catheter (Geng et al., 2012) for the same outside diameter. Catheter choice also needs to include catheter tip selection. The majority of both intermittent and indwelling catheters have a standard straight tip design that has one

hole for drainage on either side. Coude and Tieman tip catheters are curved, tipped catheters that are used for difficult catheter insertions (Geng et al., 2012), although their usage is usually related to situations involving a narrow urethra or enlarged prostate (Newman & Willson, 2011; Ramakrishnan & Mold, 2005).

This brief review of catheter features shows that different catheters have different features that are designed to provide clinical options for a range of contingencies. Catheter selection must involve understanding the individual needs of the client and balancing those needs with the various catheter types and features available in order to ensure optimum catheter management. Due to clients' different needs, it is important that a standard approach to catheter selection be avoided because a catheter that may suit one person may not suit another, and, if used, may cause further trauma and health complications.

1.3.3 Knowledge translation. Clinical reasoning requires nurses to evaluate the relevance and application of research based evidence in relation to individual client needs—that is, to overcome a research–practice gap.

Knowledge translation issues are central to the current study, and the many facets of knowledge translation and literature on the topic are worth considering as part of the context of this study. When considering the effects of knowledge translation on the use of evidence by nurses when making decisions, Yost et al. (2015) highlighted the need to understand what influences the successful implementation of interventions that support knowledge translation. Based on their research, Kent, Hutchinson and Fineout-Overholt (2009) proposed considering and evaluating the complexities involved in changing and sustaining changes to clinical practice as a way to highlight strategies to support knowledge translation. Thus, in designing the current research, it was important to acknowledge that translating complex technical knowledge to clinical decision

making in relation to urinary catheter selection involves knowledge translation, as well as clinical and contextual factors.

1.4 Study Design

Little research has been published regarding the highly specialised context in which this study occurred, which means that contemporary research must build on the early studies by Dobson et al. (1996) and Fleming et al. (2000), who assessed nursing knowledge in relation to catheter management and selection. The aim of this study is to provide an update on nursing knowledge pertaining to catheter selection and to investigate the implications of targeted education on nurses catheter selection knowledge. Although Dobson et al. (1996) and Fleming et al. (2000) called for education to improve clinical practice, they did not measure knowledge uptake or retention in relation to clinical practices that guide catheter selection. Consequently, the current study employs a quasi-experimental design with a pre-test, immediately followed by an education intervention, and then a repeated post-test at three months and a follow-up test at six months.

The design of the education intervention draws on Kolb's (1984) experiential learning theory, which closely aligns with the practical learning needs of nurses. The essence of Kolb's theory is that experience provides a platform for reflective evaluation of practice that is combined with new knowledge to form new understandings that are used to inform future clinical practice. Within this intervention, the registered nurse participants were provided with technical and catheter-specific information to increase their knowledge, as well as the opportunity to practise their skills in selecting catheters for the specified patient group. The education intervention occurred at Ferguson Lodge, with participants from both Ferguson Lodge and the Studdy MS Centre–Residential Unit. The single education intervention was undertaken by the student researcher, and as

part of this exploratory study, the registered nurse participants were given a catheter selection decision support tool. While it was originally intended that all participants would attend the same session, work scheduling conflicts necessitated that two sessions be held; the first attended by six and the second by three participants. In addition, while it was intended that each intervention would be for 40 minutes, the actual duration which included questions was approximately one-hour for both sessions. The design of the research study addresses the goal of investigating the changes in knowledge related to an education intervention, and the maintenance of those learning changes over time.

1.5 Diagnostic and Descriptive Terms Used in This Research

1.5.1 Voiding dysfunction. Voiding is governed by the brain, spinal cord and peripheral nerves (Nelson et al., 2001); thus, damage to these systems from either spinal cord injury or multiple sclerosis results in voiding dysfunction. Neurogenic incontinence is the result of disease or trauma to the central nervous system or peripheral nerves, associated with micturition (Nelson et al., 2001).

1.5.2 Urinary tract infection. A urinary tract infection is “bacteriuria with tissue invasion and resultant tissue response, signs, and/or symptoms” (Nelson et al., 2001, p. 531). Changes in the parasympathetic and sympathetic communication mean that people with a spinal cord injury or disease may experience additional signs and symptoms of urinary tract infection that are not experienced by the general population. Additional diagnostic signs and symptoms of urinary tract infection for people with spinal cord injury include increase in spasm cloudy and/or malodorous urine, increased sweat or malaise, and autonomic dysreflexia (Ronco et al., 2011; Singh et al., 2011).

1.5.3 Catheter-associated bacteriuria, asymptomatic bacteriuria and urinary tract infection. Catheter-associated bacteriuria refers to bacteriuria in patients

who are catheterised or have been catheterised within the past 48 hours. Patients without symptoms are referred to as having catheter-associated asymptomatic bacteriuria, while patients with both symptoms and significant bacteriuria are referred to as having CAUTI (Hooton et al., 2010). Hooton et al. (2010) defined CAUTI as the “presence of signs and symptoms compatible with a urinary tract infection and no other infection plus ≥ 10 (P3) colony forming units/ml of at least one bacterial species in a single urine specimen” (p. 6365).

1.5.4 Detrusor sphincter dyssynergia. Detrusor sphincter dyssynergia is “a disturbance of the normal relationship between bladder (detrusor) contraction and sphincter relaxation during voluntary or involuntary voiding efforts” (Nelson et al., 2001, p. 514).

1.5.5 Residual urine. Residual urine refers to; the amount of urine within the bladder post voluntary or involuntary void.

1.5.6 Vesicoureteral reflux. Vesicoureteral reflux is “an abnormal backflow of urine from the bladder to the ureter, resulting from a congenital defect, obstruction of the outlet of the bladder, or infection of the lower urinary tract” (Nelson et al., 2001, p. 531).

1.5.7 Autonomic dysreflexia. Autonomic dysreflexia is: a life-threatening condition that can occur in persons with a spinal cord injury at T7 or above, resulting from uninhibited sympathetic response of the nervous system to noxious stimulus. Specifically, a discharge of uninhibited sympathetic nervous system impulses as a result of noxious stimulation of sensory receptors below the level of spinal cord injury, resulting in a hypertensive episode. (Nelson et al., 2001, p. 511)

1.5.8 The novice nurse. Novice nurses are defined as, “beginners [who] have no experience with the situations in which they are expected to perform tasks” (Benner, 1982, p. 128).

1.5.9 The advanced beginner nurse. An advanced beginner nurse is defined as, “one who can demonstrate marginally acceptable performance. This person is one who has coped with enough real situations to note (or to have them pointed out by a mentor) the recurrent meaningful situational components, called aspects” (Benner, 1982, p. 128).

1.5.10 The competent nurse. Benner (1982) stated that competency: [d]evelops when the nurse begins to see his or her actions in terms of long-range goals or plans ... For the competent nurse, a plan establishes a perspective, and the plan is based on considerable conscious, abstract, analytic contemplation of the problem. (p. 130)

1.5.11 The proficient nurse. Benner (1982) stated that, “characteristically, the proficient performer perceives situations as wholes, rather than in terms of aspects ... Experience teaches the proficient nurse what typical events to expect in a given situation and how to modify plans in response to these events” (p. 130).

1.5.12 The expert nurse. Benner (1982) stated that, “the expert nurse, with her/his enormous background of experience, has an intuitive grasp of the situation and zeros in on the accurate region of the problem without wasteful consideration of a large range of unfruitful possible problem situations” (p. 131).

1.6 Thesis Structure

The six chapters that constitute this thesis follow a classical structure. Chapter 1 provides a brief overview of the research context, which discusses the problems arising from catheter selection, and provides some particular information unique to the study

participants. Chapter 2 provides a review of the literature related to nursing and critical thinking, the clinical reasoning cycle and knowledge translation. It also provides an overview of contemporary knowledge pertaining to catheter selection, and discusses what registered nurses must consider when making clinical decisions about catheter selection, as well as the consequences of inappropriate selection and use. This review identifies the learning needs of experienced registered nurses related to contemporary catheter selection for people with a long-term neurological injury or disease.

Chapter 3 outlines the research design and methodology, as well as the conceptual framework used for this study. It also justifies the statistical methods used to analyse the data. Chapter 4 presents the findings of the data analysis, while Chapter 5 discusses the findings in relation to education and knowledge translation in this particular clinical situation. It also explores the implications of clinical experience and expertise pertaining to the clinical reasoning needed to appropriately select a catheter for a person with a neurological deficit. It provides a summary of the research findings, strengths and limitations, and discusses implications for future research and clinical practice. Finally, Chapter 6 presents conclusions about the value and implications of this study and its contributions to this field of research.

Chapter 2: Literature Review

2.1 Introduction

In reviewing the research published in fields relevant to this study, several areas were selected *a priori* for investigation. As themes emerged from this, further research was identified and added to the review. The initial search topics were:

- clinical reasoning
- learning needs and decision support tools
- continence management, spinal cord injury and multiple sclerosis
- urinary catheter characteristics.

These topics included analysis of the role of registered nurses in selecting catheters, supporting clients in catheter use, and general understanding of the issues and complications experienced by clients with multiple sclerosis or spinal cord injury who use catheters. The review also incorporated a review of research on knowledge translation and the value of clinical decision support tools. The catheter selection decision support tool developed prior to the study by the student researcher, and used in the intervention, was also subjected to analytical review and comparison with existing research on the specific features of catheter construction and use.

The databases used in the search of literature were CINAHL Complete, Health Source: Nursing/Academic Edition, Medline Complete, Google Scholar and Cochran library. From these, 5,069 articles were identified that pertained to the identified topics, after limiting by language (English) and availability of abstract. Following evaluation, 118 of these articles were included in this study. The search terms used in each identified area of focus were as follows:

- clinical knowledge

- clinical reasoning in nursing and experience
- expert and novice and clinical reasoning
- nursing clinical reasoning cycle and residential care
- knowledge translation
- knowledge translation and education
- decision support tools
 - decision support tools and clinical reasoning
 - nursing decision support tools
 - decision support tools and catheter selection
 - decision support tools and continence management
- continence management spinal cord injury and multiple sclerosis
 - spinal cord injury and continence management
 - spinal cord injury and urinary complications
 - spinal cord injury and urinary catheters
 - multiple sclerosis and continence management
 - multiple sclerosis and urinary complications
 - multiple sclerosis and urinary catheters
- urinary catheter characteristics
 - urinary catheter materials
 - urinary indwelling catheters
 - urinary intermittent catheters
 - urinary catheter complications
 - urinary catheter selection and nurses.

Periodic review of the literature associated with this research involved the databases CINAHL Complete, Health Source: Nursing/Academic Edition, Medline

Complete and Google Scholar, which were searched for key researchers in the fields of knowledge translation and clinical reasoning. Key researchers identified from a manual review of the existing literature used in this study also yielded relevant publications. In the final iteration of the review, following limitation by language (English) and availability of abstract, a further 62 articles were identified, of which 46 were added to the review for this study.

A flow chart summarising this process is provided in Appendix B.

2.2 Clinical Reasoning

The Australian Code of Conduct for Professional Nurses characterises the processes of nursing as promoting and sustaining individualised health outcomes for people, regardless of age, culture, illness or disability, through the appraisal, implementation and evaluation of an individualised care plan that takes into account client choice and applicable research evidence (Nursing and Midwifery Board of Australia, 2013). To achieve this, nurses make clinical decisions during their daily practice that influence the health and wellbeing of clients. McCaughan, Thompson, Cullum, Sheldon and Raynor (2005) surveyed 33 community-based nurses and classified seven types of decisions made by nurses during their daily practice: assessment, diagnosis, intervention, communication, referral, service delivery and information seeking.

The clinical reasoning to support these decisions involves analysis and judgement based on a combination of assessment data and interpretive knowledge, rather than performing a memorised standard response to certain health symptoms. Benner, Tanner and Chesla (1996) stated that, “[c]linical judgement refers to the ways in which nurses come to understand the problems, issues, or concerns of the client/patient, to attend to salient information and to respond in concerned and involved

ways” (p. 2). However, to reason, nurses must be able to think critically about and evaluate their own skills and knowledge, and not just the client’s needs. Benner et al. (2008) claimed that:

clinicians need forethought and an ongoing grasp of a patient’s health status and care needs trajectory, which requires an assessment of their own clarity and understanding of the situation at hand, critical reflection, critical reasoning, and clinical judgement. (p. 89)

To achieve this, a nurse cannot just apply the evidence—rather, they need to critically evaluate the needs of the client against the available research evidence (Benner et al., 2008). Clinical reasoning is not made in isolation; registered nurses may consider individual client’s needs and lifestyle choices to best meet the desired goals and outcomes: “Gaining access to clinical information that is held by patients is a critical part in the clinical judgement process” (Elliott, 2010, p. 2717).

Michels, Evans and Blok (2012) used a modified Delphi process to investigate the definition of clinical skills among clinicians, and proposed that clinical skills require a mixture of procedural knowledge, underpinning fundamental knowledge and clinical reasoning. They stated that failure to incorporate all three components limits the transference of clinical skills between different clinical situations. This definition of clinical skills is relevant to this study, given that the clinical nursing skill of catheter insertion requires registered nurses to know how to insert the catheter, while also having knowledge of the lower urinary tract system, as well as clinical reasoning related to catheter management and selection that will most benefit individual clients’ health goals and outcomes. As highlighted by Michels et al. (2012), underpinning knowledge and clinical reasoning are essential to clinical practice. Without a foundation of

underpinning knowledge and clinical reason, clinicians are at risk of providing care that does not meet the goals or health outcome needs of clients.

Successful clinical reasoning requires more than evaluating evidence and gaining clinical information to make a decision. Levett-Jones et al. (2010) defined effective clinical reasoning as related to “the ability to collect the right cues and take the right action for the right patient at the right time for the right reasons” (p. 517). They identified these cues as the “five rights of clinical reasoning” and stated that, “when the ‘five rights’ of CR [Clinical Reasoning] are not understood and applied, nurses’ clinical judgement may be inaccurate and associated with inappropriate interventions that lead to increased and untimely patient mortality” (Levett-Jones et al., 2010, p. 519). In other words, in the case of registered nurses providing catheter management to clients with spinal cord injury or multiple sclerosis, the management and selection of catheters must be based on an analysis of the unique needs and associated history of individual clients to ensure optimal care.

It is essential that nurses who work with complex-needs clients in isolated settings have advanced clinical reasoning capacities. This important need for nurse clinical reasoning supports the current research into whether registered nurses in non-acute care contexts are selecting catheters based on convenience, or as a result of clinical reasoning. Providing further information on this area of nursing will help prevent and manage urinary complications associated with catheter use.

2.3 Clinical Reasoning by Experienced Nurses

In NSW, Australia, public hospital health resources have adopted as policy the five stages of clinical competency identified by Benner (1982). The five stages are: novice, advanced beginner, competent, proficient and expert (Benner, 1982). Nurses with expertise have accumulated skills through professional experience that is

demonstrated in the provision of nursing care that extends beyond competency (Benner et al., 2008). When clinicians work with a unique client group, such as clients with multiple sclerosis or spinal cord injury, Benner et al. (2008) claimed that, “Over time, the clinician develops a deep understanding that allows for expert diagnosis and intervention skills” (p. 102). Benner et al. stated that this is achieved when nurses work for long periods with a particular client group. Nurses develop skills to recognise the unique characteristics of the clients in their speciality, and critically evaluate those characteristics against the progression of treatment for someone without spinal cord injury or multiple sclerosis. Accordingly, they adapt the interpretation of evidence and associated intervention.

Benner et al.’s (2008) findings suggest that the clinical reasoning skills of registered nurses undertaking catheter selection for clients with spinal cord injury or multiple sclerosis are influenced by the type and length of experience these nurses have with clients with these specific issues. Specific client populations have a level of predictability in terms of their care needs, such as people with spinal cord injury or multiple sclerosis who are managed in residential care facilities. Thus, in line with Benner et al.’s theory, over time, registered nurse working in these facilities will develop expert interventions skills in catheter management. According to Benner et al., this skill development occurs because of deeper understanding of the needs of that specific client population, and the long-term nature of their care of specific individuals.

However, not all researchers share this view. Thompson (2003) agreed that nurses use experiential knowledge to make decisions, yet claimed that experiential knowledge is insufficient to use as a base for clinical decisions. In contrast to Benner et al.’s (2008) claims of expertise developing as a result of exposure to speciality groups, T Loveday, Wiggins, Searle, Festa and Schell (2013) distinguished between competent

and expert levels of nursing in the speciality of paediatric intensive care nursing. In their study, the average professional experience of participants was 9.8 years, and they found that “expertise does not develop as a linear function of experience but, rather it develops with the capacity to extract and use diagnostic cues” (T. Loveday et al., 2013, p. 133).

In their study, Witteman, Spaanjaars and Aarts (2012) explored the use of intuition among nurses, and highlighted that intuition is developed alongside extensive clinical experience. When investigating the gap between theory and practice for pressure ulcer prevention, Moore (2010) proposed that expert clinicians required less structured support than did novice clinicians, and that expert clinicians used intuition to facilitate and embrace the assessment process. The intuition described by Witteman et al. (2012) and Moore (2010) in relation to the nuances (unique characteristics) alluded to by Benner et al. (2008) among nurses providing extensive care to specific client groups suggests that registered nurses’ intuition in catheter selection for people with spinal cord injury or multiple sclerosis is associated with their awareness of clients’ specific needs. This skill may develop through their experiences of providing nursing care to people with a spinal cord injury or multiple sclerosis.

The dangers of relying on intuition when making clinical decisions were identified by Thompson and Yang (2009), who claimed that intuition is often used by non-experts, and leads to suboptimal clinical decisions. In addition, Thompson et al. (2009) investigated 245 nurses from Holland, the United Kingdom, Canada and Australia to analyse experienced nurses’ use of clinical information to assess critical event risks, and found that intuition afforded limited decision accuracy. In analysing the concept of intuition, Robert, Tilley and Petersen (2014) implied that knowledge is important because “intuition is a holistic, complex experience, and knowledge-based

approach to decision making” (p. 348). They warned that, if intuition is used, it must be built on a strong foundation that involves both experience and expertise.

While the research of Botti and Reeve (2003) is now quite old, their claims remain relevant in 2015. They examined the role of clinical knowledge and ability in decision making by student nurses, and found that, “decision making competence is affected by nurses’ academic ability and experience, and by clinical case complexity” (p. 46) and that, “[i]t is apparent as nurses develop greater domain knowledge, their interpretation of case information becomes more complex” (p. 46). These claims infer that nurses with greater domain-specific knowledge will consider symptoms differently to those without domain-specific knowledge, and, consequently, their clinical reasoning process is different to those without domain-specific knowledge.

A small study by Sedgwick, Grigg and Dersch (2014) investigated clinical reasoning and decision making by 15 nurses in rural hospitals in Canada. They found that clinical reasoning varied between clinicians, and was not influenced by experience. Andersson, Klang and Petersson (2012) investigated clinical reasoning in a specialised context, and found that nurses with extensive or specialist experience reasoned differently. They concluded that experience did not guarantee competency; however, a combination of education and experience was needed to develop competence. Further to this, Clarke (2014) considered that clinicians’ ability to respond appropriately to clients’ changing conditions was influenced both by their own clinical reasoning skills, and by the effective use of the clinical performance assessment process.

Clearly, there is a divergence of views among the researchers cited; however, they all agreed that domain-specific knowledge is an important platform for the initiation of effective clinical reasoning.

2.4 Knowledge Translation in Clinical Practice

The United States National Centre for Dissemination of Disability Research (as cited in Graham et al., 2006) defined knowledge translation as:

[t]he collaboration and systematic review, assessment, identification, aggregation and practical application of high-quality disability and rehabilitation research by key stakeholders (i.e., consumers, researchers, practitioners, policy makers) for the purpose of improving the lives of individuals with disability. (p. 15)

This definition implies that clinicians working in the field of disabilities will assess and evaluate their clients' clinical needs against relevant research, and, in so doing, their clinical knowledge will expand and improve client outcomes. As the essence of this study is to improve catheter selection knowledge through the registered nurses' ability to balance assessed client needs against research evidence and guidelines pertaining to catheter use, the term knowledge translation as defined by the United States National Centre for Dissemination of Disability Research is used in this study.

In Australia, the NSW Agency for Clinical Innovation (ACI) was established in January 2010 under the *Health Services Act 1997 (NSW)*. Part of its statement of purpose indicates that, “we will work with, clinicians, consumers and partners to design and drive evidence based innovation to ensure appropriate, effective and sustainable patient centred health care” (ACI NSW, 2012). The ACI commitment to supporting knowledge translation also binds the organisations involved in the current research—ParaQuad NSW and MS Australia—because they are stakeholder members of the ACI.

Knowledge translation targets a wide range of stakeholders. In a review of knowledge translation research, Grimshaw, Eccles, Lavis, Hill and Squires (2012)

concluded that “knowledge translation targeting professionals should result in practice that is more evidence-based and is likely to be observable as reflected in changes in professional behaviours and quality indicators” (p. 14). When knowledge translation is adopted as a principle of clinical practice, catheter selection will incorporate the use of evidence-based practice; however, clinical expertise and uptake of research is influenced by the availability of evidence and practical, context-based limitations on how it can be translated into clinical practice.

Several theorists have suggested strategies to translate knowledge into practice, and highlighted the processes that need to occur to manage change in clinical reasoning. Rogers (1995) presented the concept of diffusion of innovation to explain the dissemination and uptake of knowledge. Rogers (1995) stated that “the essence of the diffusion process is the information exchange” (p. 18)—that is, the focus is on communication, and how information spreads through a group. Rogers proposed that clinicians need to:

1. learn the innovation
2. form an attitude about the innovation
3. agree to adopt or reject the innovation
4. implement the innovation
5. affirm the innovation.

Rogers (1995) further noted variations in the frequency of innovation adoption—some occurred quickly, while others took longer; however, at a certain point, enough people had adopted the change for the rest to follow. The personal appraisal for adopting the innovation generally occurred through communication with similar people, rather than through synthesis of scientific research (Rogers, 1995).

Around the same time that Roger's (1995) work was occurring, a similar study by Pathman, Konrad, Freed, Freeman and Koch (1996) found "that there are sequential, cognitive, and behavioural steps physicians make as they comply with guidelines" (p. 874). To test this theory, Pathman et al. (1996) proposed the awareness-to-adherence model to investigate physicians' compliance to national paediatric vaccination recommendations. The awareness-to-adherence model is associated with the uptake by clinicians of clinical guidelines, and involves awareness of the guideline, agreement with the evidence and practice suggestions, adoption of the guideline into practice, and adherence to the guideline as part of ongoing practice. Failure to progress through the awareness-to-adherence model can occur at any time along this continuum. Pathman et al. (1996) claimed that factors that enhance or block progression along these steps include "physician characteristics, patient characteristics, practice characteristics, practice immunization policies and environmental features" (p. 875).

More recently, Mickan, Burls and Glasziou (2011) investigated "evidence in different settings on the patterns of "leakage" in the utilisation of clinical guidelines using Pathman's awareness-to-adherence model" (p. 1) and, in accord with the earlier work of Pathman et al. (1996), proposed the model to be applicable across health domains and specialities to assist in implementing clinical guidelines. Mickan et al. (2011) agreed that failure to progress along the steps of Pathman's awareness-to-adherence model can occur at any step. They suggested that "cumulative leakage is substantial and suggests that guidelines may not be being adhered to about two-thirds of the time—a significant loss in potential health gain to patients" (Mickan et al., 2011, p. 7). In relation to the current research into guidelines for catheter selection, this would suggest that there are macro and micro influences on catheter selection knowledge translation that may have either a positive or negative effect on the adoption of evidence

and adherence to recommendations in everyday practice. In addition, it indicates that it cannot be assumed that there is ongoing adherence to catheter selection evidence and guidelines.

Both the Rogers (1995) diffusion of innovation and Pathman et al. (1996) awareness-to-adherence models share a concern regarding how knowledge is spread and adhered to, rather than focusing on the creation of knowledge. That is, they consider how clinicians take up and use knowledge, and whether they commit to adhering to that change in practice.

When reviewing knowledge translation, Graham et al. (2006) proposed the 'knowledge-to-action process', which has, as its core, a mechanism for the creation of knowledge by clinicians. It identifies three of layers knowledge creation: (i) knowledge enquiry, (ii) synthesis of existing evidence and (iii) knowledge tools that are tailored to needs in daily practice. The cyclic process surrounding knowledge creation includes identification, adaption, assessing barriers, tailoring implementation, monitoring use, evaluating outcomes associated with implementation, and sustaining the implemented knowledge (Graham et al., 2006). The knowledge-to-action process by Graham et al. (2006) is not dissimilar to Pathman et al.'s (1996) awareness-to-adaption model; however, greater emphasis is placed on the creation and tailoring of knowledge within support tools, and further design of implementation interventions that aid adherence and sustainability. The importance of tailoring was further highlighted by Grimshaw et al. (2012), who claimed that knowledge translation addresses who is receiving what and how. They recommended that successful knowledge translation is dependent on assessing the associated barriers to the knowledge in order to inform knowledge translation strategies.

Although Pathman et al. (1996), Rogers (1995) and Graham et al. (2006) identified varying depths in the change process, the models are similar in highlighting three stages as essential elements for the change process to be considered effective, as follows: (i) clinicians having awareness of a need of change; (ii) trialling the change; and (iii) assessing, implementing and adhering to the change. In the case of registered nurses working at residential care facilities and catering to the specialised needs of the target group in the current study, the change process for catheter management and selection is also influenced by internal policies and procedures. These relate to tailoring and implementing evidence and clinical practice guidelines, and having access to a decision support tool for catheter selection.

According to Straus, Tetroe and Graham (2009), circulation of facts is insufficient to ensure translation of knowledge. They stressed the importance of using knowledge in clinical reasoning during the change process: “Knowledge translation involves using high-quality knowledge in the process of decision making” (Straus et al., 2009, p. 165). Further, Sniderman, Lachapelle, Rachon and Furberg (2013) proposed that the gap between incomplete research evidence and everyday practice is bridged through clinical reasoning. When this process of knowledge translation does not occur, the client may not receive care that incorporates the perceived benefits of the latest evidence or recommended guidelines, thereby increasing the risk of suboptimal care to the client (Graham et al., 2006). In the case of catheter selection, failure in knowledge translation may be associated with the use of a catheter that does not facilitate urine flow or minimise urethral trauma irritation in the specific circumstances of the individual patient. Davis et al. (2003) claimed that, “knowledge translation focuses on health outcomes and changing behaviour; it is set in the site of practice and its social, organisational, and policy environment rather than in learning situations” (p. 34).

For knowledge translation to occur, registered nurses need to engage with and critique research evidence and guidelines in relation to their clients' needs through applying clinical reasoning. Evidence-based practice is integral to the change process for clinicians; however, for some time, it has been difficult to implement. In Australia, Retsas (2000) examined the barriers to using research evidence among 400 hospital-based registered nurses, and found time to be the largest barrier to participating in and using research. Of interest, the fourth-largest barrier was related to understanding the relevance of results for implementation. Retsas (2000) suggested that, "if research teaching improved, the confidence nurses have in their ability to evaluate the quality of research studies and to recognise the extent to which findings can be translated to their settings, may also improve" (p. 605). Around the same time, Thompson et al. (2001) investigated the knowledge information sources of 61 United Kingdom hospital-based nurses, and found that nurses sourced information from specialists or experienced clinicians, rather than from published research. They also found that nurses claimed that information sourced from experienced nurses was trusted, with little critical evaluation. In a later study by Randell, Mitchell, Thompson, McCaughan and Dowding (2009), 76 primary care nurses were studied in relation to their use of electronic databases, and the results indicated that, in general, electronic databases were not considered a way to access information to inform daily clinical decision making. Rather, they were considered a source of information when studying. The researchers recommended further research to address the success of systems that seamlessly integrate research evidence into nursing-specific clinical reasoning. While that study was completed six years ago and technology has made significant advances since then, the attitudes of nurses as technology users in the workplace may not have kept pace.

Although synthesis and use of research evidence forms part of the various education programs pertaining to nursing, studies of the use of research in nursing—both in Australia and abroad—continue to warrant concern. An Australian study of 590 nurses working in a rural setting explored nurses' sources of knowledge for evidence-based practice, and found that rural practice nurses were lacking in the skills to systematically search and evaluate research for practice implementation (Mills, Field, & Cant, 2011b). As an extension to this study, the researchers also explored the barriers to knowledge translation of the same participants, finding that nurses compensated for their reduced skills by systematically searching and evaluating research via engaging with other health professionals, coupled with using intuition and fundamental nursing knowledge to reach a clinical decision. This barrier to knowledge translation was mirrored in a more recent European study by Bringsvor, Bentsen and Berland (2014), who explored sources of knowledge used by nurses working in intensive care. They found that a relationship existed between nurses' education level and reduced skills in systematically appraising research, as all participants were experienced in intensive care nursing, yet none had a masters or doctoral degree. With regard to the current study, the registered nurses working in specialised residential care facilities, providing complex management to people with spinal cord injury or multiple sclerosis, must possess knowledge of current best practice in catheter selection. Thus, it is important to understand the educational qualifications of the participating nurses.

Using research evidence in everyday practice requires greater effort than merely recognising or defining what knowledge translation is. The processes associated with knowledge translation need to overcome barriers to identifying and using research evidence and guidelines in everyday practice. In addition, changes in clinical practices require more than lecture-style education; thus, strategies aimed at changing behaviour

through knowledge translation need to understand the learning needs of the person receiving the education (Davis et al., 2003). Uptake of new knowledge is not only related to how it is disseminated, but also to how individuals learn. According to constructivist education theory, learners build knowledge through developing understanding of their experiences (Rolloff, 2010). Further, the process of making sense of experience requires both self-evaluation of those experiences, and practising a skill that involves evaluation and the opportunity for positive and negative feedback (Moore Jr, Green, & Gallis, 2009). Constructivist education goals aligned to nursing incorporate the development of skills in decision making, collaboration and investigation, which are essential to the implementation of evidence-based practice (Rolloff, 2010).

A common theme throughout these educational approaches is that learning requires contemporary reflection, constructive feedback and active learning, in an ongoing cycle in which knowledge can continue to develop and add to an expanding knowledge base. As described by Levett-Jones et al. (2010), the theoretical framework of the clinical reasoning cycle provides some guidance on investigating the effect of new knowledge acquisition on nurses following a urinary catheter selection education session.

Kolb's (1984) experiential learning theory is a theoretical model of adult learning that addresses aspects of reflective learning and feedback through active experience. Kolb's theory has four cyclical learning stages: concrete experience, reflective observation, abstract conceptualisation and active experience. Learning is viewed as a process of experience, while knowledge is created through the transformation of experience (Kolb, 1984). The learner is regarded an active participant, and learning is built through experience and reflection, making this conceptualisation of learning suitable for adults—and particularly for adults involved in a professionally

skilled activity, such as nursing. Thus, Kolb's theory provides the conceptual framework to guide this research.

Both recent and historical studies (Bringsvor et al., 2014; Mills, Field, & Cant, 2011a; Mills et al., 2011b; Retsas, 2000) have identified that a barrier to knowledge transition is the ability of nurses to synthesise quality research evidence and guidelines into everyday practice. However, once knowledge translation of a practice has occurred, the focus is then centred on sustaining that change during practice. The current research investigates the contemporary catheter selection knowledge of registered nurses who provide care for people with complex needs in a residential care facility. Kolb's (1984) experiential learning theory provides a framework that supports practice development intervention by using a decision support tool that promotes knowledge translation by providing readily accessible reference material on catheter selection. In addition, it fosters ongoing sustainability of clinician acceptance and use of current information in catheter selection.

2.5 Decision Support Tools

Various education strategies have been used to implement, support and sustain change, including the development of decision support tools. A clear example of a decision support tool is the Nursing and Midwifery Board of Australia's (2010) *Nursing Practice Decision Summary Guide* (see Appendix C), which is a generic tool to guide nursing practice decisions. Decision support tools are widely available in nursing, with numerous examples in specialised fields, such as continence management and assessment. Following a review of nurses' decision making during critical events, Thompson et al. (2009) identified the use of decision support tools as a bridge between linear reasoning and expert intuition. In investigating the use of decision support tools, following interviews with 76 practice nurses and observations of 410 nursing

consultations, they noted that, while many decision support tools are available to nurses, nurses' use of these tools was limited. They further noted that, when clinical situations arose, clinical nurses tended to rely on their past experience, rather than on decision support tools.

The issue of nurses' use of support tools may relate to the type, complexity and availability of these tools. As a guide to the development of a continence assessment tool, Winder (2001) claimed that tools need to be "clear in content, comprehensive to the variables being measured, time efficient and link responses of data to treatment plans" (p. 946). Educational strategies using decision supports tools to aid knowledge translation need to ensure that the information being communicated through the decision support tool is clear and accurate. Chapman (2007) claimed that using decision support tools resulted in improvements in decision making through changes in clinical reasoning, when knowledge supporting the clinical assessment was available. Cranney & Walley (1996) showed that the presentation of information in different ways led clinicians to reach different conclusions from the same data.

A recent study by Holland et al. (2014) investigated clinical decision making in relation to 79 paediatric clients' discharge needs, and demonstrated reduced variability of clinical decision accuracy when a clinician used a decision support tool. These findings are consistent with earlier studies, such as that by Horowitz et al. (2007), who evaluated the use of a clinical decision support model for upper abdominal gastrointestinal complaints in primary care practice. They found improvements in symptom severity and quality of life when the decision support model was used, and concluded that, "assimilation and implementation of new strategies are only possible when a well-designed intervention is used and that the use of a clinical decision support tool can facilitate and promote the implementation and management guidelines"

(Horowitz et al., 2007, p. 1282). Gotelli et al. (2008) demonstrated a reduction in catheter usage through the use of a decision support tool that empowered nurses to assess and manage the duration of indwelling catheter usage. Sheldon, Belan, Neill and Rowland (2009) argued that existing tools for identifying risk level associated with obstructive sleep apnoea lie outside a nurse's scope of practice. Consequently, they developed a nurse decision support tool to assist registered nurses to identify clients at risk of obstructive sleep apnoea, who needed referral to medical staff to improve clinical outcomes.

From the research reviewed, it is clear that decision support tools need to be factually accurate in order to guide practitioners to make decisions that benefit care recipients. In addition, it is important that such tools are accessible in terms of ease of use because a tool that is complicated or time consuming will not be used. The design of the tool also needs to consolidate research evidence in a manner that assists clinicians to be readily able to apply this evidence to situations requiring a clinical decision. In this research, the catheter selection tool, the Catheter Compass™ (Wicks, 2009) (see Appendix D) was used as part of the education intervention. The tool was developed based on research evidence and expert clinical opinion, and circulated to expert clinicians and the Continence Foundation NSW for content validation, prior to being launched at the 2009 Continence Foundation Australia national conference. The Catheter Compass™ decision support tool builds on steps encapsulated in the clinical reasoning cycle, and requires clinicians to critically evaluate clients' symptoms related to urine flow, such as the presence of sediment in the urine. It then links the symptoms to catheter characteristics and features in order to facilitate the selection of a catheter that best suits the assessed needs of individual clients. Both government and non-government agencies across Australia have requested education in the use of the

Catheter Compass™ to assist clinicians to understand catheter characteristics and explore their relationship to urinary complications.

2.6 Catheter-associated Problems among Target Client Group

2.6.1 Spinal cord injury. The last recorded national statistics for incidence of spinal cord injury in Australia indicated that, in 2007, there were 362 new spinal cord injuries, 21% of which were not related to traumatic injury (Norton, 2010). There is no available national database record of the number people living in Australia with spinal cord injury. Spinal cord injuries require complex care, and registered nurses working in this context need to understand how the nuances of spinal cord injury management affect their clinical reasoning associated with client assessment processes. Traumatic spinal cord injuries generally result in patients having a long-term reflexic or areflexic bladder. Cord injuries above lumbar vertebrae one (L1) initially result in an areflexic bladder due to spinal shock (Linsenmeyer et al., 2006). Spinal shock resolution in injuries above L1 results in unbounded bladder contractions, with high bladder pressures and detrusor sphincter dyssynergia noted in many patients (Linsenmeyer et al., 2006). Alternatively, the outcome for injuries below L1 is an areflexic bladder. The goals of urinary continence management for those with a spinal cord injury were identified some years ago by Linsenmeyer et al. (2006) as “to preserve the upper tracts, minimise lower tract complications and be compatible with a person’s lifestyle choices” (p. 13). These are still regarded as good practice by clinicians involved in this field of practice. To achieve these goals, intermittent or indwelling catheterisation may be needed, and clinicians will need a high level of competency in spinal cord injury management to make astute clinical decisions and recommendations to clients.

2.6.2 Urinary complications from catheter use by people with a spinal cord injury. Under normal circumstances, urination removes transient bacteria from the

bladder (Paul, 2005). Symptom relief for those with neurogenic incontinence, resulting in bladder over distension, is generally achieved through the use of an indwelling or intermittent catheter. However, the insertion of an indwelling catheter allows the bladder to become colonised because the removal of transient bacteria via urination is compromised. Urinary complications can lead to the prospect of urinary tract infections for those with a spinal cord injury or disease. These complications can include “bladder over distension from urinary retention, vesicoureteral reflux, high detrusor pressures, chronic stone disease, and various forms of resultant bladder outlet obstruction, such as detrusor sphincter dyssynergia, strictures, and instrumentation” (Samson & Cardenas, 2007, p. 269). Further, “persistent bacteriuria is not uncommon in patients who have SCI [spinal cord injury] and asymptomatic bacteriuria is often found regardless of the type of bladder management” (Samson & Cardenas, 2007, p. 269).

A retrospective review by Middleton et al. (2012) examined 50 years of medical records of people living with a spinal cord injury who had been admitted to a single spinal unit in Australia reinforced the necessity for continued vigilant review of the following key clinical risk areas across the lifespan of people with a spinal cord injury: respiratory management, urinary management and psychosocial management. Urinary complications occur more frequently for people with a spinal cord injury or disease than among the general population. A systematic review of urinary complications, excluding urinary tract infection for indwelling catheter users, included both spinal cord injury and non-spinal cord injury clients, and found that, “long-term catheterisation and catheter use in patients with SCI [spinal cord injury] result in even greater illness, with more than 30% of patients having several complications” (Hollingsworth et al., 2013, p. 408). Unfortunately, the study did not specify whether their use of the term ‘spinal cord injury’ was inclusive or exclusive of spinal cord disease.

Katsumi, Kalisvaart, Ronningen and Hovey (2010) compared urological complications among spinal cord injured people who used urethral catheters, and spinal cord injured people who used suprapubic catheters. The study was a retrospective analysis of 179 patients' charts, drawn from a veterans' spinal unit in America, between 1945 and 2007 (including only one female in the study). The urological complications reviewed and compared by Katsumi et al. (2010) were urinary tract infection, bladder stones, renal calculi, urethral stricture, urethral fistula, scrotal abscess, epididymitis, gross haematuria, cancer and catheter-specific complications (such as urethral erosion, urethral leak, and leakage around the suprapubic catheter). They concluded that there was no statistically significant difference between the two groups for urinary tract infection, recurrent bladder, renal calculi or development of cancer. They recommended that, "bladder management should be selected on the basis of long term comfort for the patient" (Katsumi et al., 2010, p. 325).

Earlier research by Sugimura, Arnold, English and Moore (2008) analysed the incidence of urinary tract complications in spinal cord injured people who used chronic suprapubic catheterisation, from a retrospective study of 1,018 patients' notes from a New Zealand spinal unit, where 149 patients met the inclusion criteria. The results from Sugimura et al. (2008) showed that 49% had no urinary complications, 27% had symptomatic urinary tract infection, 22% had bladder stones, 6% had renal scarring and 14% developed vesicoureteral reflux. Sugimura et al. compared these findings with various international results for spinal cord injured people, and found the New Zealand experiences to be equal or less frequent to comparative studies.

The later study by Katsumi et al. (2010) found that 93.2% of urethral catheter users and 97.9% of suprapubic catheter users had experienced at least one symptomatic urinary tract infection, and that recurrent bladder stones had occurred in 38% of the

urethral catheter group and 41.3% of the suprapubic catheter group. The percentages of those using a suprapubic catheter who had experienced bladder stones were higher than those found by Sugimura et al. (2008), who noted that all patients in their study had their suprapubic catheter irrigated weekly, and their catheter changed every two weeks. Given that Katsumi et al. (2010) did not indicate the management protocol of the participants reviewed, it is unclear whether this study was influenced by Sugimura et al.'s (2008) catheter management protocol.

Singh et al. (2011) conducted a prospective study of 545 patients from a single tertiary referral centre in India, between 1995 and 2007, in order to assess and compare the different types of bladder management in relation to urinary tract infection and other urological complications. They defined the bacterial colony count for both symptomatic and asymptomatic urinary tract infection, and also went on to define the additional criteria for symptomatic urinary tract infection as the presence of two of the following: "distension, increased urinary incontinence, increased spasm, autonomic dysreflexia, increased sweat or malaise" (Singh et al., 2011, p. 143). In their study, 84% of participants experienced discharge around the catheter, 30.8% experienced frequent catheter blockages, 44% experienced haematuria in the indwelling catheter, and there was incidence of urinary tract infection at 2.68 per 100 person-days (Singh et al.). They stated that, "[t]he passage of amorphous material in the urine was observed in almost all the patients on indwelling catheterisation" (Singh et al., 2011, p. 143; Paul, 2005) claimed that, "[obstruction is often caused by a combination of precipitated crystals, bio-film, Tamm-Horsfall protein (antibacterial mucus normally made in the kidneys) and bacteria" (p. 6). However, Singh et al. (2011) did not define the 'amorphous material' they observed in indwelling catheters, and it is unclear whether this could have triggered catheter blockages. Regardless, the 'amorphous material' noted by Singh et al.

(2011) would need to be managed by the clinician as part of the catheter management program for each individual client.

Wilde et al. (2010) reviewed the incidence and distribution of catheter-related problems in long-term indwelling catheter users. Participants were allotted to two groups: group one had no spinal injured clients, while group two (33 participants) all had spinal cord injuries. Urethral and suprapubic catheters were evenly distributed across the groups. Wilde et al. (2010) stated that, “70% reported symptomatic treated urinary tract infection, 74% reported catheter blockages and 79% reported leakage” (p. 301). In comparison to the work of Sugimura et al. (2008), Wilde et al. found that a much larger percentage of participants experienced symptomatic urinary tract infection. Wilde et al. (2010) stated that, “while most people (58%) did not irrigate the catheter at all, 40% did; some preventatively and some to treat actual catheter blockages” (p. 306). Neither Sugimura et al. (2008) nor Wilde et al. (2010) defined the quantity of fluid used for catheter irrigation, and, in Wilde et al.’s study, it is unclear whether these were true irrigations or catheter flushing in response to catheter blockage episodes.

Urinary complications associated with catheter use for those with a spinal cord injury are common. The articles reviewed (Hollingsworth et al., 2013; Katsumi et al., 2010; Singh et al., 2011; Sugimura et al., 2008; Wilde et al., 2010) did not identify the type of catheter used in relation to urinary complications. Paul (2005) stated that, “in an attempt to reduce bacterial adhesion, materials such as Teflon and silicon have been used in catheter construction, but no reduction in UTI [urinary tract infection] incidence has been shown” (p. 5). Paul (2005) claimed that, “frequent routine catheter change and a silicon catheter may reduce urinary catheter blockages if this is the cause of their recurrent UTI’s” (p. 5). These claims regarding silicon were not clarified in terms of the benefit of reduced catheter blockage frequency due to bacterial adhesion or the size of

the internal lumen of the silicon catheter; however, the selection of the appropriate catheter would need to be based on clinical assessment. However, not all urinary complications are related to catheter selection.

After discharge, a significant number of clients with spinal cord injury adapt their continence management program to suit their changed circumstances. This was demonstrated by Cameron et al. (2010), who reviewed bladder management in spinal cord injured people across 33 years. Cameron et al. found that 71% of people continued using indwelling catheterisation at 30 years post-discharge, 20% of people who were discharged on clean intermittent catheters continued using clean intermittent catheters, and 34% of people discharged on male sheaths remained on male sheaths. The reasons for these changes were not explored; however, various clinical reasons were suggested, such as the availability of carers, abdominal girth, the necessity of sphincterotomy review and the ease of catheter use.

Another study by Hansen, Biering-Sørensen and Kristensen (2004) also investigated long-term bladder emptying by reviewing clients who were between 10 and 45 years post-spinal cord injury, and claimed that, “changing of bladder-emptying method among SCI [spinal cord injury] individuals over time is common” (p. 636). Both Cameron et al. (2010) and Hansen et al. (2004) found that a significant number of clients with spinal cord injury adapted their continence management program after discharge to suit their changed circumstances. The frequency of changing from intermittent back to indwelling catheterisation after discharge has remained fairly constant over the years, and is consistent with the findings of Yavuzer et al. (2000), who identified the reason for change as being “dependence on care givers, severe spasticity interfering with catheterisation, incontinence despite anticholinergic agents and, for female patients, the inconvenience of external collective devices” (p. 762). A recent

study by Akkoç et al. (2013) also examined quality of life scores of 195 people with a spinal injury in relation to bladder management. They concluded that those managing their bladder with intermittent catheterisation had a poorer quality of life than did people living with a spinal cord injury who used an alternative bladder management technique that may hold increased risk of complications. Of note, a study by Zhang and Liao (2014) that sought to predict risk factors of upper urinary tract deterioration in people with spinal cord injury noted that the most significant risk factor related to long-term indwelling urethral catheterisation.

Based on the above findings, holistic continence assessment and associated continence management plans need to be reviewed and adjusted throughout a person's lifespan to accommodate changes in physical comfort, lifestyle factors and concurrent health problems. Without current awareness and use of contemporary catheter selection information, registered nurses are at a disadvantage in being able to provide this level of client care—a factor supporting the approach taken in the current study to investigate an attempt to improve nurses' skills and knowledge in catheter selection.

2.6.3 Multiple sclerosis. In the context of the current study, spinal cord injury includes damage caused by both disease and trauma. The most recent Australian estimates regarding incidence of multiple sclerosis showed that, in 2009, 23,700 people in Australia ($\approx 0.1\%$ of the population) were living with multiple sclerosis (Bureau of Statistics, 2012). Seth et al. (2010) described multiple sclerosis as a degenerative demyelinating disease with symptom intensity related to the rigor and location of the lesion. Fowler et al. (2009) earlier stated that, in relation to multiple sclerosis:

There is strong clinical evidence that lower urinary tract dysfunction is mainly the result of spinal cord disease and thus the several types of resulting bladder dysfunction are those known to result from disconnection between the centres in

the brainstem, critical to neurological control, and the sacral part of the spinal cord. (p. 552)

For clinicians, this indicates that, although the root cause of bladder dysfunction between spinal cord injuries and multiple sclerosis is different, the proximate cause is essentially the same—that is, failure of neural control via the spinal cord over the reflex voiding centre, or failure of the reflex voiding centre located in the sacral portion of the spinal cord. Due to the degenerative nature of multiple sclerosis, bladder management techniques need to be routinely reassessed against the burden of disability (Rantell, 2009). Central to this clinical process is the ability of clinicians to appropriately select and use catheters that are effective and have been shown to minimise harm.

2.6.4 Urinary complications associated with multiple sclerosis. De Ridder et al. (2005) recognised that urinary complications associated with catheter use are common for people with multiple sclerosis, such as “recurrent catheter blockages, persistent incontinence, chronic bacteriuria and infection, bladder stone formation and haematuria” (p. 694). However, they claimed that clinicians are poorly informed about these common complications. The United Kingdom’s National Institute for Health and Clinical Excellence developed recommendations and consensus guidelines on the management of the bladder in multiple sclerosis, recommending the need for intermittent self-catheterisation for those with repeated residual volumes post void, and, when physically unable to continue performing intermittent self-catheterisation, to use an indwelling catheter (Fowler et al., 2009). Further, Fowler et al. (2009) recommended suprapubic catheterisation over indwelling urethral catheterisation in the long term due to progressive urethral damage observed in multiple sclerosis. In regard to catheter selection, Fowler et al. (2009) proposed that, “choice of the type of catheter may

determine the incidence of urinary tract infections and consideration should be given to the individual's propensity to develop catheter blockage and encrustation" (p. 255).

Limited research is available regarding the urological management of people with multiple sclerosis. In a review of the available literature for developing evidence-based guidelines for the urological care of multiple sclerosis, De Ridder et al. (2005) claimed that, "in many instances, specific MS [multiple sclerosis] literature was not available and analogies were sought in the spinal cord literature" (p. 695). The guidelines outlined by Fowler et al. (2009) occurred well after the review by De Ridder et al. (2005), with both authors presenting a review and recommendations. De Ridder et al. (2005) claimed that, "bladder management in advanced MS is based on tradition rather than on the evidence" (p. 698). Without the availability of specific evidence of practice and reliability on traditional methods, clinicians need to be knowledgeable in contemporary catheter selection to effectively manage catheterisation care for people with multiple sclerosis. As part of the process of validating the bladder bowel subscale used in North American research on multiple sclerosis, Marrie, Cutter, Tyry, Vollmer and Campagnolo (2007) surveyed 9,688 people with multiple sclerosis. They stated that, "[r]eported symptoms were urinary frequency by 1,503 (16.5%), urgency by 1,553 (17.0%), urge incontinence by 763 (8.4%), difficulty with bladder emptying by 1,137 (12.5%) and nocturia by 1,906 (20.9%) participants" (Marrie et al., 2007). Marrie et al. (2007) also collected data on the frequency of urinary tract infections, finding that, "urinary tract infections (UTI's) were common: 6,184 (64.6%) participants reported at least one UTI in the last six months, of whom 470 of (7.6%) had three or more" (p. 1975).

De Sèze, Ruffion, Denys, Joseph and Perrouin-Verbe (2007) reviewed the existing literature on urinary dysfunction assessment in multiple sclerosis as a basis for

clinical management guidelines. They concluded that, “more than one patient out of ten is likely to develop an upper urinary tract complication during the first 18 years of disease duration” (de Sèze et al., 2007, p. 926). Around 15 years ago, Hillman, Burns and Kraft (2000) provided a case study review of a person with multiple sclerosis with a 31-year history of neurogenic incontinence, and found that deterioration in neurological status was strongly associated with severe urinary tract infection. Later, Fowler et al. (2009) built on this finding and highlighted the risk that multiple sclerosis neurological symptoms may deteriorate acutely when a person has an infection or fever.

The neurological effects of multiple sclerosis were the focus of several major studies a decade ago. For example, Achiron et al. (2005) surveyed 150 consecutive patients for cognitive patterns and disease progression in multiple sclerosis. In their findings, they stated that, “patients within MS demonstrate dynamic and differential decline in cognitive function” (Achiron et al., 2005, p. 747). Cognitive decline among people with multiple sclerosis needs to be considered by clinicians in relation to adherence to bladder management programs. Intermittent self-catheterisation should be avoided in people with poor motivation, cognition or willingness to follow an intermittent catheterisation program (Linsenmeyer et al., 2006). Fowler et al. (2009) recommended the use of a suprapubic catheter in this client group when intermittent catheterisation is no longer viable. In a later study examining the issue of intermittent self-catheterisation by people with multiple sclerosis, Seth et al. (2010) recommended that self-catheterisation only be used by people with sufficient vision, dexterity and motivation.

In the current study, the research and guidelines reviewed in the process of developing the catheter selection decision support tool indicated that the proximal cause of urinary incontinence in multiple sclerosis is the same as for spinal cord injury;

however, the features of the disease process of multiple sclerosis are different. Consequently, nurses managing clients with multiple sclerosis require a comprehensive understanding of the degenerative process of multiple sclerosis, and an informed awareness of catheter characteristics and features, so that they may apply clinical reasoning to address the specific needs of clients with multiple sclerosis as these needs change across their lifespan.

2.7 Urinary Catheter Considerations

Clinicians considering a catheter for selection examine the catheter's Fg, length and balloon capacity (Godfrey & Evans, 2000; Pomfret, 1996). Contemporary catheters are created and marketed with one or more of the following catheter features: silicon, latex, hydrogel coated, silver coated, glass, registered reusable, hydrophilic, polished or hole-punched eyelets, pre-lubricated, enclosed, non-touch, straight tipped, coude tipped, olive tipped, coude/olive tipped or tieman tipped. All of their detailed information is included when nurses consider selection, usage and maintenance of the catheter. Pratt and Pellowe (2010) suggested that, "choice of which catheter to use should depend on patient assessment and duration of catheterisation" (p. 28), and further stated that, "a catheter of the smallest gauge possible and a 10 ml balloon should be selected as this will minimise urethral trauma, mucosal irritation and residual urine in the bladder, all contributory factors to the development of CAUTI" (p. 28). In preparing and developing the decision support tool for the current study, various information sources regarding the perceived benefits of catheter features were reviewed, along with guidelines related to catheter selection and CAUTI (see Appendix A).

It was estimated in Australia in 2010 that there were 4.2 million people over 15 years living in the community with urinary incontinence, and it was further estimated that this would reach 5.6 million people by 2030 (Deloitte Access Economics Pty Ltd,

2011). Gardner, Mitchell, Beckingham and Fasugba (2014) stated that, “at present, there is no national or state level surveillance for HAUTIs [hospital-acquired urinary tract infections] in Australian hospitals” (p. 2). Gardner et al. (2014) conducted a preliminary study across six hospitals in Australia, with 1,109 participants, in order to establish the prevalence of hospital-acquired urinary tract infections and CAUTI in those six hospitals. They found that, “[t]he overall prevalence of HAUTI was 1.4% (15/1109) and the prevalence of CAUTI was 0.9% (10)” (Gardner et al., 2014, p. 3). In the United States, it is estimated that catheter-associated bacteriuria accounts for 40% of all hospital-acquired infections, and is the most frequent healthcare-associated infection worldwide (Hooton et al., 2010).

To reduce the incidence of CAUTI, the current clinical trend is to reduce the use of indwelling urethral catheterisation in favour of condom drainage or intermittent self-catheterisation (Gould, Umscheid, Agarwal, Kuntz, & Pegues, 2010; Hooton et al., 2010; Mitchell et al., 2011). While avoiding indwelling catheterisation is the main option for reducing the risk of colonisation to the bladder, unfortunately, those living with a spinal cord injury or disease using intermittent catheterisation or condom drainage continue to be at risk of urinary tract infection related to urinary complications (Samson & Cardenas, 2007). To facilitate condom drainage in people with spinal cord injury or multiple sclerosis, clients require a bladder that is contractile and a detrusor sphincter that is not overactive (Linsenmeyer et al., 2006). The occurrence of an overactive detrusor sphincter in people with an upper motor neuron bladder related to spinal cord injury or disease is common (Linsenmeyer et al., 2006). Intermittent self-catheterisation is widely used in spinal cord injury or disease; however, it requires clients to perform their own intermittent self-catheterisation, which requires dexterity

and balance. This is an issue in itself because the level of dexterity and balance is related to the severity and level of spinal cord injury or disease.

A recent study by Afsar, Yemisci, Cosar and Cetin (2013) investigated client adherence to recommended procedures of 164 new spinal cord injured clients up to seven years following discharge. They found that 42% of people performing intermittent catheterisation changed their bladder management technique, and 21.4% reverted to indwelling catheterisation. They stated that, “The reasons for changing the method were reported as; recurrent symptomatic UTIs, incontinence, nephrolithiasis, dependence on caregivers and urethral strictures” (Afsar et al., 2013, p. 647).

Hollingsworth et al. (2013) stated that, while “[t]he epidemiology of CAUTI is well described, insufficient attention has been paid to non-infectious complications” (p. 401). Hollingsworth et al.’s (2013) systematic review and meta-analysis of 37 studies, ranging between 1985 and 2011, demonstrated a high frequency of non-infectious complications related to indwelling catheter use. They further claimed that, “most frequent complications are minor (for example, leakage around the catheter), serious complications such as urethral strictures and gross haematuria, occur in a substantial proportion” (Hollingsworth et al., 2013, p. 408). Leuck et al. (2012) investigated genitourinary trauma associated with Foley catheter use and claimed that, “ridging, which was noted 36 times (0.6% of FC [Foley Catheter] days), was associated with pain, bleeding or difficult FC removal in all but 1 instances” (p. 1664). Unfortunately, Leuck’s team did not report the type of Foley catheter used, or indicate if the Foley catheter used was registered as having reduced ridging on deflation. Thus, it is impossible to determine if difficult removal is related to the insertion or removal skills of the clinician, or inappropriate catheter selection choice.

Aaronson, Wu, Blaschko, McAninch and Garcia (2011) investigated the effect of non-infectious urethral catheter-related problems across California, identifying 1,420 cases. The type of non-infectious urethral catheter-related complication was not identified in the study, but rather the incidence and associated increase in length of hospital stay. They found that, “[t]he one size fits all mentality for placement of a urethral catheter may be cheaper for the hospital, but is not a rational policy” (Aaronson et al., 2011, p.1759), and justified this through the rationalisation of catheter features and individual client needs, such as those clients with an enlarged prostate and need for coude tip. Strategies identified to reduce non-infectious urethral catheter complication included education in catheter insertion management and catheter selection (Aaronson et al., 2011). Later, Wilde et al. (2013) investigated both the urinary tract infection rate of 202 community-based indwelling catheter users, and the frequency of non-infectious indwelling catheter complications. They found that, while they varied in their primary diagnosis, a total of 63% of users either had spinal cord injury or multiple sclerosis. The non-infectious indwelling catheter complications included “blockage, dislodgement, leaking, sediment, kink/twists, bladder spasm and autonomic dysreflexia” (Wilde et al., 2013, p. 361). Despite Wilde et al. (2013) calling for improvement in catheter management practices other than balloon size and Fg size, they did not investigate the type of catheter used by each client as part of their research.

Generally speaking, the evidence from previously published research is that different types of catheters will result in different clinical outcomes; thus, there is no standard catheter that will suit everyone. Clinical reasoning around catheter selection requires individual assessment based on clinical knowledge that incorporates detailed understanding of the type of equipment that would best be applied to particular clinical situations and individual patient characteristics. Previous research reaching back

decades suggests that clinical nurses with responsibility for catheter selection in particular clinical situations may be unprepared in terms of the skills and knowledge to make such decisions.

This current study builds on the early work of Dobson et al. (1996), Fleming et al. (2000) and other international research to investigate the catheter selection knowledge of a cohort of registered nurses working in a unique and specialised clinical context. It examines these nurses' capacity to assume that knowledge and incorporate it into their repertoire of information supporting catheter selection.

2.8 Role of the Registered Nurse in Catheter Selection

Ongoing catheterisation (removal and insertion of a new catheter) is performed by many different categories of people in Australia. For example, in the Royal North Shore Hospital in Sydney, routine catheter changes are performed by trained surgical dressers (hospital aids) (The Royal North Shore Hospital Spinal Cord Injury Outpatient Services, 2010). In the Sydney metropolitan catchment area, routine catheter changes are performed by registered nurses who work for community health agencies and/or private agencies, assistants in nursing who work for private carer/nursing agencies, general medical and nurse practitioners, and family members (ACI Urology Network—Nursing, 2014; ANZUNS Catheterisation Working Party, 2013; The Children's Hospital at Westmead, 2012). In Ferguson Lodge and the Studdy MS Centre—Residential Care Unit, routine and emergency catheter changes are performed by registered nurses, while intermittent catheter changes are performed by the client, following education and competency assessment by a registered nurse.

It is widely known that urinary complications can be associated with the use of urinary catheters (Nazarko, 2010). Nurses are routinely responsible for catheterisation

and ongoing catheter management; however, according to Robinson (2006), competency training is essential for this skill to be successful. Robinson also claimed that inappropriate catheter selection is related to selection of the wrong length, wrong material and wrong Fg, as well as incorrect inflating of the balloon. In addition, Robinson recognised that the same type of catheter is not appropriate for every client, and advocated the need for the nurse to be aware of catheter features and characteristics to ensure good care. In support of Robinson's work, Nazarko (2010) claimed that, "the risks of catheter related problems can be reduced if staff choose a urinary catheter of the appropriate length, size and material" (p. 950). Catheter selection and management is targeted at reducing the occurrence of complications such as "UTI's [urinary tract infections], tissue damage, and encrustation of the catheter which may lead to catheter blockages" (Godfrey & Evans, 2000, p. 80). The consequences of inappropriate catheter selection have been discussed by Godfrey and Evans (2000), Nazarko (2010) and Robinson (2006), yet all failed to state which catheter suits which situation, and did not include selection regarding catheter tips, such as coude tip.

The epic3 *National Evidence-Based Guidelines for Preventing Healthcare-associated Infections in NHS Hospitals in England* stated that clinicians must, "select a catheter that minimises urethral trauma, irritation and patient discomfort, and is appropriate for the anticipated duration of catheterisation" (H. P. Loveday et al., 2013, p. 6). These guidelines discussed the evidence used to make this recommendation, yet fell short of defining which catheter feature suits which particular clinical need, or how clinicians should make that clinical judgement.

The NSW Government Department of Health's ACI (of which both MS Australia and ParaQuad NSW are members) stated that its aim is to drive continuous improvement in the way care is provided across NSW in both the public and private

sector. While the ACI has clear guidelines, procedures and competencies relating to both indwelling and intermittent catheterisation, these guidelines do not extend to catheter selection (ACI NSW, 2012).

The Australian and New Zealand Urological Nurses Society (ANZUNS) released catheterisation clinical guidelines in 2013 (ANZUNS Catheterisation Working Party, 2013). These guidelines discussed catheter selection and recommended increasing the lumen size in the presence of increased sediment (ANZUNS Catheterisation Working Party, 2013). However, no discussion or evidence was supplied regarding why to do this, and no alternatives were suggested, such as using uncoated catheters that offer increased internal lumen size without increased Fg size. Increasing the Fg may expose the client to complications associated with using too large an Fg (Head, 2006; Pomfret, 1996; Pomfret, 2007). Thus, these recommendations need to be considered with caution, given the finding of Singh et al. (2011) and Wilde et al. (2010) regarding increased catheter blocking in spinal cord injured/disease clients related to sediment. Further, these guidelines do not discuss the indicated use for hydrophilic, enclosed non-touch, coude-, olive-, coude/olive- or tieman-tipped catheters.

The European Association of Urology Nurses provides practice guidelines for the use of indwelling catheters in adults (Geng et al., 2012) and for urethral intermittent catheterisation in adults (Vahr et al., 2013). These guidelines make recommendations about catheter materials, coatings, tips and kits (enclosed non-touch); however, not all of the products referred to are available and registered with the Australian Government Department of Health Therapeutic Goods Administration.

Both Ferguson Lodge and the Studdy MS Centre–Residential Care Unit operate in relative isolation to the general health system. That is, there is no onsite medical

support, and little opportunity for collegial consultation in most cases because there are no other registered nurses present with whom to interact and deliberate on clinical issues. Consequently, nurses rely on accessing guidelines to guide their practice; however, because these guidelines remain vague as to which catheter to use to manage specific complications, nurse clinicians are solely reliant on their clinical reasoning skills, which are influenced by their proficiency at accessing and using evidence on which to base their practice decisions. Evidence-based practice advises clinicians during clinical reasoning of catheter selection to meet the unique needs of the client, and reduce the risk of adverse outcomes related to catheterisation (Nazarko, 2010). Pratt and Pellowe (2010) claimed that catheter selection will, “depend on clinical experience, patient assessment and anticipated duration of catheterisation” (p. 28). In Australia, the situation is complicated because of the variability of catheter selection and protocols used in different contexts and by different health practitioners.

2.9 Catheter Selection Knowledge of Nurses

In the absence of more recent studies than those by Dobson et al. (1996) and Fleming et al. (2000), which focused on assessing nurse catheter selection knowledge in Australia, it was determined that these Australian studies would be regarded seminal to the current research, in relation to education and practice development in this topic area. As such, it is useful to examine the contribution made by these researchers to the Australian context.

The study by Dobson et al. (1996) highlighted the importance of nurses having knowledge of current evidence to appropriately select and manage catheters. With regard to using existing catheter selection evidence, Dobson et al. (1996) stated that, “a considerable body of information about urinary catheter selection and management

exists. However, there has been limited evidence of the integration of these research findings by clinicians into everyday practice” (p. 140). Consequently, they sought to investigate “nurses’ knowledge and perceptions of urinary catheter selection and management” (Dobson et al., 1996, p. 142) To collect and analyse these data, Dobson et al. conducted a cross-sectional analysis of 709 nurses from both the hospital and community setting across a single area health service in the Sydney metropolitan region. The results indicated that, “nurses’ perception of their current catheter selection and management knowledge was limited” and “there is a lack of knowledge relating to catheter management strategies among hospital and community nurses” (Dobson et al., 1996, p. 144). They further reported that less than one-fifth of those surveyed thought that their knowledge in catheter selection and management was sufficient, and proposed that, “repeated catheterisation or length chemotherapeutic management of resultant infective processes may be the consequences of uninformed catheter selection and clinical decision making in catheter care” (Dobson et al., 1996, p. 144). They argued that both general and specialist-field nurses must have current catheter selection and management knowledge, concluding that, “clinical nurse consultants in continence care would play a pivotal role in the development of a standardised clinical protocol and may supply much-needed decision making skills in the appropriate use of specialised catheters” (Dobson et al., 1996, p. 144).

Building on this early work of Dobson et al. (1996), the study by Fleming et al. (2000) included nurses involved with continence management for people living with a spinal cord injury in a hospital setting. Hospital environments are distinct from the residential care facilities in which the current study is located, and were not available for comparison in 2000. The main continence management differences between these settings are as follows:

- clients in hospital rehabilitation settings are in transition from acute continence management to long-term continence management, based on their progression through rehabilitation and the duration of spinal shock symptoms
- clients at residential care facilities are accessing long-term continence management programs, as they have a firm diagnosis of their bladder function and known history of urinary complications, pertaining to their particular circumstances.

Like Godfrey and Evans (2000), Fleming et al. (2000) highlighted the value of using guidelines to provide information on managing urinary complications associated with catheter use, such as encrustation. Fleming et al. (2000) further suggested that this type of information (which is inclusive of catheter selection) is often not found in existing guidelines. Fleming et al.'s (2000) study assessed the level of knowledge among nurses, and identified subsequent management practices related to urinary catheters in a long-term rehabilitation setting. They found that:

incorrect answers were commonly chosen by more than 20% of respondents, and sometimes many more. If these results are indicative of common practice, it appears that a considerable proportion of nurses could risk making incorrect catheter selection decisions ... Overall knowledge scores were well below what the authors considered to be reasonable expectations for all classifications of nurses ... Of particular note is the lack of knowledge pertaining to catheter selection. (Fleming et al., 2000, pp. 240–243)

Fleming et al. (2000) concluded that the nurses in their study were potentially basing decisions on traditional knowledge, rather than current evidence, which “may lead to unsafe clinical practice and patient harm” (p. 245). Further, Fleming et al. (2000)

recommended “the development and, in particular, the application of best practice guidelines” (p. 245). The ACI, ANZUNS, Epic and EAUN guidelines have all been developed and implemented since these recommendations by Fleming et al. (2000).

In terms of content focus, while the initial study by Dobson et al. (1996) sought to understand the knowledge levels of nurses in regard to catheter management and selection, they did not address variations in catheter tips, catheter coatings in different scenarios, or intermittent catheters. However, they did provide a baseline on some of the knowledge associated with catheter management and selection. Similarly, the study by Fleming et al. (2000) noted the results of Dobson et al. (1996); however, it too only sought to understand current knowledge levels of catheter selection and management. Unfortunately, the data collection tools used by these studies could not be compared for differences because the data collection tool used by Fleming et al. (2000) could not be located.

Putting aside possible differences in catheter choices between then and now, and the apparent lack of assessment across the catheter range, two main concerns arise regarding the studies of Dobson et al. (1996) and Fleming et al. (2000). First, although both studies recommended the need for guideline development by expert clinicians, they also acknowledged that there was, at that time, a large amount of information available on catheter management and selection. Consequently, the recommendation to develop more guidelines by experts—while not an unrealistic recommendation in itself—fails to consider the underlying concern that relates to knowledge translation. At that time, such concerns were generally referred to as a ‘theory–practice knowledge gap’, which prompted later researchers to examine the problem. For example, the study by Thompson, McCaughan, Cullum, Sheldon and Raynor (2005) examined the barriers to evidence-based practice in 118 United Kingdom nurses, and found that, “guidelines

were seen as necessary, but not sufficient, aids to decision making; however relying on oral and experiential modes of teaching to disseminate guidelines sometimes led to unanticipated results” (p. 438). As highlighted by Graham et al. (2006) and Grimshaw et al. (2012), there are barriers to sharing knowledge and training and education needs to consider methods of overcoming those barriers. The gap in knowledge from evidence and guidelines to practice was not discussed by Dobson et al. (1996) and Fleming et al. (2000)—rather, they called for the development of more guidelines.

The second concern relates to the retention of knowledge once it has been absorbed, particularly given the findings by Micken et al. (2011) regarding the lack of clinician adherence to guidelines. Regrettably, although Fleming et al. (2000) reviewed Dobson et al.’s (1996) findings and attained similar results, they did not take the study further to determine whether education would have made a difference to either knowledge or uptake, or whether clinical experience has an effect on knowledge retention regarding catheter selection and management over time.

The focus of the early work by Dobson et al. (1996) and Fleming et al. (2000) identified a lack of catheter management and selection knowledge for indwelling catheters among nurses; however, they did not investigate the issues around catheter selection and knowledge of catheter characteristics and materials. Urinary catheters have benefitted from advances in technology and materials research, evolving in terms of design diversity and materials. However, despite these innovations by manufacturers, there is little evidence that the implications of these innovations are known or being incorporated into care planning by the clinicians who make daily decisions about which catheter to use. The current study goes some way towards addressing the lack of research attention on this aspect of catheter selection for both indwelling and

intermittent catheters for this particular group of clients living with spinal cord injury and multiple sclerosis, in this specialised care context.

2.10 Summary of Literature Review

Both Dobson et al. (1996) and Fleming et al. (2000) advocated the need for education in catheter selection; however, neither study provided nor investigated the effects of education pertaining to catheter selection. In searching the literature, no evidence was found that the situation outlined above has improved or been investigated in Australia during the intervening years, despite the known risks to client health and wellbeing caused by nurses not having the knowledge and skills to make informed clinical judgements.

Due to advancing technology, the original Foley catheter and intermittent catheter have evolved into many different designs that registered nurses are required to know about. Catheter management guidelines and associated catheter selection guidelines have existed for many years to support registered nurses in clinical reasoning related to catheter selection. The clinical importance of appropriate and informed catheter selection for spinal cord injured and multiple sclerosis clients supports this current exploration of registered nurse catheter selection knowledge in terms of nurses' clinical reasoning and decision making.

2.11 Purpose of This Study

The current study investigates whether a group of experienced registered nurses working in long-term neurological residential care facilities, caring for people living with either a spinal cord injury or multiple sclerosis, apply informed clinical reasoning pertaining to catheter selection. It is expected that this research will build on the two previous studies that examined the catheter selection knowledge of registered nurses in Australia—by Dobson et al. (1996) and Fleming et al. (2000). It will do so by exploring

catheter selection in the speciality context, and by testing clinician retention of specialised catheter information. Spinal cord injury and multiple sclerosis care contexts provide an opportunity to investigate catheter selection knowledge because of the high skill level regarding continence management needed by nurses in this specialty context. Locating the research in residential care facilities offers a unique context where continence management programs used by clients are based on their long-term need and individual history of urinary complications associated with catheter usage. These situational variables enable this study to not only assess nurses' catheter selection knowledge in a specialised context, but also evaluate the effects of targeted education and retention of catheter selection knowledge.

2.12 Aims of This Study

The aims of this research were to determine the current catheter selection knowledge base of registered nurses who manage catheters, and investigate whether a single session of targeted education, alongside provision of a catheter selection decision support tool, changed that knowledge base. In addition, if this was achieved, this research sought to determine whether the nurses retained that knowledge over time.

2.13 Research Questions

2.13.1 Research Question 1—Current knowledge. What do registered nurses know and understand about urinary catheters and the difference between catheter types?

2.13.2 Research Question 2—Knowledge translation. To what extent do participant nurses retain new information on catheter types and catheter selection for defined client groups?

2.13.3 Research Question 3—Knowledge retention. To what extent can registered nurses' knowledge about assessment, catheter selection and use for multiple

sclerosis and spinal cord injured people be retained by the nurse participants following an education intervention?

Chapter 3: Methodology

3.1 Research Design

A quasi-experimental design was selected for this research, which needed to incorporate an educational intervention and testing of the results over time. The essence of a quasi-experimental design study is that it involves an intervention with no randomisation (Polit & Beck, 2012). Guided by a positivist paradigm, this design sought to verify a phenomenon (catheter selection knowledge) and retention of that knowledge over time by the participants as part of their clinical practice (catheter selection education and use of a decision support tool).

A full double-blind experiment was not possible due to the limited number of potential participants working in this specialised setting. Thus, a quasi-experimental design was chosen because of the superiority of this design over observational studies in overcoming the Hawthorne Effect in studies of small groups (Grimshaw, Campbell, Eccles, & Steen, 2000). The Hawthorne Effect is widely accepted to be a confounding variable in behavioural studies, in which the results can be related to the effect of being involved in research, rather than because of manipulation of independent variables. It refers to the tendency of some participants to invest additional effort to perform well when they are being observed, such as during an experiment. This is why it is also known as the ‘observer effect’—causing individuals to change their behaviour due to the attention they are receiving from researchers. The Hawthorne Effect was first described in the 1950s by researcher Henry A Landsberger, during his analysis of experiments conducted during the 1920s and 1930s at the Hawthorne Works Electric Company. Here, commissioned research was undertaken to determine if there was a

relationship between productivity and the work environment, particularly in terms of the availability of electric lighting (Landsberger, 1958).

Since that time, the Hawthorne Effect (Wickstrom & Bendix, 2000) has come to refer to the effect of participants' awareness of being observed on the research outcomes. Subsequent analysis of the original data (Levitt & List, 2011) has demonstrated that the original Hawthorne experiments actually do not have a measurable effect, at least, not the one popularly attributed as the 'Hawthorne effect'. Nevertheless, the Hawthorne effect appears to exert a subtle influence on some participants, and therefore is something for researchers to consider when analysing results.

This quasi-experimental exploratory study used a pre-test/post-test design similar to that used by Lim, Chiu, Dohrmann and Tan (2010), who also studied registered nurse knowledge levels and the efficacy of education interventions in residential care facilities. Specifically, Lim et al. (2010) explored nurses' current knowledge in relation to medication management in the elderly, and then tested the effects of an education intervention on that knowledge level. The 58 participants in the study were surveyed with a 23-item knowledge-based test survey (with 17 multiple-choice questions), immediately prior to the education intervention. Lim et al. (2010) then evaluated the acquisition/retention of new knowledge via the same survey four weeks following the education intervention, which showed that the proportion of incorrect responses post-intervention had reduced in comparison to the pre-intervention questionnaire. They also gathered data on the nursing demographics of the participants, including years of experience and variations in postgraduate qualifications; however, these data were not used in their analysis of the survey results.

When considering the design for the current study, the quasi-experimental study by Bauer, McAuliffe, Nay and Chenco (2013) was also reviewed. This study explored the effects of sexuality education on Australian nurses working in aged care facilities. It involved both a pre-test and post-test design, following an intervention of a three-hour education session. The results indicated that education had a positive effect on sexuality knowledge. The limitations identified by the researchers included the need to investigate the long-term sustainability of the knowledge gained, as only one post-test data collection occurred. A further concern with the Bauer et al. (2013) study was that the post-test was done immediately following the education intervention. Given that the aim of the current study was to assess the long-term sustainability of knowledge, the design used in the Bauer et al. (2013) study—which did not explore the retention and associated sustainability of the knowledge acquired through education—was rejected in favour of the design used in the Lim et al. (2010) study.

The Lim et al. (2010) approach to the research was modified and extended in the current study by: (i) analysing the survey findings against the demographic data to determine any correlation, (ii) conducting the post-intervention survey at three-months as the catheter selection task is less frequent than the medication management task studied by Lim et al. (2010), and (iii) conducting the survey a third time, six months after the intervention. The modified design allowed better separation between the measurement of knowledge acquisition and knowledge retention, and close comparison between the pre- and post-intervention survey. In addition, due to the six-month follow-up, these repeated measures also provided test–retest validation of the survey itself. The design and methodology is summarised in Table 1.

Table 1

Design and Methodology

Stage	O ₁	X	O ₂	O ₃
Name	Pre-intervention	Intervention	Three-month Post-intervention	Six-month follow-up
Methodology	Knowledge and demographic questionnaire	One-hour catheter education session and supply of decision support tool	Knowledge questionnaire	Knowledge questionnaire
Purpose	Measure current knowledge Collect demographic data	Provide an opportunity for knowledge translation	Measure knowledge translation	Measure knowledge retention Test–retest validation

3.2 Rationale for Investigative Approach to Research Questions

3.2.1 Research Question 1. Research Question 1 asked: What do registered nurses know and understand about urinary catheters and the difference between catheter types? The previous Australian studies by Dobson et al. (1996) and Fleming et al. (2000) claimed that nurses working in the community and at a rehabilitative hospital had poor catheter selection and management knowledge. However, they made no effort to connect level of knowledge with level of competence, other than the inference that ‘poor’ knowledge was suboptimal. These are the only studies of nursing knowledge about catheter selection in Australia, and the findings suggest that, in relation to Benner’s (1982) classifications, nurses in those studies would rank in the advanced beginner or even novice range. Benner (1982) claimed that nurses pass through five levels of proficiency as clinicians: novice, advanced beginner, competent, proficient and expert. These levels represent a multifaceted assessment of knowledge and skill in advanced problem solving across multiple disciplines—an assessment that is unsuitable when asking 15 questions of nine participants on a single topic.

A randomised study to distinguish between competent and expert skill in nursing diagnosis among Australian paediatric nurses by T Loveday et al. (2013) used a four-

point knowledge assessment tool that involved identifying two static symptoms in written answers, and two recordings of a client bedside monitor in order to classify nurses as either competent or expert. T Loveday et al. (2013) claimed that it was possible to use cue-based assessment to rank nurses into these categories. As a caution, Ericsson et al. (2007) warned that, when assessing skill levels for competency, it is important that all involved participants receive the same assessment, since the goal is to study superior nursing, as opposed to the performance of an expert.

Whether the nurses in the current study are more appropriately considered experts or advanced practice nurses relates to the context in which they practice, in relative isolation from other clinicians and disciplines. For example, regarding spinal cord injury and multiple sclerosis, the nurses' level of knowledge must include awareness that such conditions will result in some form of bladder dysfunction (Fowler et al., 2009; Linsenmeyer et al., 2006). In the case of spinal cord injury, some form of catheterisation may be required from the time of injury (Nelson et al., 2001), while, in multiple sclerosis, some form of catheterisation may be needed as the disease progresses (Fowler et al., 2009). Urinary complications associated with catheter use for those with a spinal cord injury or multiple sclerosis are common (De Ridder et al., 2005; Hollingsworth et al., 2013). Given the frequency of catheter use and associated complications, it is necessary that nurses working with spinal cord injury or multiple sclerosis be proficient in catheter care, including catheter selection (Nelson et al., 2001). Consequently, assessment cues should be useful to rank the knowledge level of the participant nurses regarding catheter selection against Benner's framework.

Given that the expected knowledge level among the study participants lay at the upper end of Benner's (1982) levels, the number of levels used for comparison in this study was reduced from five to three in order to reflect the participants' skills and

knowledge, and to manage the data gathered in the study. On this basis, the following hypotheses were developed.

H₀: Participants are **novices** and have **no** knowledge or understanding of urinary catheters or the difference between catheter types. For the purposes of this study, the chance of a **novice** knowing the answer to any given question is assumed to be 0.0. That is not to say that they will not answer questions correctly, just that if they do, it is a result of luck rather than knowledge. For example, a person with no knowledge who guesses the answer to a multiple-choice question with 4 options has a chance of 0.25 of being right; therefore, the 'chance of knowing' is different from and less than the 'change of answering correctly' although the two are probabilistically related. The mathematics of this are developed in Section 3.7.4.

H₁: Participants are **competent** and have **moderate** knowledge or understanding of urinary catheters and the difference between catheter types. For the purposes of this study, the chance of a **competent** participant knowing the answer to any given question is assumed to be 0.5. The distinction between 'knowing' and 'correctly answering' is still applicable.

H₃: Participants are **experts** and have **high** knowledge or understanding of urinary catheters and the difference between catheter types. For the purposes of this study, the chance of an **expert** knowing the answer to any given question is assumed to be 0.8. Again, the same distinction between 'knowing' and 'correctly answering' applies.

The allocation of probabilities to each of these hypotheses was subjective, but not arbitrary, and followed careful consideration of Benner's definitions of nurse development stages (novice, competent and expert), as well as the structured content of the multiple-choice survey used in each testing phase. The multiple-choice questions were developed to:

1. present simple and unambiguous questions that required nursing knowledge
2. contain the correct answer as one of the choices, thereby providing significantly more clarity and less options than required when assessing a real patient presenting with real symptoms.

Benner (1982) described an expert as having “an intuitive grasp of each situation and zeros in on the accurate region of the problem without wasteful consideration of a large range of unfruitful, alternative diagnoses and solutions” (p. 405). From this, it is expected that, given the constraints of multiple-choice questions, the expert would know the answer to most of the questions presented. For this reason, a probability of $p = 0.8$ was established for the current research.

At the other extreme, Benner’s (1982) novice “has no experience with the situations”, “must use context-free rules to guide their task performance” and has an “inability to use discretionary judgement” (p. 1403). For these reasons, it is assumed that the novice knows nothing and, even when presented with the correct answer, is unable to distinguish it from similar incorrect choices. Therefore, a probability of $p = 0.0$ was assigned in this research.

For the competent nurse, Benner (1982) stated that he or she had “a feeling a mastery and the ability to cope with and manage the many contingencies of clinical nursing” and can plan “based on considerable conscious, abstract, analytic contemplation of the problem” (p. 404). However, they are not at the stage of the proficient nurse for whom “[a]spects stand out ... as being more or less important to the situation at hand.” (Benner, 1982, p. 405). This suggests a probability value well below that given to the expert; however, it would be unreasonable to describe someone as ‘competent’ if they are unable to know the answers to at least half the questions. For

these reasons, a value of $p = 0.5$ was established as the standard required for competence in the current study.

3.2.2 Research Question 2. Research Question 2 asked: To what extent do participant nurses retain knowledge on catheter types and catheter selection for defined client groups? This question essentially tests the transfer of knowledge to practice, and the following hypotheses were constructed on the basis that nurses will apply the knowledge that they possess to clinical situations:

H₀: Participant nurses **do not** retain knowledge on catheter types and catheter selection for defined client groups. That is, their responses to the post-intervention survey will be unchanged from their responses to the pre-intervention questionnaire.

H₁: Participant nurses **do** retain knowledge on catheter types and catheter selection for defined client groups. That is, their responses to the post-intervention survey will improve by 20% from their responses to the pre-intervention questionnaire.

The studies by Lim et al. (2010) and Madigan, Fleming, Wright, Stevenson and MacAuley (2014) measured knowledge uptake pre- and post-survey assessment. In the study by Lim et al. (2010), demographic data were collected; however, they were not paired to the responses. Thus, uptake of knowledge was seen to occur by comparing the number of correct responses in the pre-test to the number of correct responses in the post-test. In the case of Lim et al. (2010) there was a difference of 13% between the pre and post-test responses. The study by Madigan et al. (2014) was a cluster randomised control trial that measured changes in correct responses between cluster groups pre- and post-intervention. It claimed knowledge uptake with an increase of four correct responses. The statistical techniques used in these studies were not directly transferable to the current study, where each participant's responses were individually paired and correlated with the demographic data.

In the current study, a value of 20% (or three questions) was chosen as the standard, based on existing work as the expectation of the knowledge to be gained from a one-hour intervention, where the expectation was that the participants' level of knowledge and skill was already between competent and expert. Thus, it was anticipated that the participants would score in the range of seven to 12 correct questions initially.

3.2.3 Research Question 3. Research Question 3 asked: To what extent can registered nurses' knowledge about assessment, catheter selection and use for multiple sclerosis and spinal cord injured people be retained by the nurse participants following an education intervention?

Research published by Grimshaw et al. (2012) indicated that changes in clinical practice can occur as a result of knowledge uptake. Grimshaw et al. claimed that knowledge translation requires agreement and knowledge of guidelines; thus, this uptake will be reflected in practice based on the new knowledge. Similar findings were published by Bielby, Norris, Freeman and Piper (2015), who sought to educate staff in 22 residential care facilities in the prevention of pressure ulcer development. To measure the success and retention of the knowledge, six months prior to the education session, all pressure ulcers were classified and recorded. Following this, the same data were collected during the six months following the education intervention. Bielby et al. (2015) found a statistically significant reduction in the development of pressure ulcers; however, the Hawthorn Effect (Wickstrom & Bendix, 2000) cannot be ruled out, as these nurses were aware of the observation of client data. In the current study, while it was originally proposed to include a similar testing of clinical outcomes (such as measuring changes in client urinary complications associated with catheterisation), it

was deemed beyond the scope of a masters-level thesis. Thus, alternative methods to measure knowledge retention and sustainability were devised.

In investigating alternative ways to measure knowledge retention in residential care facilities, the study by Lim et al. (2010) was again reviewed because it measured knowledge uptake and retention four weeks after a one-hour education intervention. The limitations recognised by Lim et al. included the inability to match which nurse had gained knowledge and retained it for four weeks. Although demographic data were collected (such as years of experience, which ranged from one to 50 years), they were unable to be paired. In Lim et al.'s study, it was impossible to determine whether, using Benner's (1982) levels of proficiency, the expert, experienced, advanced beginner or novice nurses in the group benefitted. These limitations of Lim et al. (2010) were used to guide the development of the following hypotheses to measure knowledge.

H₀: Registered nurses' knowledge about assessment, catheter selection and use for multiple sclerosis and spinal cord injured **will be** retained by the nurse participants following an education intervention. That is, their responses to the six-month follow-up survey will be unchanged from their responses to the **post-intervention** questionnaire.

H₁: Registered nurses' knowledge about assessment, catheter selection and use for multiple sclerosis and spinal cord injured **will not be** retained by the nurse participants following an education intervention. That is, their responses to the six-month follow-up survey will be unchanged from their responses to the **pre-intervention** questionnaire.

It is important to note that these hypotheses are reliant on the nurses actually changing their answers following the intervention; either from correct to incorrect or vice-versa. Clearly, it is meaningless to ask if a change that did not happen was retained.

3.3 Educational Intervention

A review of teaching and learning strategies identified approaches appropriate for the intervention session. The content of the one-hour education intervention in the current research was provided by the researcher, who is a Grade 3 Clinical Nurse Consultant in spinal cord injury management and continence, specialising in neurogenic continence management. The session consisted of a group presentation regarding catheter selection complexity and use of a catheter decision support tool. The nature of the learning—which was associated with understanding specialist and technical information, and using this information during clinical decision making—required an approach that acknowledged these requirements.

The design of adult and professional teaching and learning approaches has attracted the interest of researchers. For example, Drach-Zahavy and Pud (2010) highlighted that learning needs to facilitate gathering and analysing information, and facilitating change, while Diner et al. (2007) stated that passive education sessions do not promote knowledge translation. This is further supported by Moore Jr et al. (2009), who outlined that practice and feedback are essential to learning. A recent study by Madigan et al. (2014) sought to investigate the benefits of a single education session of less than one hours duration on knowledge retention and sustainability across six months. The study design used by Madigan et al. was a cluster randomised control trial that included a total of 234 participants, comprising general practitioners and nursing home nurses. The education focused on nutrition enteral feeds, which included problem-solving care of the stoma and use of equipment. Participant knowledge was assessed immediately before and after the intervention, and then six months later. Madigan et al. claimed an initial gain in knowledge; however, this was not sustained over the six months. In reviewing the data, Madigan et al. suggested that the education intervention

sessions were of sufficient duration and quality, but that providing online education material after the intervention may have improved the outcome.

The educational intervention consisted of two components: an educational presentation and the use of a decision support tool. The decision support tool was not tested separately for effect. rather it provided the content within the framework used to structure the education intervention.

3.3.1 Decision support tool. Decision support tools can come in many forms, including electronic integrated systems or paper-based systems. The aim of these tools is to reduce variation in clinical care to improve clinical outcomes. The more experience clinicians have with the technology—in whatever format it is presented—the more successful their use of the decision support tool. In reviewing decision support systems, Kawamoto, Houlihan, Balas and Lobach (2005) claimed that successful implementation of a decision support system is influenced by four factors: “(a) decision support provided automatically as part of clinician workflow; (b) decision support delivered at the time and location of decision making; (c) actionable recommendations are provided; and (d) the tool is computer based” (p. 768).

In the current study, the catheter selection decision support tool is available as either a computer software application format for iPad, or a paper-based version. The Catheter Compass™ requires clinicians to critically evaluate clients’ symptoms related to urine flow, and then link the symptoms to catheter characteristics and features to facilitate selection of a catheter that best suits the assessed needs of individual clients. The development of the Catheter Compass™ involved an extensive review of research literature pertaining to urinary catheter trials and catheterisation guidelines, review of all the catheters available in Australia, and gathering of expert opinion. The Catheter Compass™ does not aim to recommend a specific brand, but to classify which catheter

features are available in Australia, and their related benefits. The Catheter Compass™ was developed in 2009. Thus, at the commencement of this research, a further literature search was undertaken to locate any other catheter selection tools that would be suitable to form part of the education intervention for this study, and any guidelines developed in this field since 2009. No other tool was identified that dealt specifically with catheter selection. The Catheter Compass™ was reviewed for currency, accuracy and completeness against the following guidelines:

- *Epic 3 National Evidence-based Guidelines for Preventing Healthcare-associated Infections in England* (H. P. Loveday et al., 2013)
- *The Australian New Zealand Urological Nurses Society Catheterisation Clinical Guidelines* (ANZUNS Catheterisation Working Party, 2013)
- *European Association of Urology Nurses Practice Guidelines for Indwelling Catheters in Adults* (Geng et al., 2012)
- *European Association of Urology Nurses Practice Guidelines for Intermittent Catheters in Adults* (Vahr et al., 2013).

Two issues emerged from this review. First, the *European Association of Urology Nurses Practice Guidelines for Indwelling Adult Catheterisation* (Geng et al., 2012) discussed the use of nitrofurazone catheters (antibiotic impregnated), expressed concerns regarding toxicity, and concluded that these catheters not be recommended for routine use. Antibiotic impregnated catheters are not available in Australia, and consequently were not included as recommended options in the Catheter Compass™. The second issue relates to recommendations from the *Australian New Zealand Urological Nurses Society Catheterisation Clinical Guidelines* (ANZUNS Catheterisation Working Party, 2013), who advocated for increasing the catheter lumen

size in clients with sediment that causes blockages, however, no evidence was given in support of this recommendation. Further, the *European Urology Nurses Association Practice Guidelines for Indwelling Male Catheterisation* (Geng et al., 2012) noted that increasing the Fg (external lumen size) does not ensure wider internal drainage channel. The Catheter Compass™ recommends using a non-coated catheter with a larger internal lumen in the presence of sediment that may block the catheter. However, the education presentation also incorporated alternative options when a non-coated catheter was not achieving the desired clinical outcome. The additional articles reviewed in relation to catheters are located in Appendix A.

The Catheter Compass™ computer application format is part of a suite of decision support tools called the Tools of the Trade™, developed by the researcher outside of the requirements for the masters-level work. The computer application generates a prescription for equipment and provides an opportunity for report writing within the prescription for client notes. As neither Ferguson Lodge nor the Studdy MS Centre–Residential Care Unit used iPad technology for client notation, the paper-based version of the Catheter Compass™ was supplied for this study, and left with the participants to use in their clinical areas if they wished.

3.3.2 Educational intervention structure and content. The intervention in this quasi-experimental study aimed to present complex and technical information through a targeted interactive education session that embraced critical thinking in a manner that could facilitate participants' practical learning of information gathering and critical analysis, as a basis for making clinical decisions. Case studies were used to assist with the development of critical thinking and decision making, focusing on the urinary complications that are known to occur among people living with spinal cord injury or multiple sclerosis who use catheters.

During the education session, the information pertaining to catheter Fg size and length was in accordance with Booth and Clarkson (2007), Dobson et al. (1996), Head (2006), Nelson et al. (2001), Pomfret (2007), Pomfret (1996) and Robinson (2006). Information related to balloon size was in accordance with JM Smith (2003) and the *European Urology Nurses Association Practice Guidelines for Indwelling Catheters in Adults* (Geng et al., 2012).

Details related to catheter features presented in the educational intervention and Catheter Compass™ consisted of information from the presentation ‘Catheter Selection: Finding the Evidence’ to the National Continence Conference 2013; relevant articles reviewed in the preparation of the presentation are summarised in Appendix A. This material was further reviewed and compared to the recommendations of the *European Urology Nurses Association Practice Guidelines for Indwelling Catheters in Adults* (Geng et al., 2012), *European Urology Nurses Association Practice Guidelines for Intermittent Catheters in Adults* (Vahr et al., 2013) and *Australian New Zealand Urological Nurses Society Catheterisation Clinical Guidelines* (ANZUNS Catheterisation Working Party, 2013). The information included was related to hydrophilic catheters, silver-coated catheters, 100% silicon-coated catheters, three-way catheters, non-touch catheters, registered reusable intermittent catheters, and catheter tips (both regarding design and length).

To ground the technical content during the intervention, three case studies were discussed in small groups of three, and then as a large group. The case studies focused on common complications associated with catheter use among people with a spinal cord injury or multiple sclerosis, as identified by De Ridder et al. (2005) and Hollingsworth et al. (2013). Case study one covered repeated catheter blockages without urinary tract infection and bladder calculi. Case study two covered a description of intermittent

catheter sensation as feeling like razor blades cutting. Case study three involved requesting advice on a silver-coated catheter from a client using an Fg 18 Dover catheter that was repeatedly blocking. Across all three case studies, the participants were expected to evaluate the most appropriate catheter for the situation and explain their views. The answers were then supplied by the researcher by drawing on her clinical expertise in the field.

To develop the education intervention and guide analysis of the effect of the intervention, Kolb's (1984) experiential learning theory provided the conceptual model to frame the intervention. Kolb's experiential learning approach endorses providing adult learners with an opportunity for reflective analysis of their practice, and encourages critical thinking behaviours, which are essential to clinical reasoning and judgement. It also states that learning occurs through active participation by calling on experience and reflection. The education intervention on catheter selection was designed to align with Kolb's (1984) adult learning cycle, which can be self-directed. The intent of the study's education intervention—based on synthesis of information and findings from previous studies—was to facilitate reflection through an active education session. The result was a tailored education program that incorporated different learning modalities, as indicated by the learning cycle (Kolb, 1984).

The registered nurse participants were provided with information to increase their knowledge and opportunities to practise skills in selecting catheters for the defined client group. The education intervention also drew on participants' experience, and facilitated reflection by presenting information, case studies and tactile experience with catheters to assist them to develop skills to identify individual clinical features of the various catheters, and how they can be applied in the clinical setting to support client clinical outcomes. As part of the education intervention, the participant registered

nurses were each given a catheter selection decision support tool (see Appendix D) to assist with dissemination of easily accessible information, and provide opportunities for self-reflection after the intervention.

3.4 Knowledge Measurement

3.4.1 Knowledge assessment instrument availability. Knowledge assessment associated with the intervention would ideally have involved the use of a validated assessment scale; however, despite an extensive search of the published literature, no validated instrument addressing the particular focus of this research could be located. Replication of earlier research by Fleming et al. (2000) was not possible because the instrument used in that study could not be found. Further searches based on anecdotal claims that the instrument used in Fleming et al.'s study closely resembled that used in an unpublished study from Robinson et al. (1996) gave some encouragement; however, neither the instrument nor the results of that study could be located. The assessment tool used in another Australian study by Dobson et al. (1996) did not address catheter selection criteria in regard to intermittent catheters or catheter complications, tips or coatings, and so was deemed unsuitable for the current research. For this study to proceed, a knowledge assessment survey needed to be developed that would test the participants' understanding of the topics and skills identified.

3.4.2 Assessment survey item development. Issues associated with catheter selection were identified through a review of published research and clinical guidelines, in consultation with nursing experts in the field of neurogenic continence management. In designing the assessment, the work of Dowding and Thompson (2003) was considered, which examined the quality of decision making by nurses. They warned that assessment either: (i) measures clinical outcomes, which is characterised by uncertainty, or (ii) is based on a comparison with expert opinion, which is limited by bias.

Alternatively, the studies by Lim et al. (2010) and Madigan et al. (2014) measured knowledge uptake by comparing pre- and post-intervention knowledge, using an assessment tool derived from expert opinion. The current study does not aim to measure the clinical consequences of failure to adhere to protocol or evidence; rather, it measures knowledge uptake and retention against expert opinion criteria. Therefore, for the purposes of the knowledge survey construction, all questions in the survey tool were deemed to have equal value.

The knowledge survey included items related to catheter suitability in terms of size, materials and purpose, as well as commonly occurring problems experienced by clients and nurses performing catheterisation in this context. The survey consisted of 15 multiple-choice questions on catheter selection (see Appendix E), covering the following three categories:

- catheter suitability in terms of size and purpose
- commonly occurring problems experienced by patients
- issues for nurses performing or teaching catheterisation in this context.

For the six-month follow-up, an additional qualitative question was added to ask the participants to self-assess any changes they had made to their practice as a result of the intervention.

Content related to all questions in the survey question tool was covered during the education session; however, not all survey question content was covered by the Catheter Compass™. The content not covered was included in Questions 2, 3, 4, 5, 11 and 12 because they pertained to catheter sizing for adults only, and the decision support tool was designed to be used in conjunction with existing local continence assessment for either paediatric or adult services.

3.4.2.1 Catheter suitability in terms of size and purpose. Survey Questions 1 to 5 dealt with indwelling catheter size and purpose. There are two options for indwelling catheterisation: urethral indwelling catheterisation and suprapubic catheterisation. All medical devices, such as catheters, must be registered with the Therapeutic Goods Administration in terms of their intended purpose before being distributed in Australia (Commonwealth Department of Health, 2011). Catheter packaging must state whether the indwelling catheter is fit for urethral indwelling catheter use only, or is also suitable for suprapubic use. Not every indwelling catheter is fit for the purposes of either urethral indwelling catheter use or suprapubic catheter use. This is related to the ridging effect of the balloon cuff on deflation, and the associated trauma on removal (Parkin et al., 2002). In regard to catheter length, this can be divided into paediatric or adult use, and further divided by gender.

For this study's survey tool, the questions were only related to adults because the residential care units at which the participants worked only admitted adults. As the female and male urethras are different lengths, the primary concern regarding length for male urethral catheterisation is that the catheter is sufficiently long that the retention balloon is inflated in the bladder—and not the urethra—to avoid trauma (Dobson et al., 1996; Doherty, 2006; Nazarko, 2010). The concern with female adults is that, if the catheter is too long, there is increased risk of kinking, which impedes the flow of urine (Godfrey & Evans, 2000; Head, 2006).

In regard to suprapubic catheterisation, either a long or short catheter can be used, and this is determined by ease of use (Robinson, 2007). The diameter of the catheter is measured in Fg. Some guidelines recommend an Fg size for male and a different size for females but do not distinguish between urethral or suprapubic (Booth & Clarkson, 2007; Dobson et al., 1996). Other guidelines recommend the Fg that causes

the least irritation and trauma, yet allows sufficient urine flow (H. P. Loveday et al., 2013; Pomfret, 1996; Pomfret, 2007). Further, when considering the Fg size, one must also consider the associated catheter blockage incidence that occurs with some clients (Singh et al., 2011; Wilde et al., 2010). Indwelling catheters come with a variety of balloon inflation sizes. It is generally recognised that a 10 ml balloon is used routinely (H. P. Loveday et al., 2013); however, some urological conditions dictate a larger size balloon (Dobson et al., 1996; H. P. Loveday et al., 2013). JM Smith (2003) stated, for all indwelling catheterisations, the balloon size must be inflated according to manufacturers' guidelines to avoid catheter obstruction and irritation to the bladder from a non-uniform balloon.

3.4.2.2 Commonly occurring problems experienced by patients. Survey tool Questions 6, 7, 8, 9 and 13 outlined the symptoms and experiences expressed by patients. Catheter blockages are common for people with spinal cord injury or multiple sclerosis (De Ridder et al., 2005; Wilde et al., 2010). It was also highlighted by Singh et al. (2011) that many experience amorphous material floating in their catheter. When a nurse is assessing catheter type, the potential for catheter blockage from sediment must be considered, and additional treatment and investigation may be needed. Catheter choice can assist with reducing the frequency of blocking. For example, catheters that are 100% silicon have a larger internal lumen that takes longer to block (Godfrey & Evans, 2000; Gould et al., 2010; Hooton et al., 2010; Morris & Stickler, 1998). Further, additional drainage holes at the tip give a larger drainage area for debris floating from the bladder through to the catheter (Ramakrishnan & Mold, 2005).

There is some debate among clinicians regarding the use of silver-coated catheters. The *International Clinical Practice Guidelines* of the Infectious Disease Society of America suggested that silver alloy may be useful in the short term, but

additional data are needed for long-term use recommendations (Hooton et al., 2010).

The *European and Asian Guidelines on Management and Prevention of Catheter-associated Urinary Tract Infections* claimed: “There is some evidence of reduced risk for symptomatic UTI [urinary tract infection]. Therefore they may be useful in some settings” (Tenke et al., 2008, p. 22). When discussing catheter material, the EAUN stated: “Silver alloy coated catheters significantly reduce the incidence of asymptomatic bacteriuria, but only for less than 1 week. There is some evidence of reduced risk for symptomatic UTI. Therefore, they may be useful in some settings” (Geng et al., 2012).

The Australia Society of Infectious Diseases and Australia Infection Control Association’s position statement for the prevention of CAUTI claimed that there is no evidence to support the general use of silver alloy catheters (Mitchell et al., 2011). In contrast, various researchers have demonstrated reductions in urinary tract infection occurring with the use of silver-coated catheters (Estores, Olsen, & Gómez-Marin, 2008; Gentry & Cope, 2005; Karchmer et al., 2000). To further complicate the situation, some studies have found the use of hydrophilic-coated catheters more comfortable than non-hydrophilic-coated catheters (Cindolo, Palmier, Autorino, Salzano, & Altieri, 2004; Hedlund, Hjelmås, Jonsson, Klarskov, & Talja, 2001; Wyndaele, De Ridder, Everaert, Heilporn, & Congard-Chassol, 2000). There is agreement that, when an intermittent catheter is inserted, friction occurs as the catheter glides along the urethra, and hydrophilic-coated catheters have been shown to reduce urethral irritation (Doherty, 2005; Stensballe et al., 2005; Vahr et al., 2013).

Catheters also differ in regard to catheter tip length and design. The length of the catheter tip of an indwelling catheter varies, and may need to be considered for clients who experience catheter blockages due to the catheter tip being obstructed by the bladder mucosa (Geng et al., 2012). In addition, some patients will have a hyper

contractile small capacity bladder (Linsenmeyer et al., 2006) and tip length may need to be considered, while those who are diagnosed with a compromised urethral tract may require the use of a coude or tieman tip catheter to ease difficult insertion (Geng et al., 2012; Newman & Willson, 2011; Ramakrishnan & Mold, 2005; Vahr et al., 2013).

3.4.2.3 Issues for nurses performing or teaching catheterisation in this context. Survey tool questions that addressed neither urinary complications nor catheter size or purpose were incorporated into survey Questions 10, 11, 12, 14 and 15. Much confusion persists around the terms ‘catheter flush’ and ‘catheter irrigation’. For the purposes of this project, ‘catheter irrigation’ refers to catheters that require routine catheter irrigation, rather than in response to an emergency situation, which is more accurately described as a ‘catheter flush’. Three-way catheters are designed for repeated irrigation that maintains a closed system (Geng et al., 2012; Ramakrishnan & Mold, 2005; Robinson, 2006).

With regard to selecting intermittent catheters that are suitable for teaching intermittent self-catheterisation, the length of the catheter is the same as that used for indwelling urethral catheterisation, given the anatomical structure of the male and female urethra. However, recommendations for Fg size vary. The principle for selection is that the catheter needs to be large enough to enable good flow, but small enough to reduce risk of trauma. Vahr et al. (2013) suggested Fg 12 to 14 for men and Fg 10 to 14 for women, while Robinson (2006) recommended Fg 12 to 16 for men and Fg 10 to 14 for women. In developing the current study’s survey questions, this was considered in line with Nelson et al.’s (2001) recommendations of Fg 14 to 16 for men with a spinal cord injury. When selecting an intermittent catheter, the principles presented by Linsenmeyer et al. (2006) regarding the goals of bladder management for people with spinal cord injury or disease are to “preserve the upper tracts, minimise lower track

complications and be compatible with a person's lifestyle choices" (p. 13). These principles continue to be a baseline for intermittent catheter selection. Due to lifestyle choices, some people will face a greater risk of cross-contamination and infection. Limited studies have demonstrated that non-touch catheters are associated with reduced risk of infection (Day et al., 2003; Hudson & Murahata, 2005; Linsenmeyer et al., 2006). With regard to catheter tip design for intermittent catheters, length is not a concern because there is no balloon; however, the principles applied to indwelling catheter shape and design also apply to intermittent catheters (Newman & Willson, 2011; Ramakrishnan & Mold, 2005; Vahr et al., 2013).

The survey questions were then tested for face validity among nursing colleagues involved with catheterisation (excluding the nurses who were potential participants), and any ambiguities or formatting feedback were addressed. Each question was evaluated for repetition, bias and discrimination quality of the answer options. Psychometric analysis of the survey was not possible because the participant population was small, and testing the instrument with these nurses would have compromised the study.

In its final form, the survey consisted of 15 multiple-choice questions (see Appendix E). At the National Continence Conference 2013, the researcher tested the face validity of the survey by presenting the details of the literature reviewed, evidence for developing the survey question tool, structure of the education intervention, and evidence supporting the catheter selection that informed the survey. This was presented at the invitation of the convenors. Following this, feedback was sought and received, confirming the structure, content and approach of the intervention. At the National Continence Conference 2014, when a brief review of study was presented, a recommendation was made for an additional qualitative question added to the six-month

follow-up survey. It was suggested that, as a measure of knowledge uptake, the participants be asked whether they had changed their catheter selection practice.

3.4.3 Delivery of the Knowledge Assessment Instrument

The paper based instrument used to assess knowledge and retention was delivered on three separate occasions: immediately before the intervention, three-months post-intervention and as a six-month follow up.

The pre-intervention and three-month post-intervention surveys were completed without access to the decision support tool under exam conditions where no time limit was imposed. The six-month follow-up survey was similar except that a single participant completed it by post.

3.5 Participant Demographic Data

A second survey (see Appendix F) focused on participant demographics, and was collected to allow comparison with the findings of the knowledge measurement survey in order to determine whether there were any correlations. The questions focused on nursing experience, speciality experience, work role, qualifications and previous training in catheter selection. The questions were predominately categorical, except for years of experience as a registered nurse, and years of experience nursing in the spinal cord injury or multiple sclerosis fields, which were a mixture of categorical and numeric data. For the purposes of analysis, the categorical data for these variables were converted to numeric data, assuming that the participant sat in the midpoint of the range. This was unlikely to introduce any significant error; however, checks were made by using the minimum and maximum of the range.

3.6 Participant Recruitment

This study required residential care facilities dedicated to the care of people with spinal cord injury or multiple sclerosis in NSW. Only two residential care facilities were identified that provided registered nurse care to people with either a spinal cord injury or multiple sclerosis. In these facilities, a limited number of registered nurses were employed. The two residential care facilities identified were Ferguson Lodge (which is owned and operated by ParaQuad NSW [2015]) and the Studdy MS Centre—Residential Unit (which is operated by MS Australia [2015]).

The nurses practising in this speciality context have expertise in how to adapt bodily functions for the preservation of life and optimal health outcomes, despite disability. In addition, these nurses are aware of complications associated with the adaption of bodily functions, and have the knowledge and skills to proactively manage people's health needs, and promote optimal health outcomes (Nelson et al., 2001). In addition, these nurses are aware that multiple sclerosis requires catheter selection knowledge because it “affects the white matter of the brain and spinal cord, resulting in demyelination. It causes a variety of clinical syndromes according to the site and severity of the lesion” (Seth et al., 2010, p. 94). It follows that nurses who provide nursing care to either spinal cord injured or multiple sclerosis clients need specific skills and expertise in continence management that must incorporate catheter management and selection, given the aetiology of the incontinence (Nelson et al., 2001).

3.6.1 Inclusion and exclusion criteria. This study only included registered nurses with particular experience practising in an extended or advanced role involving catheter insertion in this speciality clinical context, focused on neurogenic continence management. On that basis, the inclusion criteria required participants to have:

- a minimum of 12 months post-registration clinical practice as a registered nurse

- a minimum of 12 months working in the field of spinal cord injury or multiple sclerosis as a registered nurse.

The exclusion criteria were as follows:

- self-exclusion by not participating in the intervention
- absence of consent.

From a total of 12 potential participants, nine (75%) agreed to participate. One potential participant was away on leave, and two others declined to be part of the study.

3.6.2 Ethical considerations. Ethics approval was received from the Australian Catholic University Human Research Ethics Committee (see Appendix G). Approval to approach potential participants was received from the governing bodies of the two residential care facilities. ParaQuad NSW approval was provided by the ParaQuad NSW Clinical Governance committee, which is chaired by the chief executive officer, and consists of internal staff and external medical practitioners practising in the area of spinal cord injuries in NSW. MS Australia approval was provided by the chief executive officer. Approval from both ParaQuad NSW and MS Australia was provided contingent on ethics approval being granted by the Australian Catholic University Human Research Ethics Committee.

The participant registered nurses' confidentiality and privacy were ensured through coding responses and restricting access to their identities to the student researcher and project supervisor. All were assured that they would not be able to be identified in any publication or report, despite being a small cohort of participants. All participant information and data were stored in a locked filing cabinet or secure password-protected computer, held by the researcher at her home, for hard and soft copy data, respectively.

All participants understood that their consent to be part of the study was voluntary, and that their refusal to participate would not be questioned and would not affect their relationships with their employer, their clients, the student researcher or the Australian Catholic University. All participants received an information pack that included an information letter and consent form (see Appendix H).

3.7 Analysis Plan

3.7.1 Statistic and other analytical assistance. The appropriateness of the analysis plan and the most appropriate statistical tools were confirmed via preliminary statistical analysis options explored by the student researcher, and follow-up discussions with Dr Belinda Butcher BSc (Hons) MBiostat PhD. Formulation and quantification of the hypotheses for each research question were completed by the student researcher. Calculation of the theoretical probability distributions, the linear regression model and construction of a Microsoft Excel template were undertaken with the assistance of Mr Dale Morrell BSc BE(Hons) MDesSc (Bldg Serv.), MBA (Executive).

3.7.2 Descriptive statistics. Descriptive statistics for each survey are presented to summarise the central tendencies (mean and median) and variability (standard deviation, minimum, maximum and interquartile range) of the findings. For purposes of comparison, the descriptive statistics of all three questionnaires are presented together.

3.7.3 Statistical techniques. This study involved a small number of participants ($n = 9$). While it is possible to conduct rigorous and robust statistical analysis with very small samples, small sample sizes mean that very careful and considered selection and application of statistical techniques is required. The selected techniques and reasons for selecting them are detailed below.

Hypothesis testing was generally conducted in accordance with the Neyman-Pearson technique—that is, two or more very specific hypotheses are proposed that make clear and measurable predictions (Gigerenzer, Krauss, & Vitouch, 2004). For this study, which has limited data, the hypothesis selected was the one with the greatest likelihood. This study performed specific calculation of the probabilities of Type I (denoted α ; incorrect rejection of a true hypothesis) and Type II (denoted β ; the failure to reject a false hypothesis) errors. Where it was not possible to construct an alternative hypothesis that can make specific predictions (that is, the alternative hypothesis is not simply the null hypothesis), the Fischer technique of hypothesis testing was used (Gigerenzer et al., 2004). In all cases, due to the low number of participants ($n = 9$), conclusions drawn about the hypotheses are tentative and provisional. The best use of such conclusions is to serve as a starting point for further research.

3.7.4 Research Question 1—Current knowledge. Three hypotheses were proposed to answer Research Question 1, with the participants assigned different probabilities (p_k) of knowing the answer to any given question. It is worth noting that ‘knowing’ in this sense means having a distinct preference for the correct answer ahead of all other choices—it does not mean that the participant is convinced that the answer is correct, only that they believe it is the *most* correct of the choices presented.

It is assumed that, if a participant does not know the answer to any given question, then he or she will guess, with each potential answer having equal probability. This is a simplification because it is possible that he or she is unable to decide between two or three possible answers—in effect, knowing that some of the choices are *not* correct. This has not been accounted for because: (i) it cannot be measured and (ii) the assumption of equal probability between choices is more conservative. Under this simplification, each guessed question is a Bernoulli experiment with a probability of

success equal to the number of correct choices (always 1) divided by the total number of choices ($p_g = 0.\bar{3}$ for Question 1, which has three choices; $p_g = 0.2$ for Question 11, which has five choices; and $p_g = 0.25$ for all other questions, which have four choices) (Weisstein, 2015a).

It is possible that the participants may have false knowledge (p_f)—that is, they are convinced that an incorrect answer is actually correct. This would lead to results that are worse than simply guessing because the correct answer would not form part of the selection set. This factor is included in the calculations, but is assumed to be zero because:

1. it is limited to the range $0 \leq p_f \leq 1 - p_k$
2. its effect will be small unless it is reasonably large—of the order of the chance of a successful guess
3. it is not expected to be large because it requires the participant to have sought or been given information, and for that information to be wrong or misinterpreted
4. in the size of the sample, its effect cannot be disentangled from the normal variance involved in guessing.

Thus, each question can be treated as a Bernoulli experiment (Weisstein, 2015a)—a single trial that can either be correct or incorrect, generating a Bernoulli random variable, which takes the value of 1 when correct, and 0 when incorrect, with a probability given by Equation 1.

*Equation 1**Bernoulli Probability of Correctly Answering Any Given Question*

$$p_c = p_k + (1 - p_k)(1 - p_f)p_g$$

where:

- p_c : the probability the participant correctly answers the question
- p_k : the probability the participant knows the answer
- p_f : the probability the participant has false knowledge (assumed to be 0)
- p_g : the probability of guessing the answer when the participant does not know and does not have false knowledge.

Table 2 shows the results of evaluating this equation for each hypothesis and for questions with three, four and five possible answers because these are representative of Question 1, all other questions, and Question 11, respectively.

Table 2

Probability of Correctly Answering a Question Under Each Hypothesis

Choices	Questions	p_g	H ₀	H ₁	H ₂
			0.0	0.5	0.8
3	1	0.3	0.3	0.6	0.86
4	All others	0.25	0.25	0.625	0.85
5	11	0.2	0.2	0.6	0.84

These three hypotheses can be tested on the basis of both participant and question by adding up the Bernoulli random variables for either the questions the participant answered ($n = 15$) or the number of participants who answered each question ($n = 9$). The sum of n Bernoulli random variables with probability p is a Binomial random variable, with probability p and number of trials n , denoted $B(p, n)$ (Weisstein, 2015b). Thus, for the ‘by participant’ basis, this is a sum of three Binomial random

variables (accounting for the three, four and five choice questions) and the ‘by question’ is a single Binomial random variable.

3.7.4.1 ‘By participant’ hypotheses. The ‘by participant’ hypotheses are random variables with the following distributions:

$$\mathbf{H_0:} \quad B(0.25, 13) + B(0.3, 1) + B(p = 0.2, n = 1)$$

$$\mathbf{H_1:} \quad B(0.625, 13) + B(0.6, 1) + B(0.6, 1)$$

$$\mathbf{H_2:} \quad B(0.85, 13) + B(0.86, 1) + B(0.86, 1)$$

Microsoft Excel was used to calculate the probability mass functions—that is, the probability of achieving a given score, for each of these distributions. The results are plotted and shown in Figure 1 below. Also shown are the ranges in which each hypothesis is the most likely—referred to as critical values.

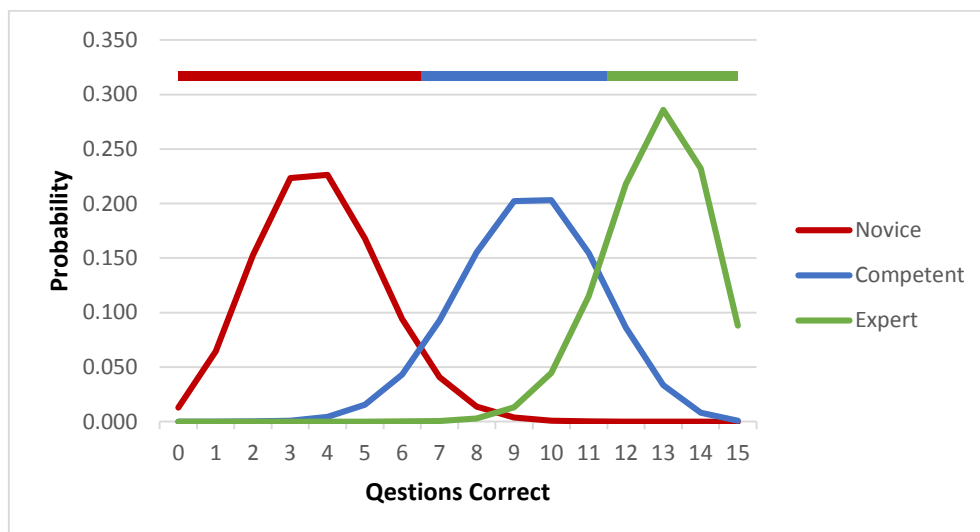


Figure 1. ‘By participant’ hypotheses probability distributions.

The purpose of calculating these distributions is to establish a method for assigning participants to a category (Novice, Competent or Expert) based on the result achieved. For example, a Novice participant has a probability of answering 9 of 15

questions correctly of 0.001, for a Competent participant the probability is 0.202 and for an Expert the it is 0.001; therefore, if a participant *has* scored a 9, the most likely category they would belong to is Competent.

Table 3 shows the range the critical values for each hypothesis—that is, if a participant achieves a score within the indicated range, he or she is assumed to fall into that hypothesis. It also indicates the Type I error probability (α)—the chance that, if the hypothesis is correct, the result will not fall in the critical range—and Type II error probability (β)—the chance that, if one of the other hypothesis (as indicated) is correct, the result will fall into the critical range for this hypothesis.

Table 3

Critical Ranges and Type I and II Error Probabilities by Participant

Critical range	Accepted hypothesis	Type I error (α)	Type II error (β)		
			H ₀	H ₁	H ₂
0–6	H ₀ : Novice	0.06	N/A	0.06	0.00
7–11	H ₁ : Competent	0.19	0.06	N/A	0.18
12–15	H ₂ : Expert	0.17	0.00	0.13	N/A

With this information, the score a participant achieved could be used to place that participant within one of these three hypotheses.

3.7.4.2 ‘By question’ hypotheses. The ‘by question’ hypotheses are random variables with the following distributions:

	Question 1	Question 11	All other questions
H ₀ :	$B(0.\dot{3}, 9)$	$B(0.2, 9)$	$B(0.25, 9)$
H ₁ :	$B(0.\dot{6}, 9)$	$B(0.6, 9)$	$B(0.625, 9)$
H ₂ :	$B(0.8\dot{6}, 9)$	$B(0.84, 9)$	$B(0.85, 9)$

The probability mass functions for each of these are plotted in Figures 2, 3 and 4. The hypotheses critical values for each hypothesis, along with Type I and II error probabilities, are given in Tables 3, 4 and 5.

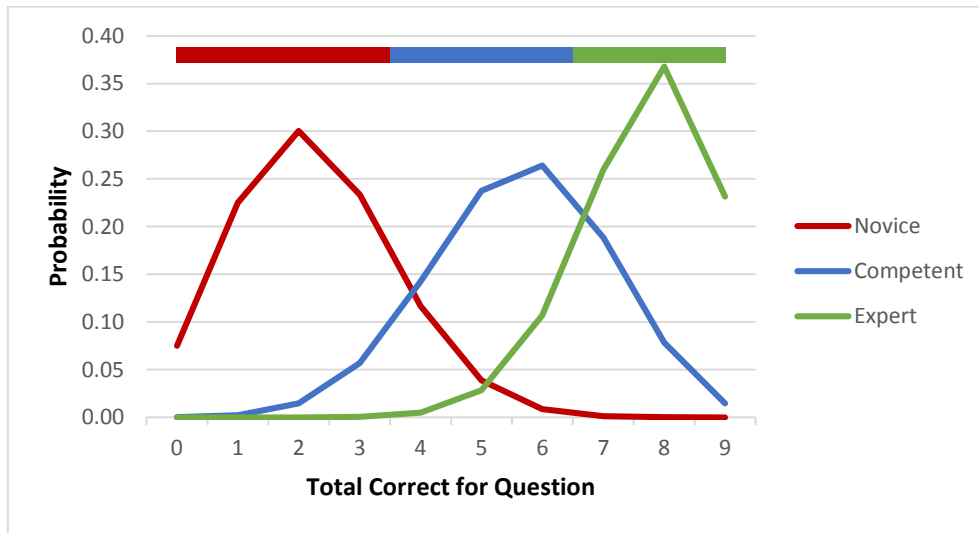


Figure 2. 'By question' hypotheses probability distributions for Question 1.

Table 4

Critical Ranges and Type I and II Error Probabilities for Question 1

Critical range	Accepted hypothesis	Type I error (α)	Type II error (β)		
			H ₀	H ₁	H ₂
0–4	H ₀ : Novice	0.14	N/A	0.14	0.00
5–6	H ₁ : Competent	0.52	0.14	N/A	0.11
7–9	H ₂ : Expert	0.11	0.01	0.38	N/A

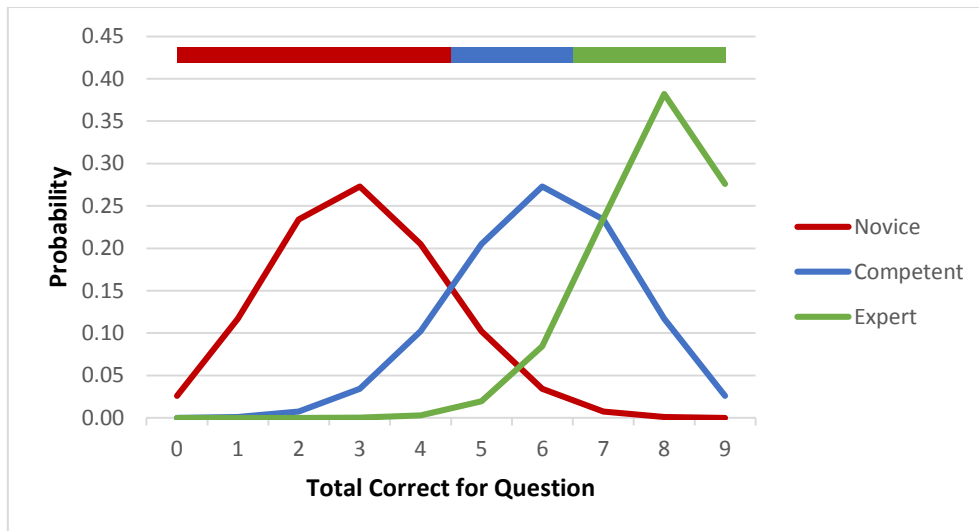


Figure 3. 'By question' hypotheses probability distributions for Question 11.

Table 5

Critical Ranges and Type I and II Error Probabilities for Question 11

Critical range	Accepted hypothesis	Type I error (α)	Type II error (β)		
			H ₀	H ₁	H ₂
0–4	H ₀ : Novice	0.09	N/A	0.10	0.00
5–7	H ₁ : Competent	0.33	0.09	N/A	0.16
8–9	H ₂ : Expert	0.16	0.00	0.23	N/A

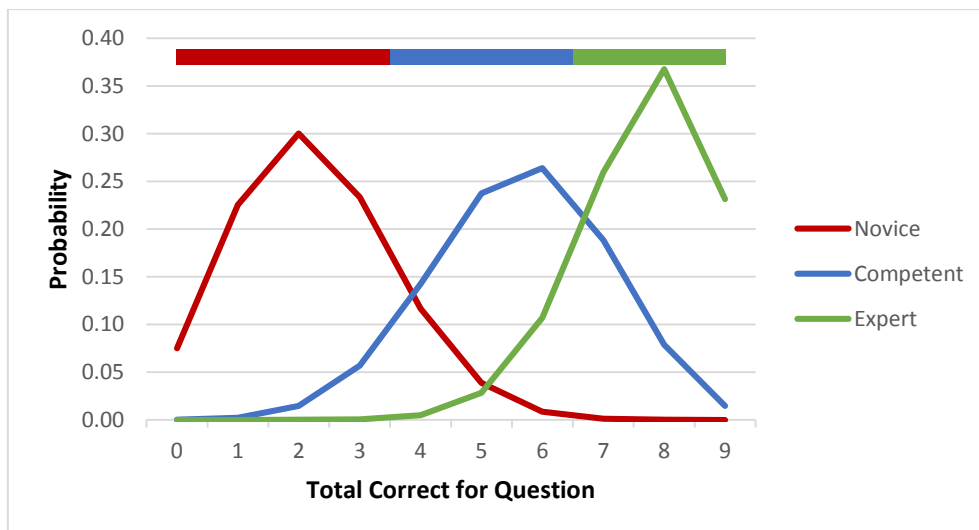


Figure 4. 'By question' hypotheses probability distributions for all other questions.

Table 6

Critical Ranges and Type I and II Error Probabilities for All Other Questions

Critical range	Accepted hypothesis	Type I error (α)	Type II error (β)		
			H ₀	H ₁	H ₂
0–3	H ₀ : Novice	0.17	N/A	0.07	0.00
4–6	H ₁ : Competent	0.36	0.17	N/A	0.14
7–9	H ₂ : Expert	0.14	0.00	0.28	N/A

3.7.5 Research Question 2—Knowledge translation. The null hypothesis for this question was that participant nurses do not retain knowledge on catheter types and catheter selection for defined client groups, following the intervention. If this was the case, then the participants’ responses to the post-intervention survey would be indistinguishable from those to the pre-intervention questionnaire. The alternative hypothesis was that participant nurses do retain knowledge on catheter types and catheter selection for defined client groups. That is, their responses to the post-intervention survey will improve—specifically, they will improve by 20% (three or more questions on a ‘by participant’ basis). The figure of 20% was chosen as a target improvement because it was large enough to represent a significant change, but not so large that it could not be achieved during an hour-long educational intervention.

Given the small sample size ($N = 9$), it is not possible to make any assumptions regarding the distribution of the responses—that is, the data points are too sparse to suggest that the data follow any well-known distribution. This dictated the use of a non-parametric test that makes no such assumptions.

3.7.5.1 ‘By participant’ analysis. For the ‘by participant’ analysis, the data were paired—that is, the responses of specific participants could be matched between questionnaires, and interval scaled, so that the difference between values was meaningful. For example, the difference between a score of six and four was as

significant as the difference between a score of two and four. The most appropriate statistical test for this hypothesis was the Wilcoxon (1945) signed rank test.

3.7.5.2 ‘By question’ analysis. For the ‘by question’ analysis, the data were paired as above, but categorically—that is, as correct or incorrect. Thus, the Wilcoxon signed rank test was not suitable. The most suitable test was the exact McNemer test (Fay, 2015), which has as its null hypothesis of marginal homogeneity, that is, the probability of discordant pairs (correct, followed by incorrect, and incorrect, followed by correct) is equal. Note that it is not possible with this test to use the Neyman-Pearson technique; thus, the Fischer technique was used and *p*-values directly reported (Gigerenzer et al., 2004).

While it was not considered likely, it was possible that the participants’ knowledge could decline after the intervention. For example, this might occur if the education was delivered poorly or the participants found the decision support tool confusing. As this possibility could not be eliminated, a two-sided exact McNemer test was appropriate (Fay, 2015; Polit & Beck, 2012).

3.7.6 Research Question 3—Knowledge retention. The null hypothesis for Research Question 3 was that the registered nurses’ knowledge about assessment, catheter selection and use for multiple sclerosis and spinal cord injured would not be retained by the participants following an education intervention. That is, their responses to the six-month follow-up survey would be unchanged from their responses to the pre-intervention questionnaire. The alternative hypothesis was that the registered nurses’ knowledge about assessment, catheter selection and use for multiple sclerosis and spinal cord injured would be retained by the participants following an education intervention. That is, their responses to the six-month follow-up survey would be unchanged from their responses to the post-intervention questionnaire.

For the reasons described above, the Wilcoxon signed rank test was the most appropriate technique for the ‘by participant’ analysis. Similarly, the exact McNemer test was the most appropriate statistical techniques for the ‘by question’ analysis. However, in this case, the alternative hypothesis could be used to make a specific prediction—that the responses to the six-month follow-up would be the same as the post-intervention. For the ‘by question’ analysis for this research question, two McNemer tests were performed and their probabilities compared to select the most likely.

3.7.7 Test–retest validation. The basic premise of test–retest validation is that, if the same person completes the same survey at different times, then—all else being equal—they should attain approximately the same score. However, any changes in the person’s ability to complete the questionnaire—for example, through an educational intervention—will invalidate the core assumption of ‘all else being equal’. Given the structure of this research, the post-intervention and six-month follow-up findings were candidates for test–retest validation; however, the pre-intervention was not suitable because the intervention would probably change the participants’ test scores.

The test statistic for the test–retest validation is the interclass correlation coefficient (ICC), which measures relative reliability by accounting for consistency from test to retest (within the subject change) and any change in the average performance of the group (systematic change in mean) (Vaz, Falkmer, Passmore, Parsons, & Andreou, 2013). The specific ICC used was ICC (3,2) because this is a Class 3 situation (every participant is rated by all judges—the judges in this case being the questionnaires) and the questionnaires were applied twice (Shrout & Fleiss, 1979). This measure is heavily influenced by outliers; thus, the raw data need to be reviewed to address this before calculation. The calculated value and a 95% confidence interval

were provided. This ICC is equivalent to Cronbach's (1951) alpha measure, and, for the purposes of this research, a value greater than 0.7 would indicate acceptable test–retest reliability (UCLA: Statistical Consulting Group, 2015).

Chapter 4: Findings

4.1 Guide to Presentation of Findings

All 15 questions in the survey were completed by all nine participants. Their responses were then analysed, and the findings are detailed below. Detailed calculations are included in Appendices H, I, J and K. The findings were considered as both a score out of 15 for each of the nine participants (by participant), and as a score out of nine for each of the 15 questions (by question). In each subsection below, they are presented and discussed in that order. When one or more participants did not answer (one in the pre-intervention and three in the six-month follow-up) or selected more than one answer (one in the pre-intervention and one in the post-intervention), this was treated as an incorrect answer.

4.2 Outliers

4.2.1 Question 13. In examining the data, there was a particular question—Question 13—that was an outlier in the post-intervention and six-month follow-up. While it was not an outlier in the pre-intervention, it received the minimum value, with no participant answering correctly. The question was as follows (with the correct answer shown in bold):

13. Client describes urethral discomfort on intermittent self-catheterisation, what would you suggest?

- a. Use a hydrophilic ☐
- b. Use a pre-lubricated catheter ☐
- c. Reduce the size of the catheter ☐
- d. Use xylocaine jelly for each catheter ☐

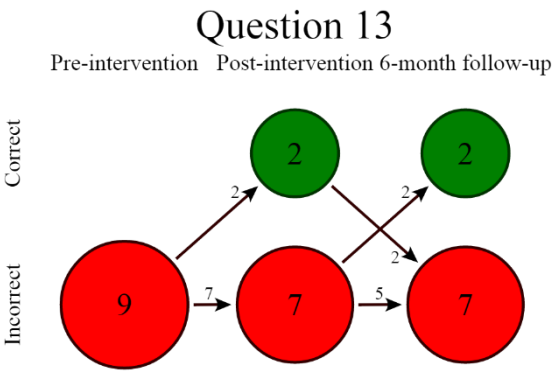


Figure 5. Graph of participant responses to Question 13.

For this question, Figure 5 shows that all participants answered incorrectly in the pre-intervention. Two participants then answered correctly in the post-intervention, while a different two participants answered correctly in the six-month follow-up.

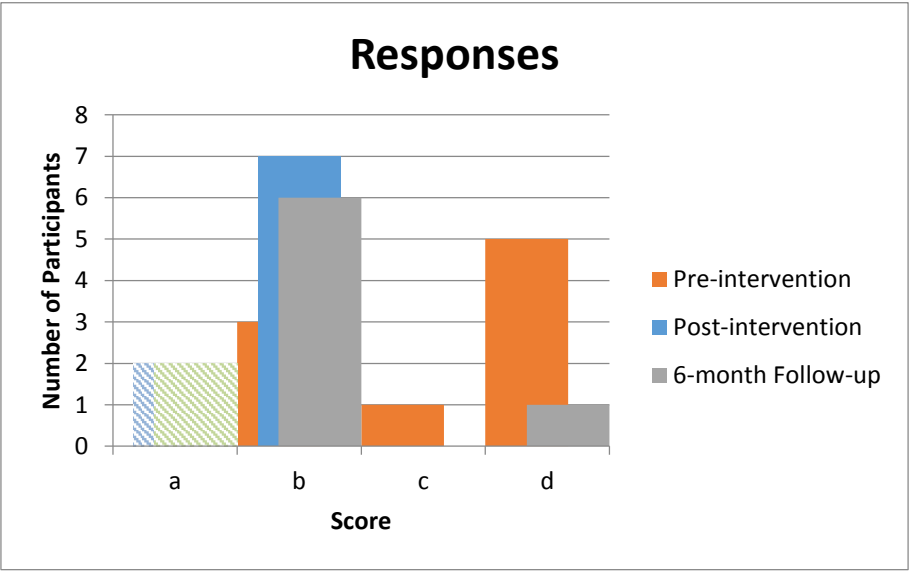


Figure 6. Histogram of participant responses to Question 13.

Further, Figure 6 shows that most participants either maintained or changed to the same incorrect answer (b) in the post-intervention and six-month follow-up. This

suggests that, although the participants recognised urethral discomfort was minimised by lubrication to reduce trauma, they continued not to uptake knowledge regarding catheter design that addresses urethral discomfort. Overall, the effect of this question on the statistics was marginal and its removal from the analysis was not clearly justifiable. However, the findings for the numerical statistics and hypothesis testing are presented with this question both included and excluded. The graphical representations of the data include this question. In terms of Research Question 1, removal of this question would change the critical ranges and error probabilities, as shown in Table 7 below.

Table 7

Critical Ranges and Type I and II Error Probabilities by Participant

Critical range	Accepted hypothesis	Type I error (α)	Type II error (β)		
			H ₀	H ₁	H ₂
0–6	H ₀ : Novice	0.04	N/A	0.04	0.00
7–10	H ₁ : Competent	0.28	0.11	N/A	0.17
11–14	H ₂ : Expert	0.15	0.00	0.14	N/A

4.2.2 Question 12. While not an outlier, Question 12 was answered correctly by every participant in every data collection. The possible reasons for this are examined in the Discussion chapter, while the statistical implications are discussed here. The effect on Research Question 1 of removing this from the analysis had the same effect as removing Question 13; therefore, the findings with this removed are also presented. This question had little effect on the findings for Research Questions 2 or 3, as there was no change in answers between data collections—specifically, the *p*-values would be altered slightly by reducing the number of points from 15 to 14. Therefore, separate findings with this question removed are not shown.

4.3 Descriptive Statistics

4.3.1 Descriptive statistics by participant.

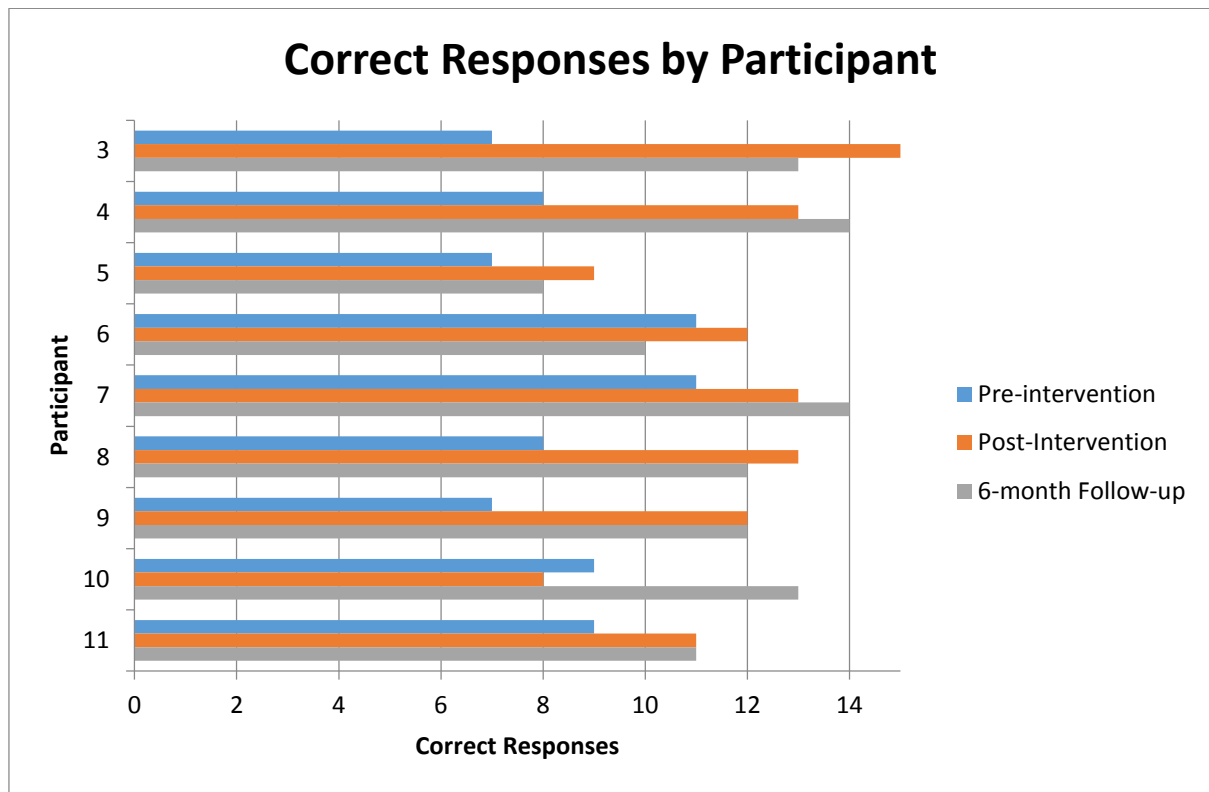


Figure 7. Correct responses to individual questions by number of participants.

The individual participant's results are shown in Figure 7 in order of participant identification number. From this figure, it can be seen that:

1. No participant scored less than seven in the pre-intervention questionnaire.
2. All participants except one (Number 10) achieved higher scores on the post-intervention survey than on the pre-intervention survey.
3. All participants except one (Number 6) achieved higher scores on the six-month follow-up survey than on the pre-intervention survey.

Table 8

Summary Statistics by Participant

Data collection point	All questions			Q12 removed			Q13 removed		
	Pre-intervention	Post-intervention	Six-month follow-up	Pre-intervention	Post-intervention	Six-month follow-up	Pre-intervention	Post-intervention	Six-month follow-up
Sample size	9	9	9	9	9	9	9	9	9
Mean	8.6	11.8	11.9	7.6	10.8	10.9	8.6	11.6	11.7
Standard deviation	1.6	2.2	2.0	1.6	2.2	2.0	1.6	1.9	1.9
Quartile 1	7	11	11	6	10	10	7	11	11
Median	8	12	12	7	11	11	8	12	12
Quartile 3	9	13	13	8	12	12	9	13	13
Interquartile range	2	2	2	2	2	2	2	2	2
Minimum	7	8	8	6	7	7	7	8	8
Maximum	11	15	14	10	14	13	11	14	14
Range	4	7	6	4	7	6	4	6	6

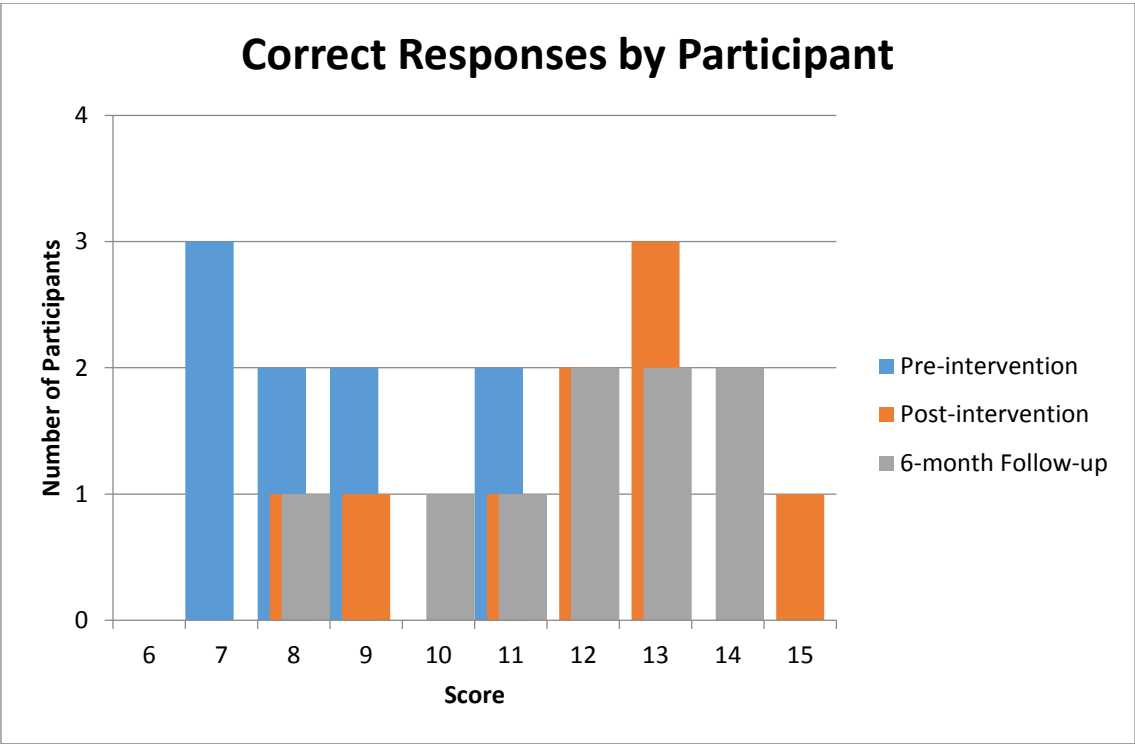


Figure 8. Superimposed histogram of the total scores of each by number of participants.

Table 8 presents the cohort summary statistics, while Figure 8 displays them as a histogram and Figure 9 displays them as a box-whisker plot. Simple observation suggests that there was very little difference between the post-intervention and six-month follow-up data; however, they were different and showed distinct improvement to the pre-intervention data, with the mean improving by 3.2 and the median improving by four. The results also became more spread, as indicated by the increase in standard deviation. Thus, on average, each participant answered three to four more questions correctly in the post-intervention than they did in the pre-intervention, and this result was largely unchanged in the six-month follow-up.

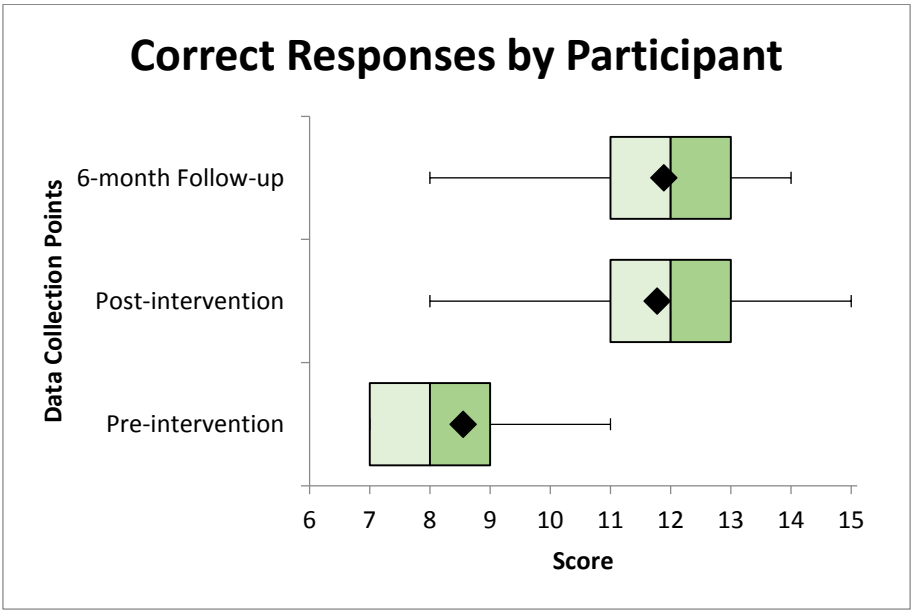


Figure 9. Box-whisker plot of participant responses to the three data collection points.

4.3.2 Descriptive statistics by question.

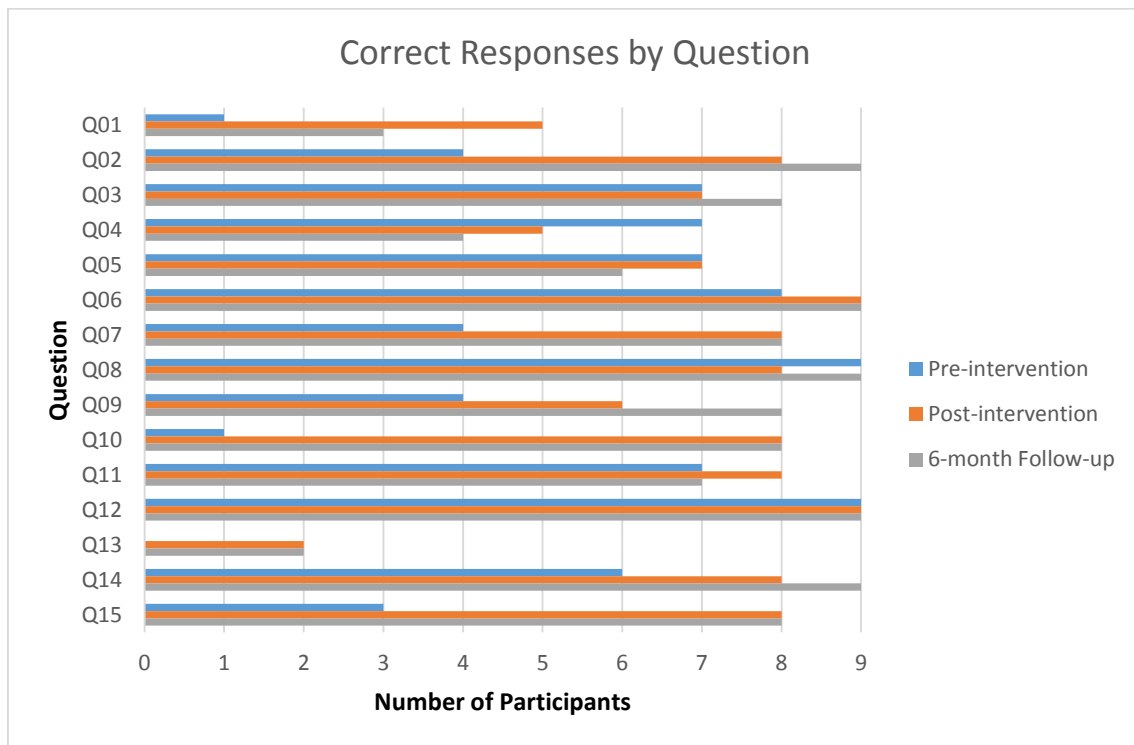


Figure 10. Correct responses by question.

The findings for each question are shown in Figure 10 in ascending order of the number of correct responses from the pre-intervention data collection. From this figure, it can be seen that:

1. Most questions showed an improvement between the pre-intervention and post-intervention. A notable exception was Question 4—the only question to show a decline.
2. The improvement was generally quite large for questions that had scope for large improvement—that is, for questions with initially poor results. Questions 1 and 13 were notable exceptions.

3. The difference between the post-intervention and six-month follow-up was typically zero, plus or minus one. Only two questions (Questions 1 and 9) had a greater change—of minus two and plus two, respectively.

Table 9

Summary Statistics by Question

Data collection point	All questions			Q12 removed			Q13 removed		
	Pre-intervention	Post-intervention	Six-month follow-up	Pre-intervention	Post-intervention	Six-month follow-up	Pre-intervention	Post-intervention	Six-month follow-up
Sample size	9	9	9	8	8	8	8	8	8
Mean	5.1	7.1	7.1	4.9	6.9	7.0	5.5	7.4	7.5
Standard deviation	2.8	1.8	2.2	2.9	1.9	2.4	2.7	1.3	1.9
Quartile 1	3	6	6	3.3	6.3	6.3	4.0	7.0	7.3
Median	6	8	8	5	8	8	6.5	8	8
Quartile 3	7	8	9	7	8	8.75	7	8	9
Interquartile range	4	2	3	4	2	3	3	1	2
Minimum	0	2	2	0	2	2	1	5	3
Maximum	9	9	9	9	9	9	9	9	9
Range	9	7	7	9	7	7	8	4	6

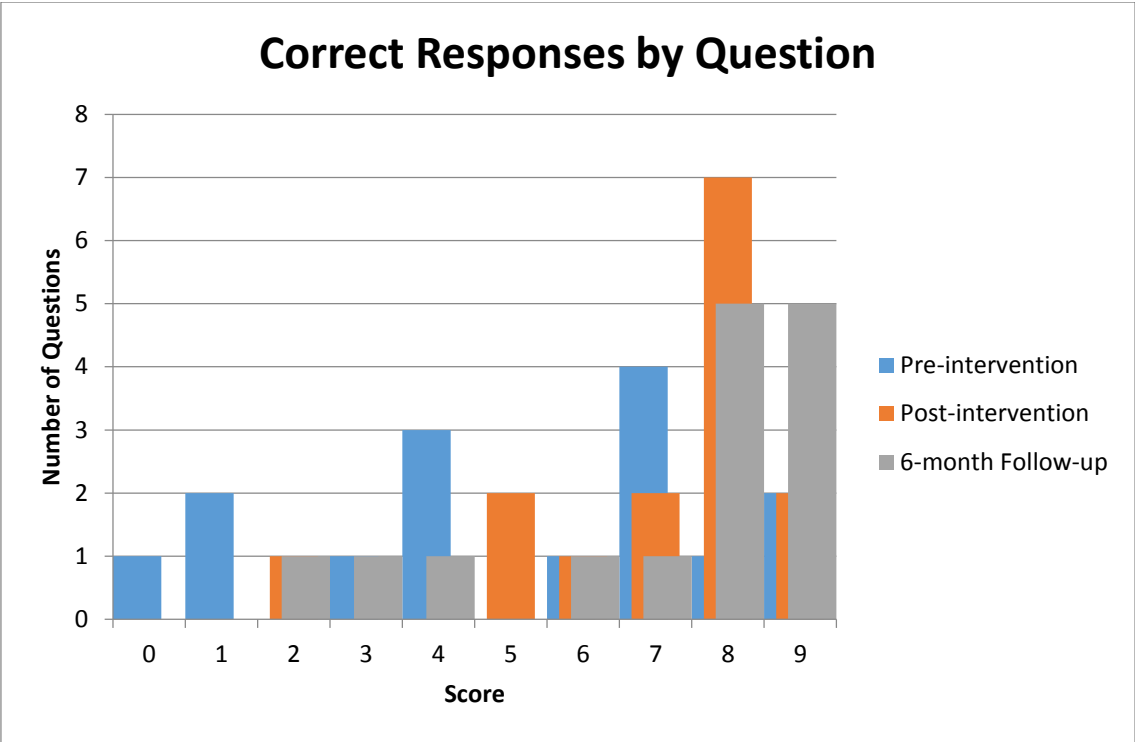


Figure 11. Superimposed histogram of correct responses by question of the three data collection points.

Table 9 presents the ‘by question’ summary statistics, while Figure 11 displays them as a histogram, and Figure 12 displays them as a box-whisker plot. Simple observation suggests that the number of participants who answered each question correctly in the pre-intervention data was widely scattered—from none (Question 13) to all (Questions 8 and 12), with a mean of 5.1 and median of six. In the post-intervention, there was an overall improvement to a mean of 7.1 and median of eight, and a tighter clustering, with the standard deviation dropping from 2.8 to 1.8. The six-month follow-up maintained the same mean and median; however, the data were more spread, with the standard deviation increasing to 2.1. The histogram indicates that this increased spread was a result of correct responses moving from the middle to the extremes.

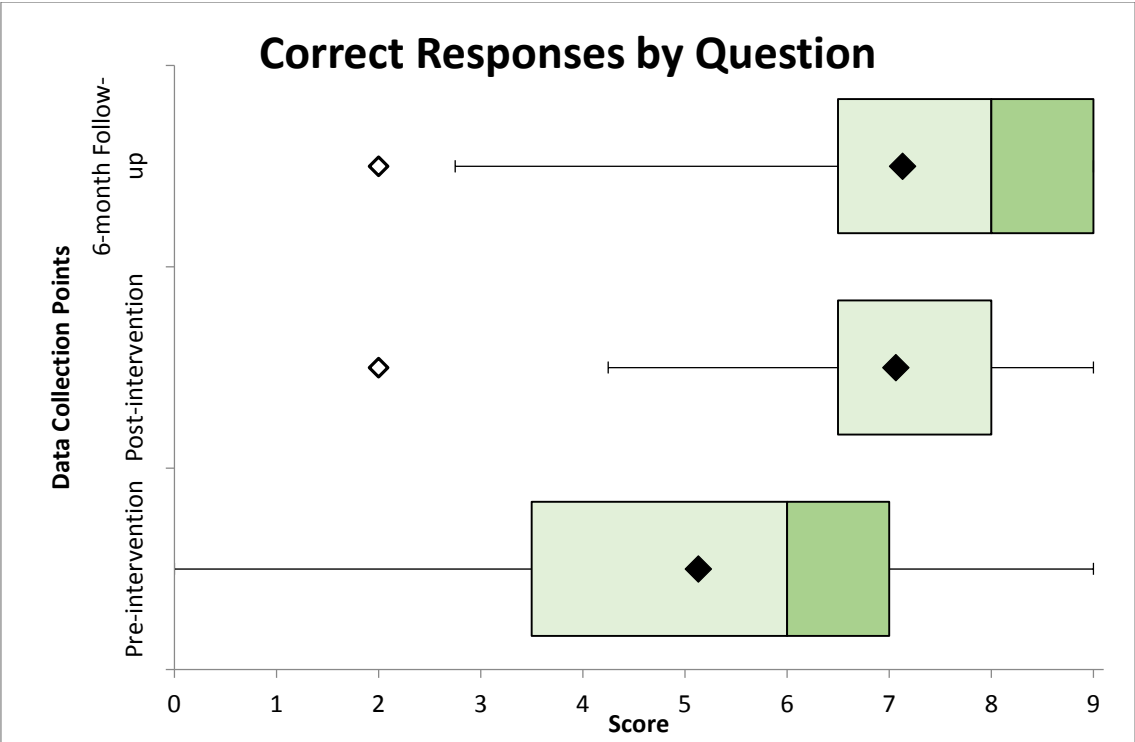


Figure 12. Box-whisker plot of question responses to the three data collection points.

4.4 Research Question 1—Current Knowledge

Research Question 1 asked: What do registered nurses know and understand about urinary catheters and the difference between catheter types?

4.4.1 Current knowledge by participant.

Table 10

Participants’ Current Knowledge¹

Participants	Score ²	Preferred hypothesis (all questions)	Score	Preferred hypothesis (Q12 removed)	Score	Preferred hypothesis (Q13 removed)
1, 3, 7	7	H ₁ : Competent	6	H ₀ : Novice	7	H ₁ : Competent
2, 6	8		7	H ₁ : Competent	8	
8, 9	9		8		9	
4, 5	11		10		11	H ₂ : Expert
Cohort (median)	8	H ₁ : Competent	7	H ₁ : Competent	8	H ₁ : Competent
Cohort (mean)	8.6	H ₁ : Competent	7.6	H ₁ : Competent	8.6	H ₁ : Competent

As detailed in the Methodology section, three alternative hypotheses were presented. The participants’ responses to the pre-intervention survey supported the hypotheses shown in Table 10. When all questions were included, all participants fell into the range where **H₁: Competent** was the most likely of the three hypotheses. That is, they had a probability of 0.5 of knowing the answer to any given question. When Question 13 was excluded, the two participants who scored eight moved into the critical range for **H₂: Expert**; however, it must be remembered that this arose by eliminating a question that they both answered incorrectly.

4.4.2 Current knowledge by question.

The number of participants who correctly answered individual questions varied, which gave support to different hypotheses, as shown in Table 11.

¹ The preferred hypotheses were based on the calculation of critical ranges in Sections 3.7.4 and 4.2.1.
² As no participant answered Question 13 correctly in the pre-intervention, removing it from the data did not affect the participants’ scores.

Table 11

Current Knowledge—Questions Supporting Each Hypothesis³

Preferred hypotheses	Number of questions supporting	Questions
H ₀ : Novice	4	1, 10, 13, 15
H ₁ : Competent	4	2, 7, 9, 14
H ₂ : Expert	6	3, 4, 5, 6, 8, 11, 12

This shows that, while the participants were all rated as competent (or expert), when their total results were considered, there were some questions with which the participants as a group struggled, and others where they excelled. These will be considered in the Discussion chapter to determine whether the questions in each group share any similarities.

4.5 Research Question 2—Knowledge translation

Research Question 2 asked: To what extent do participant nurses retain knowledge on catheter types and catheter selection for defined client groups?

4.6 Knowledge translation by participant.

This question was answered by comparing the pre-intervention and post-intervention data using the Wilcoxon (1945) signed rank test. This was done directly for the null hypothesis and by adding three to the pre-intervention scores for the alternative hypothesis in order to simulate the predicted improvement of 20%. These calculations are presented in Appendix I.

³ The preferred hypothesis was based on the calculation of critical ranges in Section 3.7.4.

The calculations indicated that there was a difference at the 0.05 level for the null hypothesis; however, there was no difference for the alternative. This supported rejection of the null hypothesis in favour of the alternative hypothesis: **that the educational intervention has improved the participants’ results by three questions** (20% of the total number of questions). These findings were unchanged by excluding Question 13.

4.6.1 Knowledge translation by question. When considering each question, the alternative hypothesis—that the participants gained or lost knowledge—could not be used to make specific predictions. Thus, the Fischer technique was used instead of the Neyman-Pearson technique (Gigerenzer et al., 2004). The data in Table 12 summarise the level of support against the null hypothesis—that participants did not gain or lose knowledge. Full calculations are shown in Appendix J.

Table 12

Evidence against Null Hypothesis—Research Question 2

Strength of evidence against null hypothesis	<i>p</i> -value	Number of questions	Questions
Strong	= 0.0078	1	10
Moderate	= 0.0625	4	1, 2, 7, 15
Little to nil	> 0.0625	10	3, 4, 5, 6, 8, 9, 11, 12, 13, 14

While the ‘by participant’ analysis indicated that there was strong support that participants did take up new knowledge, when considering individual questions, there was only one question for which this could be said assertively, and four questions where it could be offered tentatively. The remaining 10 questions did not show a measureable change. These findings will be considered in the Discussion section to determine whether the questions in each group shared any similarities.

4.7 Research Question 3—Knowledge Retention

Research Question 3 asked: To what extent can registered nurses' knowledge about assessment, catheter selection and use for multiple sclerosis and spinal cord injured be retained by the nurse participants following an education intervention?

4.7.1 Knowledge retention by participant. This question was answered by comparing the six-month follow-up data with the pre-intervention (null hypothesis) and post-intervention (alternative hypothesis) data, via with the Wilcoxon (1945) signed rank test. These calculations are shown in Appendix K. The calculations indicated that there was a difference at the 0.05 level for the null hypothesis; however, there was no difference for the alternative. This supports rejection of the null hypothesis in favour of the alternative hypothesis: **that the participants did retain the knowledge they gained from the intervention.** These findings were unchanged by excluding Question 13.

4.7.2 Knowledge retention by question. The questions that supported each hypothesis are shown in Table 13 below. Detailed calculations are presented in Appendix L.

Table 13

Questions Supporting Each Hypothesis: Research Question 3—Knowledge Retention

Hypotheses	Number of questions	Questions
H ₀ : Knowledge retained	8	2, 4, 6, 7, 9, 10, 14, 15
Neither	5	1, 3, 5, 12, 13
H ₁ : Knowledge not retained	2	8, 11

More questions showed retention of knowledge than were either indecisive or showed knowledge loss, which is consistent with the 'by participant' findings. These will be

considered in the Discussion chapter to determine whether the questions in each group shared any similarities.

4.8 Qualitative Question in Six-month Follow-up

The qualitative question in the six-month follow-up asked:

1. Following the education intervention, have I changed my catheter selection choices?

a. Yes ☐

b. No ☐

Why or why not?

Question 16 was only asked at the six-month follow-up data collection point. All nine participants stated that their catheter selection choices had changed following the education intervention. Five of the nine participants elaborated further with the following comments:

- “I now understand a wide choice of catheter selection available for each situation.”
- “More knowledge to employ when making choices for recommendation.”
- “Better understanding of the benefits of different catheters for individual needs.”
- “I now have more confidence with catheter selection.”
- “I’ve learnt that there are a variation of catheters to be used depending on the individual circumstances as every person has different problems.”

4.9 Test–retest Validation of Knowledge Questionnaire

The post-intervention and six-month follow-up findings were used as a measure of the reliability of the survey to produce similar results at different times. As the

research was structured, there was no intervention between these two measures that could have changed the participants' knowledge base. However, it is possible that other circumstances may have changed the participants' knowledge base, either individually or as a whole. Examples would include self-directed study, further third-party education, and consistent use of the decision support tool. The test statistic accommodated changes in the group; however, individual changes could incorrectly invalidate the result. Thus, such outliers must be addressed and consciously included or omitted from the data.

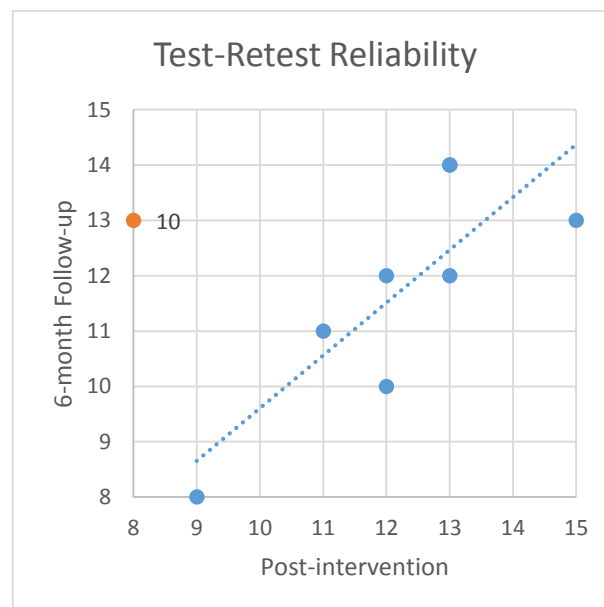


Figure 13. Test–retest scores.

The participants' test–retest scores are shown in Figure 13. It can be seen that all participants' scores for the post-intervention, except one, were within one or two of their six-month follow-up scores. However, Participant 10 increased their score from eight to 13—a 60% improvement, after dropping from nine to eight between the pre- and post-intervention. This participant commented in the six-month follow-up that, “I’ve learnt that there are a variation of catheters to be used depending on the individual

circumstances as every person has different problems”. However, this was not evident in their findings from the post-intervention questionnaire. Thus, under these circumstances, it was reasonable to consider this result an outlier and exclude it from the analysis. The intra-class correlation coefficient for this data had a point estimate of 0.89 and a 95% confidence interval of 0.46 to 0.98, which indicates extremely robust test–retest reliability.

4.10 Participant Demographic Findings

The demographic survey collected the following information about the participants:

1. years of nursing experience
2. years of nursing experience in spinal cord injury or multiple sclerosis
3. job description
4. frequency with which the participant made catheter selection decisions
5. location of basic nursing education and training
6. postgraduate qualifications
7. year in which the participant most recently received training in catheter selection, if any.

Table 14 presents the participants’ responses, along with their total scores in each of the questionnaires.

Table 14

Demographic Responses

Participant	Nursing experience (years)	SC/MS experience (years)	Job description ⁴	Catheter selection frequency ⁵	Training ⁶	Postgraduate qualifications	Catheter training	Pre-intervention	Post-intervention	Six-month follow-up
3	48	24	Registered Nurse	Monthly	Hospital			7	15	13
4	41	2–4	Registered Nurse	Weekly	Hospital		2014	8	13	14
5	0–4	2–4	Registered Nurse	Daily	University		2013	7	9	8
6	14	7	Registered Nurse	Monthly	University	Diploma in Disability		11	12	10
7	6–10	2–4	Registered Nurse	Never	University		2013	11	13	14
8	36	26	Registered Nurse	Monthly	Hospital	Diploma in Disability	2012	8	13	12
9	32	32	Registered Nurse	Never	Hospital	Diploma in Disability		7	12	12
10	10+ ⁷	14	Registered Nurse	Monthly	University			9	8	13
11	DNR ⁸	24	Registered Nurse	Monthly	Hospital	Diploma in Disability	2012	9	11	11
Median	24	14						8	12	12

⁴ The choices offered were as follows: Registered Nurse, Clinical Nurse Specialist, Nurse Educator, Clinical Nurse Educator, Clinical Nurse Consultant, Nurse Unit Manager and Independent Nurse Practitioner.

⁵ The choices offered were as follows: daily, weekly, monthly and never.

⁶ The choices offered were as follows: hospital, college and university.

⁷ This must be at least 14, as this is the number of years in nursing in spinal cord injuries or multiple sclerosis.

⁸ This must be at least 24, as this is the number of years in nursing in spinal cord injuries or multiple sclerosis

The participants' demographic responses are summarised as follows:

1. Nursing experience responses ranged from zero to four years, to 48 years, with a median of 24 years. For hospital-trained nurses, the median was 36 years. For university-trained nurses, the median was 10 years.
2. Nursing experience in spinal cord injury or multiple sclerosis ranged from two to four years, to 32 years, with a median of 14 years. For hospital-trained nurses, the median was 24 years. For university-trained nurses, the median was five years.
3. All participants identified their current job description as Registered Nurse.
4. The most common response regarding catheter selection frequency was monthly (five), followed by never (two). Daily and weekly were selected by one participant each.
5. Five nurses were hospital trained and four were university trained.
Unsurprisingly, the years of experience—both generally and in spinal cord injury or multiple sclerosis—were higher for the hospital-trained nurses.
6. Four of the participants had postgraduate qualifications all of which were a Diploma in Disability.
7. Five participants had previously received catheter selection training in 2012, 2013 or 2014.

All demographic variables were analysed to determine whether they could serve as predictor variables for the participants' responses. In general, these were not statistically significant, with the following exception.

4.10.1 The effect of years of nursing experience on knowledge gain. Years of nursing experience was found have a statistically significant correlation at an $\alpha \leq 0.05$ level, based on the findings of the post-intervention questionnaire. Further investigation showed a far more significant correlation existed between years of nursing experience and the change from pre- to post-intervention, that is, the gain in knowledge following the intervention.

In following this up, a linear estimation of the difference between the pre- and post-intervention findings—that is, the change ostensibly caused by the intervention—was found to be statistically significantly influenced by years of nursing experience, at an $\alpha \leq 0.01$, by years of nursing experience. Thus, a linear regression model was constructed (Sheather, Chatterjee, & Ohlson, 2003). Given the small size of the data set, extreme care was exercised in determining the validity of the model. While the model appeared to be valid, it can only be considered provisional and as a guide for future research. What can be said is that the data in this research showed a very strong correlation between years of nursing experience and the gain in knowledge following the intervention.

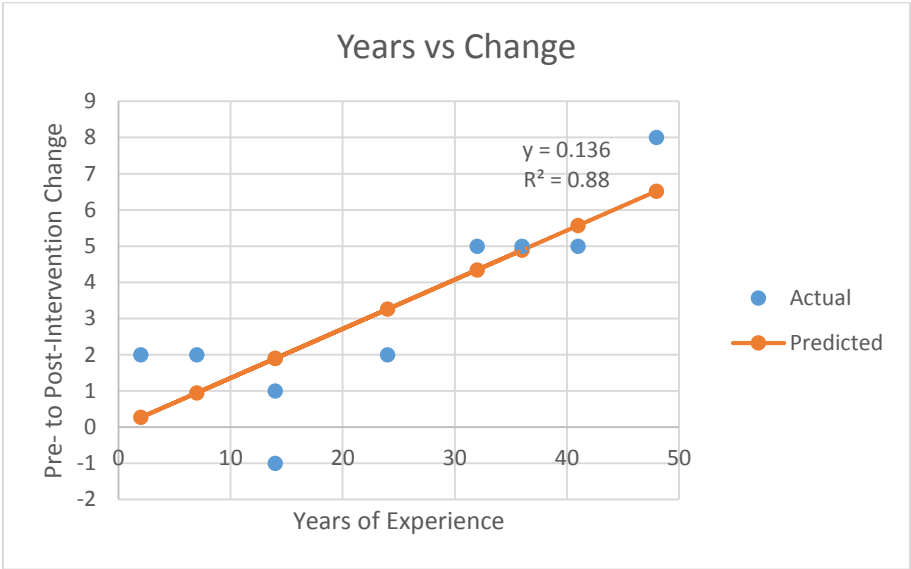


Figure 14. Experience v. knowledge change pre- to post-intervention.

Figure 14 shows the relationship between the knowledge change and the years of experience, with the actual values and those predicted by the regression model.

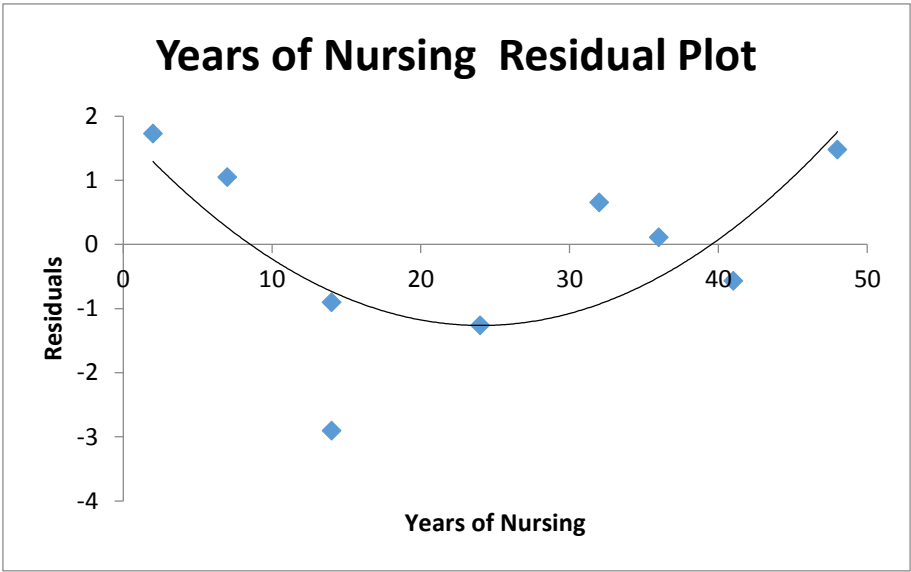


Figure 15. Standardised residuals.

The validity of the model was assessed by examining the standardised residuals for patterns and constant variance. These are shown in Figure 15, and it was at this point that the limited data points became problematic. There was suggestion of a quadratic in the plot of the residuals (as shown); however, there were too few data points to determine if this is a real effect or merely caused by normal variation. A transformation of the data failed to eliminate this, which indicates that it may not be systematic—that is, it may be a random effect and does not affect the validity of the model.

The data were also examined for the effects of outliers (points a long way from the bulk of the data) and leverage points (points that have a disproportionate effect on the model), and neither were discovered. Based on this, the model should be provisionally adopted, with the strong recommendation that further research be targeted at this effect. Table 15 shows that the model predicted 76% of the variation in the change of score, with a standard error of 1.49.

Table 15

Summary Regression Statistics

Regression statistics ⁹	
Multiple R ¹⁰	0.94

⁹ This is commonly referred to as ‘goodness of fit’ statistics.
¹⁰ This is the correlation coefficient, which determines how strong the linear relationship is. For example, a value of one indicates a perfect positive relationship, while a value of zero indicates no relationship at all. It is the square root of r squared.

R square ¹¹	0.88
Standard error ¹²	1.49
Observations ¹³	9

The details of the model are shown in Table 16 below. Given that the initial modelling indicated that the intercept was very close to zero (less than 0.25 standard deviations), and because assuming that it was zero was not unrealistic, the intercept was forcibly set to zero. This gave a ratio between the increase in score and years of nursing experience of 0.14, with a 95% confidence interval of 0.10 to 0.18. This indicated an increase of one correct question for every 5.5 to 10.5 years of nursing experience. Note that the *p*-value of the *t*-statistic was significant at a 0.0001 level.

¹¹ This is r^2 —the coefficient of determination. It indicates how much of the data is explained by the regression model. For example, 0.8 indicates that 80% of the variation of *y*-values around the mean is explained by the *x*-values.

¹² This is an estimate of the standard deviation of the error μ . The standard error of the regression is the precision with which the regression coefficient is measured.

¹³ This is the number of observations in the sample.

Table 16

Linear Regression Coefficients

	Coefficients ¹⁴	Standard error ¹⁵	T-stat ¹⁶	P-value ¹⁷	Lower 95% ¹⁸	Upper 95% ¹⁹
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
Years of nursing	0.14	0.017	7.78	0.000053	0.096	0.18

Based on the analysis of variance (Table 17), there was a highly significant $\alpha < 0.001$ association between years of nursing experience and the change in score between the pre- and post-intervention.

Table 17

Analysis of Variance

Analysis of variance	df ²⁰	SS ²¹	MS ²²	F ²³	Significance F ²⁴
Regression ²⁵	1	135.1	135.1	60.56	0.00011
Residual ²⁶	8	17.9	2.2		

¹⁴ The least squares estimate.¹⁵ The least squares estimate of the standard error.¹⁶ The t-statistic for the null hypothesis (that the coefficient is zero) v. the alternate hypothesis (that the coefficient is not zero).¹⁷ The p-value for the hypothesis test.¹⁸ The lower boundary for the confidence interval.¹⁹ The upper boundary for the confidence interval.²⁰ Degrees of freedom.²¹ The sum of the squares.²² The sum of the squares divided by the degrees of freedom.²³ The overall F-test statistic of H_0 : all coefficients = 0 versus H_a : at least one of the coefficients does not equal zero.²⁴ The P-value associated with the F-test.²⁵ Variance associated with the model.

Total	9	153
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²⁶ Variance associated with the residual values—i.e. not associated with the model.

Chapter 5: Discussion

5.1 Introduction

Catheter selection is fundamental to catheter management, particularly in the type of residential care facilities where this study occurred. Due to the specialisation focus of this care context, catheters are obtained and stored in relation to individual client need, rather than purchased in bulk. This is because it is crucial that clients are able to use appropriate equipment according to their individual requirements, and changed when clinically indicated, rather than following a standard routine or protocol.

To measure catheter selection knowledge, this study constructed a 15-item multiple-choice survey instrument, based on catheter selection choices related to catheter types and urinary complications associated with catheter use. This survey was used to collect and compare pre-intervention data to post-intervention data. Follow-up data collection occurred three months and six months post-intervention.

By testing clinicians' knowledge in these areas, greater awareness was promoted regarding whether these clinicians understood their catheter selection choices and were able to recognise when good catheter selection choices were not being made due to poor knowledge. Follow-up testing allowed some measure as to whether the clinicians maintained good catheter selection knowledge for future practice after being made aware of good practices in catheter selection.

To validate the test and further assess the sustainability of the knowledge change, data were again collected at six months post-intervention using the same survey in order to ascertain consistency of the results across time. The findings indicated that

all but one registered nurse scored one to two marks difference between their three-month post-intervention and six-month post-intervention data collection (see Figure 13). Excluding the one outlier, the retest showed strong validation of the questionnaire.

5.2 Current Catheter Selection Knowledge

Essentially, this study identified the uptake and sustainability of new catheter selection knowledge among registered nurses who practice in a specialised context that necessitates frequent catheter selection. To measure the uptake and sustainability of knowledge, a baseline from which to measure must be understood. Evaluating the quality of nurses' decision making is often undertaken through measuring clinical outcomes or nurses' awareness and adherence to expert consensus (Dowding & Thompson, 2003). With regard to this study, as clinical outcomes were not able to be measured, a data collection instrument was developed to assess catheter selection knowledge (Appendix E). To measure the current quality of the registered nurses' catheter selection knowledge—and considering Dobson et al.'s (1996) and Fleming et al.'s (2000) earlier claims of poor catheter selection knowledge among Australian nurses—three hypotheses were developed to classify the registered nurses' catheter selection knowledge. The classification of novice, competent and expert were drawn from Benner's (1982) levels or stages of competency.

Based on the findings, this study rejected the hypothesis that the participant registered nurses' catheter selection was akin to that of either a novice or an expert. The demographic findings (see Table 14) showed that the participant registered nurses' experience of working with spinal cord injury or multiple sclerosis ranged from two years to 32 years, with a median of 14. Of the three participants who identified as

working only with spinal cord injured or multiple sclerosis clients for two to four years, only one had four or fewer years of experience as a registered nurse.

The overall correct results per participant for the survey (see Table 10) ranged from seven to 11. The three participant registered nurses who had two to four years experience in spinal cord injury or multiple sclerosis received the following pre-intervention scores: seven, eight and eleven. This is inclusive of the worst score and best score achieved by the whole group. Applying the Benner et al. (2008) claim that expertise is learnt over time, it would be expected that the majority of these participant registered nurses were operating at an expert level, and the three participant registered nurse with two to four years experience in spinal cord injury or multiple sclerosis would be operating between a competent to expert level. The critical range (see Table 3) for estimating competence level was:

- a score of zero to six to indicate the participant as a novice
- a score of seven to 11 to indicate the participant as competent
- a score of 12 to 15 to indicate the participant as an expert.

Prior to the education intervention, a score between seven and 11 correct questions per participant most likely meant the group as a whole was competent compared to the critical range. Consequently, the hypothesis that the participant registered nurses were competent and had moderate knowledge was accepted as correct for their current level of knowledge. Ericsson et al. (2007) claimed that experience coupled with domain knowledge does not necessarily lead to expertise, and that experience itself is a poor indicator of expertise. The acceptance of the hypothesis that the participant registered nurses in this study were competent, rather than expert, aligns more closely with the

claim by Ericsson et al. (2007) than the claim by Benner et al. (2008), who stated that extensive experience in a domain-specific area leads to expert nursing.

Despite practising in this specialised environment, it appeared from the survey findings that not all participant registered nurses were making conscious decisions about which catheter to use. In view of the low levels of nursing knowledge found at the start of this study regarding catheters and their selection, it is possible that this may explain any reticence the nurses may have had about choosing which catheters to use in particular situations. However, of great concern were the participant registered nurses who identified that they made catheter selection choices, yet had knowledge deficits regarding catheter selection. These findings align with those of Michels et al. (2012), who, when defining clinical skills, claimed that these skills are a combination of procedural knowledge, underpinning scientific knowledge and clinical reasoning. They stated that, when teaching clinical skills, all three components must be considered. The clinical reasoning cycle relies on nurses making critical decisions through a combination of cognitive reasoning skills and client interaction. Levett-Jones et al. (2010) claimed that poor clinical reasoning skills lead to a failure to diagnose, the provision of inadequate treatment and inappropriate management of complications, which result in unsafe care. When applied to catheter selection decisions, clinician uncertainty about catheter specifications and materials in relation to particular client needs would also undermine clinical decision making and catheter management.

For example, for people with spinal cord injury or multiple sclerosis, urine is often reported as containing amorphous substance (Singh et al., 2011), which results in frequent catheter blocking, which may result in associated autonomic dysreflexia. In

this situation, clinical decision making by nurses depends on their knowing and understanding that the use of coated catheters with a much narrower internal lumen will increase the frequency of catheter blocking in this type of client, and should subsequently be avoided. Most clinicians are able to respond to symptoms such as autonomic dysreflexia, which can be treated as it occurs; however, preventing frequent autonomic dysreflexia in the example given cannot be fully addressed if catheter selection is not informed and considered.

Most of the group in this study gave incorrect responses to the following questions:

- Question 1: Are all Foley catheters suitable for suprapubic use?
- Question 10: For clients requiring repeated irrigation, what should be used?
- Question 13: For a client who describes urethral discomfort on intermittent self-catheterisation, what would you suggest?
- Question 15: When difficulty passing the urethral sphincter, what type of catheter should be trialled?

These survey questions, with the exception of Question 1, were related to intermittent catheter use, and the incorrect responses may indicate that the participant registered nurses had less familiarity with such catheters.

Question 1 of the survey related specifically to indwelling catheter use, and this information needs to be ascertained by the nurse prior to inserting an indwelling catheter, rather than in response to a urinary complication. Decisions related to suprapubic or urethral indwelling catheter must consider balloon ridging on deflation of

the balloon for removal of the catheter, as ridging can make suprapubic catheter removal difficult (Wicks, 2009). Thus, Question 1 constituted fundamental knowledge in catheter selection that registered nurses need to apply in relation to the catheter they intend to use when inserting an indwelling catheter. In the pre-intervention data collection, only one participant answered this question correctly, yet seven of the nine registered nurse participants claimed that they made catheter selection choices. It is possible that those who claimed to be making catheter selection decisions were doing so; however, the appropriateness of those decisions related to indwelling catheters was questionable, given the low participant awareness of a fundamental issue related to catheter selection, insertion and management.

In contrast, the survey questions that most participants answered correctly were:

- Question 3: What length and size catheter is used for an adult male urethral indwelling catheter?
- Question 4: What length and size catheter is used for an adult female urethral catheterisation?
- Question 5: What length and size is used for an adult suprapubic catheterisation?
- Question 6: For clients experiencing sediment blockages, which type of catheter should be used?
- Question 8: For clients experiencing bladder wall irritation, which type of catheter should be trialled?
- Question 11: What size intermittent catheter should be used when teaching intermittent self-catheterisation to male adult clients?

- Question 12: What size intermittent catheter should be used when teaching intermittent catheterisation to adult females?

Survey Questions 3, 4, 5, 11 and 12 were related to Fg size and catheter length selection. Fg size and catheter length are discussed in many catheter guidelines (Geng et al., 2012; Nazarko, 2010; Pomfret, 1996); however, it is unknown whether these participants' answers were informed because of awareness to guidelines, or due to observation of the catheter length and Fg used by clients on arrival at Ferguson Lodge and Studdy MS Centre—Residential Care Unit.

While survey Questions 6 and 8 related to client urinary complication symptoms, Question 6 was of particular relevance to people living with a spinal cord injury or multiple sclerosis because of sediment in the catheter being a common situation, as noted by Singh et al. (2011), who investigated urinary complications and related bladder management programs. Increased sediment may warrant further clinical investigation; however, on a daily basis, optimum catheter drainage is needed. Question 8 related to bladder wall irritation, which needs to be considered in regard to catheter tip choices for clients with small capacity bladders. For those with a spinal cord injury or disease with an indwelling catheter on free drainage, long-term bladder capacity will be reduced as the bladder is not filling and emptying. The survey did not ask the participant registered nurses which urinary complications their clients experienced most frequently; thus, it is unclear whether their answers to Questions 6 and 8 were a result of clinical experience and judgement, as suggested by Benner et al. (2008) (who claimed that long-term work in a designated field will lead to expert skills), or whether their responses were informed by prior catheter selection education.

Earlier studies in catheter selection and management by Dobson et al. (1996) and Fleming et al. (2000) claimed that Australian nurses had poor catheter selection knowledge, and that the way forward was to develop more guidelines for improved practice. However, creation and dissemination of guidelines is insufficient to improve knowledge (Straus et al., 2009). Although the current study did not ask the participant registered nurses if they were aware of catheter selection and management guidelines, these guidelines have been available since at least 1996. According to Benner's (1982) stages of clinical competency, the participant nurses in this study, as a group, were able to demonstrate competent levels of catheter selection knowledge. However, it remains a concern that these nurses, who have extensive experience (median 14 years) in the care of spinal cord injured and multiple sclerosis clients—and, by extension, with urinary complications associated with catheter use—in an environment where catheter guidelines are available, demonstrated skill levels below that expected of nurses who have worked for extensive periods in one speciality. This finding has implications for promoting the use of the clinical guidelines that are available to guide practice. There are also implications for professionals and managers in this context who have legal and ethical obligations to provide resources and care that meets both quality and safety standards.

5.3 Knowledge Uptake

The second focus of this study was to investigate whether the participant registered nurses, when provided with information on catheter selection, absorbed that knowledge, and to what extent. Two hypotheses were tested to determine whether the participants increased their knowledge in catheter selection, by correctly answering an

additional three questions to those answered correctly during the pre-intervention data collection. The overall mean for the group rose from 8.6 in the pre-intervention to 11.8 in the first post-intervention, while the median changed from eight in the pre-intervention to 12 in the first post-intervention. In addition, the statistical analysis indicated that the data were more likely to have arisen under the hypothesis that the participants increased their knowledge sufficiently to score three more correct questions.

When comparing the demographic data to the uptake of knowledge (see Table 16 and Figure 14), the ability of the participants to absorb new knowledge was highly correlated with their years of nursing experience. Specifically, for every 5.6 to 10.4 years of general nursing experience, the participants answered an additional question correctly, following the post-intervention. The demographic data showed that years of nursing experience, as well as years of experience in the speciality area, supported the uptake of knowledge following the education intervention. In this context, this would lead to expertise in catheter selection. This somewhat aligns with Benner et al.'s (2008) claim that years of experience in a speciality context lead to the development of expertise. However, the findings of this study suggest that clinical skill is linked to the synthesising of underpinning knowledge and associated clinical reasoning, as indicated by Michels et al. (2012), and that expertise occurs following the synthesis of fundamental knowledge.

In the same manner as the current study, Madigan et al. (2014) also found improvements in knowledge base following an education intervention. Madigan et al. assessed the benefits of the education intervention for improving the knowledge of

community staff in enteral feeding. The participants were assessed immediately after the education, and then six months later. It was a clustered randomised controlled trial based in Northern Ireland, including 64 general practitioners, 113 community nurses and 56 nurses from residential aged care. The findings claimed significant improvement in knowledge across all three groups in the initial post-intervention data collection. The study similarly involved a short education session that was less than one hour, and included lecture-style presentation, inclusive problem-solving, tactile experiences with product and an education package. The difference in the education intervention in the present study was that case studies were given to the registered nurse participants to problem solve, and were reflected on by all in the group. In addition, as part of the education package, the participants were given a decision support tool regarding catheter selection. Further, Madigan et al. (2014) held the first post-intervention data collection immediately after the education session, and claimed that significant improvement had occurred. In contrast, in the current study, the first post-intervention data collection occurred three months after the intervention. This was done as a means to assess uptake of knowledge embedded as a result of understanding the information. In addition, it enabled opportunities for reflection in practice, as recommended in Kolb's (1984) experiential learning theory, as opposed to only assessing the knowledge given, without an opportunity to reflect and embed this knowledge in practice.

There are similarities between the present study and another Australian study by Lim et al. (2010), which sought to assess the benefits of a short education session on knowledge related to medication administration, for 58 nurses working in residential care. In addition to the education session, participants in Lim et al.'s study had access to

an online self-directed learning package. Post-intervention testing occurred four weeks after the education intervention using the same survey. Lim et al. claimed that uptake of knowledge occurred; however, the results of the final post-intervention data collection are unknown. However, when considering uptake and retention of knowledge, it appears that the greater the timespan between the education session and the post-intervention data collection, the more likely the knowledge being measured is not transient.

The establishment of an alternative hypothesis to gauge knowledge uptake required the establishment of a specific threshold of knowledge uptake. This was informed by the studies of Lim et al. (2010), who saw an improvement of 13% (0.40 to 0.27 incorrect answers), and Madigan et al. (2014), who saw an improvement of 30 to 40%, depending on the group. The number of three questions was adopted as an indication of improvement because it was considered a reasonably significant change (20%)—based on the critical ranges in Table 3—that was sufficient to move a participant who scored in the middle of the novice range into the competent range, or the middle of the competent range into the expert range.

Four questions showed strong to moderate uptake, as follows:

- Question 1: Are all Foley catheters suitable for suprapubic use?
- Question 2: What size should the balloon of the indwelling catheter be inflated to?
- Question 7: For clients experiencing continuous symptomatic infection, which catheter may they benefit from trialling?
- Question 10: For clients requiring repeated irrigation, what should be used?

Of the four survey questions for which the greatest uptake of knowledge across the participant registered nurse group occurred, three survey questions (Questions 1, 7 and 10) referred to the integral stages of the clinical assessment process in the catheter decision support tool. This result suggests that a combination of both education and supply of a catheter decision support tool may have prompted the uptake of new knowledge pertaining to catheter selection. This finding aligns with the knowledge-to-action process proposed by Graham et al. (2006), which emphasises the importance of tailoring knowledge tools to assist in solidifying the information needed by the clinician, and thereby ensuring the knowledge needs of the clinician are met.

Horowitz et al. (2007) noted that the uptake of knowledge occurs concurrently with the use of decision support tools. Horowitz et al. examined treatment outcomes when using decision support tools, as opposed to not using decision support tools. They claimed that uptake of practice guidelines improves in the presence of decision support tools, as clinicians have difficulty keeping abreast of new information. Clear, concise information made available through the use of decision support tools can overcome the issues identified by Mills et al. (2011a) in relation to clinicians finding it difficult to synthesise research evidence for use in practice. More recently, the benefits of using decision support tools were summarised by Holland et al. (2014), who proposed that, “standardising decision support improves decisions by systematising the process based on best evidence” (p. 156).

Survey Question 10 addressed the participants’ knowledge about catheter irrigation. During the education intervention, the nurses believed that irrigation could be accomplished using a 60 ml catheter tip syringe because only 30 ml of normal saline

was used. This response demonstrated that the nurses did not have the fundamental knowledge to understand the difference between a catheter flush used to unblock an encrusted catheter when treating autonomic dysreflexia (as per *NSW Health Safety Notice 012/08* [Greater Metropolitan Clinical Taskforce, 2008]), and continuous or intermittent catheter irrigation in response to draining blood clots (as recommended in the *ACI Bladder Irrigation Guidelines* [Mcleod & McDonald, 2008]). In the pre-intervention data collection, only one person answered this question correctly; however, following the education intervention, all except one person answered this question correctly. The responses to this question demonstrated the greatest uptake of knowledge across the participant registered nurses, and, to some extent, supported the claims of Dobson et al. (1996) and Fleming et al. (2000) that developing guidelines improves catheter selection knowledge. However, the current study demonstrates that it is not just the development of guidelines that influences clinical practice, but also the way in which they are implemented.

The guidelines for bladder irrigation were originally presented by the NSW Government Department of Health's ACI in 2008, and are readily available via the internet without access restriction. The change in participant knowledge in this study was related to knowledge translation. Pathman et al. (1996) proposed the awareness-to-adherence model as a way to promote the uptake of guidelines. The awareness-to-adherence model requires clinicians to:

1. be aware of the guidelines or evidence
2. critically evaluate the information and agree to practice the recommendations

3. adopt and adhere to the practice changes (Pathman et al., 1996).

The current study participants' lack of knowledge about catheter irrigation was a clear demonstration of their lack of awareness of existing guidelines. The uptake of the information supplied in the education intervention pertaining to catheter irrigation was demonstrated through the number of participants who changed to the correct answer in the post-intervention survey, and retained the information over time. Testing of whether implementing these changes would lead to better clinical outcomes for clients was deemed beyond the scope of this masters-level research project.

If clinical reasoning is not processed properly, inappropriate interventions may occur, resulting in adverse clinical outcomes (Levett-Jones et al., 2010). That is, nurses who are unaware of practice guidelines will lack the underpinning knowledge with which to assess and apply clinical reasoning. While awareness and the use of existing catheter selection guidelines were not investigated in this study, given such a dramatic change to survey Question 10, it is important to recognise that knowledge is shared in a variety of ways. For the purpose of this study, the participant nurses were provided with a one-hour, face-to-face, interactive education session that allowed reflective feedback on practice, and a takeaway catheter selection decision support tool. It is not known with certainty if the change in knowledge was related to the education session, the supply and subsequent use of the catheter selection decision support tool, or both. According to Mills et al. (2011a), nurses lack the ability to search, read and analyse research evidence for practice, despite evaluation of research evidence being part of many nursing baccalaureates—a factor that warrants further research.

The only survey question that indicated uptake of knowledge that was not included in the decision support tool was survey Question 2. This question asked: what size should the balloon of the indwelling catheter be inflated to? Discussion occurred during the education session regarding bladder wall irritation and occlusion of drainage eyelets through the inappropriate filling of catheter balloons. This is a significant concern in the client group cared for by the participant nurses. It is unclear whether the clients cared for by the nurses in this study experienced catheter blocking and impaired drainage related to the sediment experiences of those living with spinal cord injuries or disease, as noted by Singh et al. (2011), or whether the clients experienced catheter blockage or impaired drainage because of catheter eyelet obstruction from a non-symmetrical balloon. Non-symmetrical balloons may result in the catheter tip rubbing on the bladder mucus, resulting in impaired drainage (L. Smith, 2003). This issue has implications for adverse clinical outcomes, particularly in this client group, because, prior to the education intervention, some participant nurses may have been making clinical decisions about balloon size, despite their lack of awareness. The moderate uptake of this knowledge across the participant group may have improved if it had been included in the decision support tool; however, this cannot be determined from this study. Thus, future research and updating of the catheter decision support tool is recommended.

5.4 Knowledge Retention

The third research question explored retention of catheter selection knowledge by the participants. For the third research question, two hypotheses were proposed that essentially measured how closely the answers in the three-month data collection

resembled those in the six-month data collection phase. The findings indicated that the participants did retain knowledge following the intervention.

Of the 15 survey questions, the participants demonstrated retention of knowledge in eight questions. In five questions, it was not possible to determine whether knowledge was retained or not. In two questions, knowledge was not retained. The following questions were those that showed no knowledge retention:

- Question 8: For clients experiencing bladder wall irritation, which type of catheter should be trialled?
- Question 11: What size intermittent catheter should be used when teaching intermittent self-catheterisation to male adult clients?

Survey Question 8 is fundamental to catheter selection in people with neurogenic incontinence who use indwelling catheters over a long period. The clinical experience being, long-term free drainage via an indwelling catheter in the spinal cord injured or multiple sclerosis client who has a reflexic bladder, does not facilitate filling and storage capabilities of the bladder. Thus, the capacity of the bladder is not retained, and a long catheter tip may cause irritation to the bladder wall. In the pre-intervention data collection, all participant nurses demonstrated knowledge in catheter selection to reduce bladder wall irritation by the catheter. At the six-month post-intervention, all participant nurses demonstrated knowledge in catheter selection. However, this could not be considered retention of knowledge because one participant nurse changed from a correct response in the pre-intervention to an incorrect one in the three-month post-intervention, and back to a correct answer in the six-month post-intervention. The hypothesis for retention of knowledge analysed how closely the six-month data

collection matched either the pre-intervention data collection or three-month post-intervention data collection. In this case, it matched the pre-intervention data collection. The participants' years of experience in spinal cord injury or multiple sclerosis correlated with Benner et al.'s (2008) expectations of competency expected of an expert nurse; thus, it is possible that this participant relied only on clinical experience for the answer.

Survey Question 11 was correctly answered by most participants in the pre-intervention data collection. Although the same number answered this question correctly in the six-month follow-up, the results more closely matched the pre-intervention, rather than the three-month post-intervention survey responses. Further, the same participants who answered incorrectly in the pre-intervention data collection were different to those who answered incorrectly in the six-month follow-up. It is unknown if the participants had more clinical experience with indwelling or intermittent catheters, as this was not asked in this research. The same Fg is used for indwelling urethral catheterisation in adult women in this specialty context. It is possible that participants transferred their knowledge as one would expect of nurses with expertise, according to Benner (1982), or had prior knowledge regarding this question that was not influenced by the education session. It was beyond the scope of the current research to explain why these participants correctly answered survey Question 11.

Clear evidence of knowledge retention was found in the answers to eight questions. These questions were:

- Question 2: To what size should the balloon of the indwelling catheter be inflated?

- Question 4: What length and size catheter is used for an adult female urethral indwelling catheterisation?
- Question 6: For clients experiencing sediment blockages, which type of catheter should be used?
- Question 7: For clients experiencing continuous symptomatic infection, which catheter may they benefit from trialling?
- Question 9: For clients with a diagnosed compromised urethral tract, which type of catheter should be trialled?
- Question 10: For clients requiring repeated irrigation, what should be used?
- Question 14: When should a catheter with a non-touch applicator be used?
- Question 15: When difficulty passing the urethral sphincter, which type of catheter should be trialled?

In the first instance, retaining knowledge is predicated on knowledge being gained.

Thus, survey questions in which the participants showed little or no change were not able to indicate retention if little or no knowledge was gained.

These eight survey questions indicated both a lower initial knowledge base and a greater than average gain in knowledge by the participants than the entire set of 15 questions did. Specifically, for these eight survey questions, the median number of correct answers increased from four to eight, compared with six to eight for the entire 15 survey questions, between the pre-intervention and three-month post-intervention data. In both cases, a median of eight was maintained in the six-month follow-up data.

These data initially indicate that knowledge was retained in both cases; however, for these questions, the statistical test (McNemer's exact) showed a greater significance

at least partially because the initial gain was greater. In essence, the McNemer's exact test measures how 'far' the six-month follow-up data had progressed from both the pre-intervention and three-month post-intervention data. When these data are initially further apart, the test is more sensitive than when they are initially close together.

Survey Question 2's content was not covered by the catheter decision support tool, although discussion occurred during the education intervention in relation to current evidence. It was beyond the scope of this research to determine whether education alone or the combination of education and a decision support tool would improve knowledge retention. However, the findings regarding knowledge retention pertaining to this survey question suggested that knowledge retention was improved by the facilitated education session that allowed reflection on clinical practice, without the use of a decision support tool.

Survey Question 4's content was also not covered by the catheter decision support tool, but is covered in catheter selection guidelines regarding the potential for kinking due to excess length external to the body (Godfrey & Evans, 2000; Head, 2006; H. P. Loveday et al., 2013). However, in the field of spinal cord injury and multiple sclerosis, the majority of clients who use an indwelling catheter—regardless of whether it is for suprapubic use or indwelling use—will be mobilising in a wheelchair, which may be electric, rather than manual. When using a wheelchair for mobility, the leg bag is drained into the toilet while the client remains in the wheelchair. The larger the wheelchair, the greater the distance to the toilet, and electric wheelchairs are generally larger than manual wheelchairs. The use of a wheelchair—whether manual or electric—is important to this group of participant registered nurses because ease of access to drain

a leg bag directly into a toilet can be difficult if using a female (short 16 to 23 cm) catheter, or if the client is wearing trousers, regardless of whether the catheter is connected to a short or long tube leg bag. The participants' knowledge pertaining to female catheter length requirements for indwelling catheterisation aligned with Benner et al.'s (2008) proposition that experiential learning is derived from working long term in a speciality context, and supports the application of that expertise in that context, because the registered nurse is aware of the unique characteristics of the clients in that speciality and may apply clinical reasoning to those unique characteristics.

Survey Question 6 scored well in the pre-intervention data collection; however, not all responses were correct. Research Question 3 measured how closely the correct responses in the six-month post-intervention follow-up were to the three-month post-intervention follow-up responses. All participant registered nurses were correct for this survey question at the three-month post-intervention data collection, and at the six-month data collection. Survey Question 6's content knowledge was included in the catheter decision support tool, and was of particular relevance to people using an indwelling catheter who have a spinal cord injury or multiple sclerosis (Singh et al., 2011). Whether this difference in information source influenced the retention of this knowledge is unknown because it was deemed beyond the scope of a masters project to ask participants to record the urinary complication experienced by their clients using indwelling catheters. However, the participant who incorrectly answered this survey question had over 20 years' experience with spinal cord injury or multiple sclerosis. In the education intervention, the characteristic of sediment and associated blocking in this specialty context was discussed, thereby allowing opportunity for that participant to

recognise the unique characteristics of the client group relevant to catheter selection through facilitated reflection on practice. This activity may explain why the knowledge was retained.

Survey Question 7's results depicted both good uptake and good retention of knowledge. All except one participant gave correct responses to this question at the three-month post-intervention collection, and remained correct at the six-month survey. In addition, using Benner's (1982) stages of clinical competency, the participant who was incorrect would still fall into the competent category. The uptake and retention of knowledge by all other participants for this question can be explained in terms of either Pathman et al.'s (1996) awareness-to-adherence model or Graham et al.'s (2006) knowledge-to-action model. During the current study's education intervention, current research (Estores et al., 2008; Gentry & Cope, 2005; Karchmer et al., 2000) and guidelines (Hooton et al., 2010; Lo et al., 2008; Mitchell et al., 2011; Tenke et al., 2008) on the use of silver-coated catheters were included in the discussion as evidence of the frequency of infections for those with a spinal cord injury or multiple sclerosis. This discussion raised awareness of the need for information about silver-coated catheter practices. Being given an opportunity to examine the evidence and guidelines in a reflective discussion of practice may have influenced the responses to survey Question 7 in the three-month data collection. Although retention of knowledge does not mean adherence in practice, it does prepare clinicians to choose to adhere if they are aware of and assume new knowledge. Further, this survey question was covered by the catheter decision support tool, which synthesised research evidence that had been explained and discussed during the education intervention.

Consideration needs to be given to the claim of Mills et al. (2011a) that Australian nurses struggle to synthesise research evidence and guidelines, and often seek advice from peers, especially considering the isolation in which the current study's participants work. The uptake and retention of knowledge may have occurred because the intervention education session synthesised the research and guideline evidence for participants, or because the decision support tool provided practice recommendations based on synthesis of the research evidence. Whatever the explanation, it is clear that knowledge was gained and retained by the participants.

Survey Question 9 showed that uptake and retention of knowledge had occurred in the participant group. At the pre-intervention collection, five participants gave incorrect responses; however, three participants gave incorrect answers at the three-month post-intervention collection, while only one response was incorrect at the six-month post-intervention survey. Whether this change was due to external additional training in catheter selection is unknown because participants were not asked. It may relate to how quickly they could uptake new knowledge and use the decision support tool, which had survey Question 9 as a catheter selection decision, and the use of the tool would have continued to reinforce the correct knowledge associated with Question 9. This result aligns with Rogers's (2004) claim that diffusion of innovation in its simplest form is the way in which information spreads. Rogers (1995) further claimed that the uptake and adherence of guidelines occurs at different rates for different people, with some taking longer to synthesis and adopt change. While beyond the scope of the current study to address delays in knowledge uptake, as outlined by Rogers (1995),

these and further data need to be examined in correlation with Benner's (1982) stages of clinical competency.

Survey Question 10 showed almost 100% uptake in the three-month post-intervention collection, and this level of understanding was maintained at the six-month post-intervention collection. Question 10's content was covered in the decision support tool, and discussion regarding current evidence and guidelines occurred during the education session.

The results for survey Questions 14 and 15 will be discussed together. At the pre-intervention phase, good knowledge was not apparent in the responses to Questions 14 and 15. This is unsurprising given that, during the education intervention, the participants revealed they did not teach clients much self-catheterisation, compared to catheter selection for indwelling catheters. In addition, for those clients for whom they managed and selected catheters, the majority had suprapubic indwelling catheters, rather than urethral indwelling catheters. The clinical indicators for both Questions 14 and 15 were discussed during the education intervention, and were part of the assessment process in the decision support tool used in this study. The results for these questions demonstrated changes in uptake and retention once awareness and agreement with the knowledge had occurred. Mickan et al.'s (2011) proposition that failure to move from awareness to adherence can occur anywhere along Pathman et al.'s (1996) awareness-to-adherence model is relevant to explaining the responses to Questions 7, 14 and 15, prior to the education intervention. Failure to progress along Pathman et al.'s (1996) awareness-to-adherence model occurred early, as the participant registered nurses did

not demonstrate an awareness and therefore a need to pursue catheter selection knowledge pertaining to survey Questions 7, 14 and 15.

A distinction needs to be drawn between what was measured in this study (knowledge retention) and the broader and more wide-ranging concept of sustainability of innovations in nursing, as clarified by Fleischer, Semenik, Ritchie, Richer and Denis (2015). Fleischer et al. (2015) proposed that the sustainability of an innovation in nursing suggests embedded change and evolution of that change. The features for sustainable innovations incorporate benefits for improved health outcomes, the embedding of the innovation in nursing practice and practice setting and the ongoing evolution of the innovation (Fleischer et al., 2015). Research Question 3 simply asked to what extent the change in the participants' knowledge was maintained over time; while this is a pre-requisite for sustainability it is not a proxy for it. The fact that a participant has retained the knowledge that he or she gained from the intervention does not indicate the extent (if any) to which it has become embedded in practice and practice settings, is providing improved health outcomes, or is evolving in the participant's organisation.

However, there were some elements of what Fleischer et al. (2015) referred to as "preconditions of sustainability" (p. 1492) present in the intervention. These were defined by Fleischer et al. (2015) as being divided into four categories: innovation factors, contextual factors, leadership factors and process factors. Essentially, these four categories involve understanding:

- what is being innovated (innovation factors)
- the relevance of the innovation at both macro and micro levels, and the associated competency of the end user (contextual factors)

- who is advocating the innovation (leadership factors)
- the implementation process itself (process factors).

With regard to this study and the “preconditions of sustainability” defined by Fleischer et al. (2015), the education intervention provided evidence to the participant registered nurses regarding the beneficial health outcomes of appropriate catheter selection.

Although the clients’ health outcomes were not studied in relation to catheter selection, all participant registered nurses at the six-month data collection phase indicated in survey Question 16 that they had changed their catheter selection choices following the education intervention. This lends support to the sustainable retention of catheter selection knowledge.

The relevance of the education intervention to the participants of this study was high because catheter selection is an integral component of catheter management for people with neurogenic incontinence secondary to spinal cord injury or multiple sclerosis; thus, enabling competency in catheter selection was outlined in Research Question 1 of this study. With regard to relevance, an influencing factor in sustainability focuses on the recognised skill level of who is delivering the innovation (in this instance, the education). The extent of influence of the education session delivered by the researcher (who is recognised in Australia as an expert in neurogenic continence management and catheter selection) cannot be ignored, yet it also cannot be measured. As highlighted by Fleischer et al. (2015), leadership of innovation forms part of the “preconditions of sustainability”. The process of the study lends itself to implementation in that participant registered nurses self-nominated for involvement in this study. There was no attrition of participation and the education intervention

provided knowledge, fostered communication and shared decision making, which are all part of the “process factor” defined by Fleischer et al. (2015).

The findings showed significant retention of knowledge by participants for up to six months following the intervention. The systematic review by Mosley, Dewhurst, Molloy and Shaw (2012) of 105 studies investigated knowledge retention and sustainability of skills following participation in structured resuscitation training. They found that knowledge assessed by written examination offered the best results immediately after the training session, but found there was deterioration in retention of that knowledge as early as three months later. Mosley et al. (2012) claimed that the education sessions in the reviewed studies had incorporated Kolb’s experiential learning theory to foster learning and were similarly structured, and suggested that a way to boost retention was through refresher sessions. These claims align with those of Madigan et al. (2014), who investigated the benefits of education on knowledge for community staff in enteral feeding immediately after an intervention, and six months later. Madigan et al. claimed that there was good uptake of knowledge after the intervention, but the knowledge was not sustained across six months. Madigan et al. identified that the availability of online material to boost knowledge may have been needed for sustained knowledge uptake. In contrast, the current study not only found that participant uptake of knowledge in catheter selection improved following the intervention, but that knowledge was also retained for six months. Neither Madigan et al. (2014) nor Mosley et al. (2012) examined the benefits of a decision support tools in conjunction with an education intervention—rather, they called for boosted training

sessions. However, in principle, they were recommending some means of providing ongoing reinforcement of the learning.

The retention of knowledge in this study may have occurred due to the “preconditions of sustainability” identified by Fleischer et al. (2015) that were present in this study in the construction elements of the intervention and testing. Other explanations may include the knowledge-to-action process identified by Graham et al. (2006), which supports tailoring interventions to sustain knowledge. In this study, this involved ongoing participant access to the catheter selection decision support tool. In regard to education comparisons, further investigation is needed to determine if the use of a decision support tool negates the need for refresher sessions in relation to knowledge retention. Further investigation is also needed to examine the effects of knowledge retention and sustainability across periods greater than six months when decision support tools have been incorporated in the implementation process associated with the intervention.

5.5 Summary

The positive and significant findings in this study could be explained by the voluntary nature of participant involvement in a research project in which they were the focus of attention, and were receiving expert information with which they could develop their practice and skills in a way that suited their learning needs. The participants were aware of the reasons for the study, and that they were the only cohort of nurses in NSW practising in this specialist environment; thus, they knew they were quite special.

By using Kolb’s (1984) experiential learning theory as a framework for the educational intervention in this study, similar findings to those reported by Davis et al.

(2003) and Moore et al. (2009) were achieved through group interaction that fostered information sharing through a targeted education session, where participants were encouraged to undertake reflective analysis of their practice through critical thinking and case studies of clinical reasoning.

The education intervention in the current study also used an interactive education group session and provided ongoing education support options. In this research, the participants received a clinical decision-making tool to support ongoing practice and reinforcement of the information and skills learnt during the intervention session. Thus, it is plausible that this type of education approach could be an influential factor in promoting learning and retention of information on a specific topic.

The current study can be closely compared to that of Lim et al. (2010) and Madigan et al. (2014) because these also involved registered nurse participants in residential care facilities with extensive experience working as a registered nurse. In addition, both studies indicated poor knowledge levels in relation to complex nursing issues that were critical to the wellbeing of their particular clients. The major difference between this study and those of Lim et al. (2010) and Madigan et al. (2014) was that this study demonstrated knowledge retention across six months, as well as an indication that practice had been changed as a result.

The context of the current study was a highly specialised environment focused on neurogenic conditions in a defined range; thus, the expectation of clinician proficiency and knowledge about these particular conditions was much higher than that in a general hospital ward. The importance of context was examined by Elliott (2010),

who found that clinical judgement is more than cognitive reasoning skills because it includes the way nurses interact with clients to access information in order to support the clinical judgement process, and includes the contextual influences of the location in which the nurses work.

The findings from this research demonstrate that targeted education can change the clinical knowledge of registered nurses—specifically their understandings of catheter selection—and that it is possible for this change in knowledge to be retained for at least six months following the education intervention. The findings also show that nurses with greater years of professional experience in any nursing context have a greater capacity for uptake of knowledge, proportional to their years of nursing experience.

Chapter 6: Conclusions

6.1 Background

This quasi-experimental study builds on the two previously published Australian research studies in catheter selection by Dobson et al. (1996) and Fleming et al. (2000), which occurred over 15 years ago. This study addresses the subsequent neglect by researchers in this field, and extends knowledge related to the catheter selection knowledge of registered nurses who solely specialise in the care of people with spinal cord injury or multiple sclerosis.

The focus of this enquiry was nurses' level of current knowledge of catheter selection and changes in catheter selection, following the provision of a tailored education session and the introduction of a catheter decision support tool. This was measured using a pre-test post-test design to assess knowledge retention and provide an opportunity for data collection at three and six months post-intervention. Nurses working in residential care facilities exclusively for people with spinal cord injury or multiple sclerosis were recruited. Although only a limited number of nurses practice in such residential care facilities, the use of urinary catheters and the effect of urinary complications associated with urinary catheter use are significant and warrant investigation.

This context provided access to nurses with clients using an established bladder management program, who were experienced in managing the urinary complications associated with catheter use—factors that could be drawn on for reflective discussion during the education intervention. The Catheter Compass™ (Wicks, 2009) supplied

during the tailored education session to the participant nurses formed an integral part of the intervention. It facilitated the analysis of guidelines and research evidence, and provided opportunity for constructive learning through reflecting on practice and feedback. These aspects of the intervention design align with the framework for adult learning recommended in Kolb's (1984) experiential learning theory.

6.2 Major Findings, Limitations and Recommendations

6.2.1 Current catheter selection knowledge. The registered nurses were found to be competent, but to have limited understanding and knowledge about urinary catheters and the difference between catheter types, despite this being central to their ability to provide expert care and advice to patients in this specialty context. This finding aligns somewhat with that of earlier Australian studies. These studies by Dobson et al. (1996) and Fleming et al. (2000) investigated the catheter management and selection knowledge of nurses in NSW, and found that catheter selection knowledge was poor. While the definition of 'poor' was not clearly stated, it is a reasonable assumption that the finding of 'competent' in the current study may be similar or, at best, a slight improvement. This study suggests that extensive domain-specific experience does not guarantee domain expertise, and that the ingredients for expertise in nursing are likely to be more complex than years of experience.

Clearly, the level of knowledge in this study still falls short of that expected among registered nurses who work in an area in which catheter selection knowledge is fundamental to their practice. Clinical guidelines around catheter selection were developed following the earlier studies by Dobson et al. (1996) and Fleming et al. (2000), and have been available for nurses for several years. However, this does not

appear to have improved nurses' catheter selection knowledge, which further highlights that adherence to best practice guidelines does not result from simple dissemination of guidelines. A limitation associated with this aspect of the study is that the participant nurses were not asked if they were aware of or agreed with catheter selection guidelines. Further research is warranted to investigate registered nurses' awareness of and agreement with existing catheter management and selection guidelines. This will further guide the development, implementation and maximum exposure to catheter selection guidelines in both speciality and non-speciality contexts.

6.2.2 Uptake of catheter selection knowledge. This study found that clinical knowledge can be learnt when registered nurses in a specialty context understand basic knowledge of catheter selection, and then further develop this knowledge through exposure to research evidence and applying clinical reasoning skills to transfer it to practice. The extent to which the participant nurses took up and applied new information on catheter types and catheter selection for defined client groups was found to exceed 20% between the pre- and post-tests around the single interactive education intervention and the use of a decision support tool. The outcomes of this research suggest that the tailored education session and use of the Catheter Compass™ (Wicks, 2009) assisted nurses to synthesise existing catheter selection evidence for incorporation in their clinical reasoning process relating to catheter selection.

It is unknown whether catheter selection knowledge would improve with a single education session that did not include the use of a decision support tool, or whether the use of a decision support tool without an education session would demonstrate equivalent or better uptake of knowledge. This could be an issue for future

research. This would extend the current area of research interest and provide guidance for clinicians and managers in specialty nursing contexts.

The uptake of complex technical information and knowledge synthesis was proportionately affected by the participants' experiences in general nursing. This finding was unexpected because previous research suggests that specialty knowledge flourishes only with speciality experience. However, in this study, the findings suggest that it is not extensive time in the speciality field that ultimately results in the capacity of nurses to take in expert knowledge. Rather, this results from clinical exposure through time spent working as a registered nurse, and nurses' capacity to understand and apply novel evidence relevant to the field of practice. The findings of this study correlating years of experience with knowledge retention were significant at $\alpha \leq 0.01$, and were carefully validated in this study. However, replication of this research with a larger and perhaps cumulative sample, as well as comparisons across acute and long-term care contexts, could overcome the limitations of the small dataset used here in order to provide provisional results and guide future research.

The benefits gained by clients being able to access appropriate catheter selection are well documented. However, prior to this study, no research was found that measures the uptake of catheter selection knowledge, in either specialty or non-speciality fields, following the introduction of a catheter decision support tool and tailored education session. The moderate uptake of this knowledge across the participant registered nurse group may have benefitted from including more information in the decision support tool; however, this would require further research and updating of the catheter decision support tool. Further research is also recommended to investigate whether success in

knowledge uptake is related to years of nursing experience, as opposed to years of experience in a speciality context.

6.2.3 Catheter selection knowledge retention. When comparing the similarities between responses in the three-month and six-month data collections, the registered nurse participants were found to have retained their increased knowledge in catheter selection following the intervention and for the subsequent six months. Factors affecting long-term retention of complex information for this participant group included:

- working in residential care facilities that specialise in spinal cord injury or multiple sclerosis, and therefore having ongoing opportunities to use this new knowledge
- working in relative isolation in these residential care facilities, thereby restricting collaboration and consultation with colleagues, and having to rely heavily on practice reflection to develop critical understandings of the value of the information.

No other studies were found that investigated long-term knowledge retention in such a speciality context; thus, the influence of this type of reflection in residential care facilities cannot be compared to prior studies. It may be beneficial to replicate this study and intervention involving a comparison group specialising in the care of people with spinal cord injury and multiple sclerosis who are not in residential care facilities in order to determine whether the context supports nurses' retention of complex technical information and knowledge over time. Better understandings of what influences

knowledge retention would inform the development of education practices that achieve knowledge retention and practice development. Any results of such future research could also be used to guide the development and promotion of policy related to the implementation of clinical guidelines in residential care facilities.

Nursing practice in speciality and general contexts requires nurses to make decisions based on clinical judgement in relation to catheter management, and that involves catheter selection choices. In the absence of knowledge regarding the different catheter solutions to match a range of urinary problems, registered nurses are left providing care in the limits of their knowledge and skill, thereby resulting in case management that may not meet the identified clinical needs of clients. Management of people with neurogenic incontinence, such as those with spinal cord injury or multiple sclerosis, requires registered nurses to make appropriate catheter selection choices based on relevant evidence and existing guidelines in order to optimise health outcomes. It is expected that registered nurses working in the specific domains of spinal cord injury or multiple sclerosis would be familiar with the urinary complications associated with catheter use, and that the relevant guidelines that assist in managing those complications are embedded in their everyday clinical practice.

While the findings of this research indicate that the participant nurses were not performing at an expert level prior to or following the intervention, it is clear that education and the use of a decision support tool that synthesised current evidence and guidelines did increase their knowledge base to a level of competence well beyond their initial understanding. Further, the findings of this study showed that this improved knowledge base was retained for six months. This study did not seek to investigate the

sustainability of change in clinical practice; however, the sustainability of change in practice related to catheter selection must involve the uptake and retention of knowledge that informs catheter selection. Further investigation is needed to analyse sustained change in catheter selection practices following the uptake and retention of catheter selection knowledge.

6.2.4 Validity testing of the knowledge survey. Face validity for the survey was developed over several iterations that involved expert clinicians and exposure to national conferences in this field, with feedback incorporated in each stage. The knowledge survey was tested to reveal an intra-class correlation coefficient of 0.89, and a 95% confidence interval of 0.46 to 0.98, thereby indicating extremely robust test–retest reliability, and establishing the survey as a useful component of future research in this field.

6.3 Implications of This Research

The implications of this research lie in better understanding what influences knowledge retention and the provision of information in order to guide the development of education practices that achieve knowledge retention and practice development. The findings could inform the development and promotion of policy related to implementing clinical guidelines in residential care facilities, as well as the need for tailored, effective practice development for specialists in the practice context.

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Appendix A Catheter Features and Catheter Table

Catheter features		
Source	Method	Evidence
Biering-Sørensen, Hansen, Nielsen, and Looms (2007) Residual urine after intermittent catheterization in females using two different catheters.	24 participants Prospective, single blind, randomised, crossover study.	No significant difference in urine residual. Greater satisfaction with hydrophilic.
De Ridder et al. (2005) Intermittent catheterisation with Hydrophilic-Coated Catheters (SpeediCath) Reduces the Risk of Clinical Urinary Tract infections in Spinal Cord Injured Patients: A Prospective Randomised Parallel Comparative.	57 participants Prospective, randomised, parallel comparative trial.	Freedom from urinary tract infection doubled in hydrophilic group.
Spinu et al. (2012) Intermittent catheterization in the management of post spinal cord injury (SCI) neurogenic bladder using new hydrophilic, with lubrication in close circuit devices - our own preliminary results.	45 participants Non randomised retrospective questionnaire.	Increase satisfaction with hydrophilic. Hydrophilic caused lower level of catheterisation bleeding episodes.
Fader et al. (2001) Coated catheters for intermittent catheterization: smooth or sticky?	61 participants 4 different types of hydrophilic coated catheters. Prospective randomised study.	Different brands have different effects on the mucosa.
Stensballe, Looms, Nielsen, and Tvede (2005) Hydrophilic-coated catheters for intermittent catheterisation reduced urethral micro trauma: A prospective, randomised, participant-blinded, Crossover study of three different types of catheters.	49 participants Prospective, randomised, participant-blinded, crossover study. 3 types of catheters included 2 hydrophilic and 1 pre lubricated.	Demonstrated reduced micro trauma; however, it was not proven that it exerted less friction than standard non-coated catheter
Day, Moore, and Albers (2003) A pilot study comparing two methods of intermittent catheterization: limitations and challenges.	11 participants Pilot study. Compared closed system intermittent catheter with traditional open system intermittent catheter.	Indicates lower rate of urinary tract infection with closed system intermittent catheter although the results were not statically significant
Hudson and Murahata (2005) The 'no-touch' method of intermittent urinary catheter insertion: can it reduce the risk of bacteria	In vitro parallel experimental study at independent testing laboratory.	Bacteria significantly lower with non-touch

entering the bladder?		
Gentry and Cope (2005) Using silver to reduce catheter-associated urinary tract infections	Quality improvement program 133 medical and surgical patients in an acute NHS hospital. Used silver alloy hydrogel coated catheter.	Lower urinary tract infection rate
Karchmer, Giannetta, Muto, Strain, and Farr (2000) A Randomized Crossover Study of Silver-Coated Urinary Catheters in Hospitalized Patients.	27878 participants 12 month randomised crossover trial.	Claimed silver alloy lowered rates of urinary tract infection
Kassler and Barnett (2008) A Rehabilitation Hospital's Experience with Ionic Silver Foley Catheters.	42 bed rehabilitation hospital Quality audit, 4 month product trial.	Claimed 100% reduction in urinary tract infections
Sabbuba, Hughes, and Stickler (2002) The migration of <i>Proteus mirabilis</i> and other urinary tract pathogens over Foley catheters.	In vitro experiment	Claimed hydrogel-coated catheters facilitated migration of organisms
Parkin et al. (2002) Urinary catheter 'deflation cuff' formation: clinical audit and quantitative in vitro analysis	clinical audit and quantitative in vitro analysis.	Increased resistance to withdrawal due to balloon cuffing on deflation with all silicon catheters

CAUTI guidelines

Author	Method	Recommendation
Gould, Umscheid, Agarwal, Kuntz, and Pegues (2010) Guideline for Prevention of Catheter-Associated Urinary Tract Infections 2009.	Systematic review.	More research needed on antimicrobial catheters. Hydrophilic may be more desirable than standard non-coated catheters, while silicon may reduce risk of encrustation.
Hooton et al. (2010) Diagnosis, Prevention, and Treatment of Catheter-Associated Urinary Tract Infections in Adults: 2009 International Clinical Practice guidelines from Infectious Disease Society of America.	Systematic review.	Silver alloy may reduce onset of catheter-associated bacteriuria but more research needed to make recommendations on their use on and reduction of CAUTI. Hydrophilic catheters did not reduce the risk of catheter-associated bacteriuria or CAUTI.
Lo et al. (2008) Strategies to Prevent Catheter-Associated Urinary Tract Infections in Acute Care Hospitals.	Systematic review.	Silver-coated catheters not for routine use.
Mitchell et al. (2011) (HICSIG)/AICA Position Statement: Preventing catheter-associated urinary tract infections in patients.	Systematic review.	Silver alloy had no significant advantages. Further research required to determine which catheter material best delays the onset of bacteriuria, bacterial adherence and bacterial growth.
Tenke, P., Kovacs, B., Bjerklund Johansen,	Systematic review.	Silver alloy catheters may be

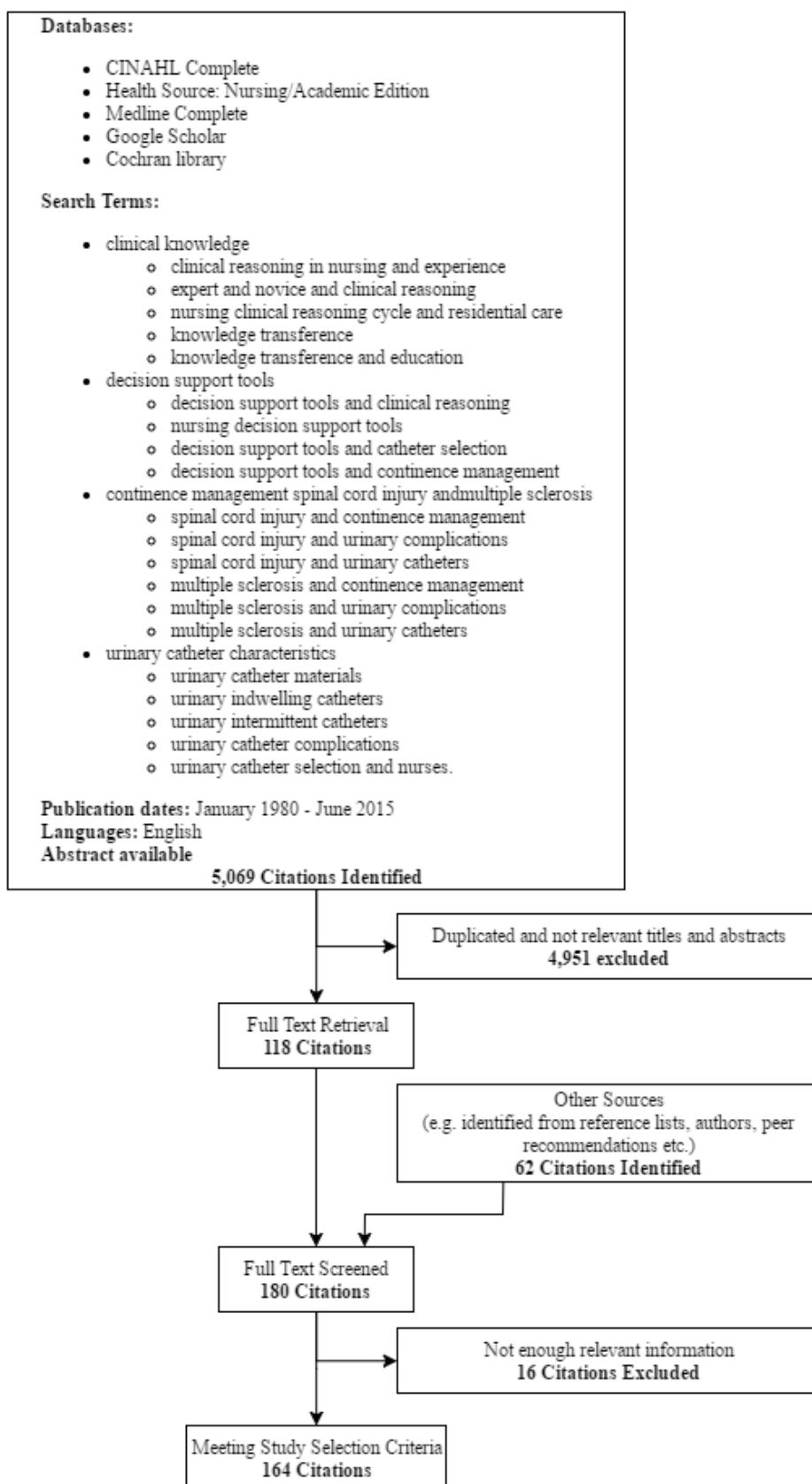
T. E., Matsumoto, T., Tambyah, P. A., & Naber, K. G. (2008). European and Asian guidelines on management and prevention of catheter-associated urinary tract infections. <i>International Journal of Antimicrobial Agents</i> , 31, Supplement 1(0), 68-78. doi: 10.1016/j.ijantimicag.2007.07.033		useful but did not make further recommendations on catheter materials.
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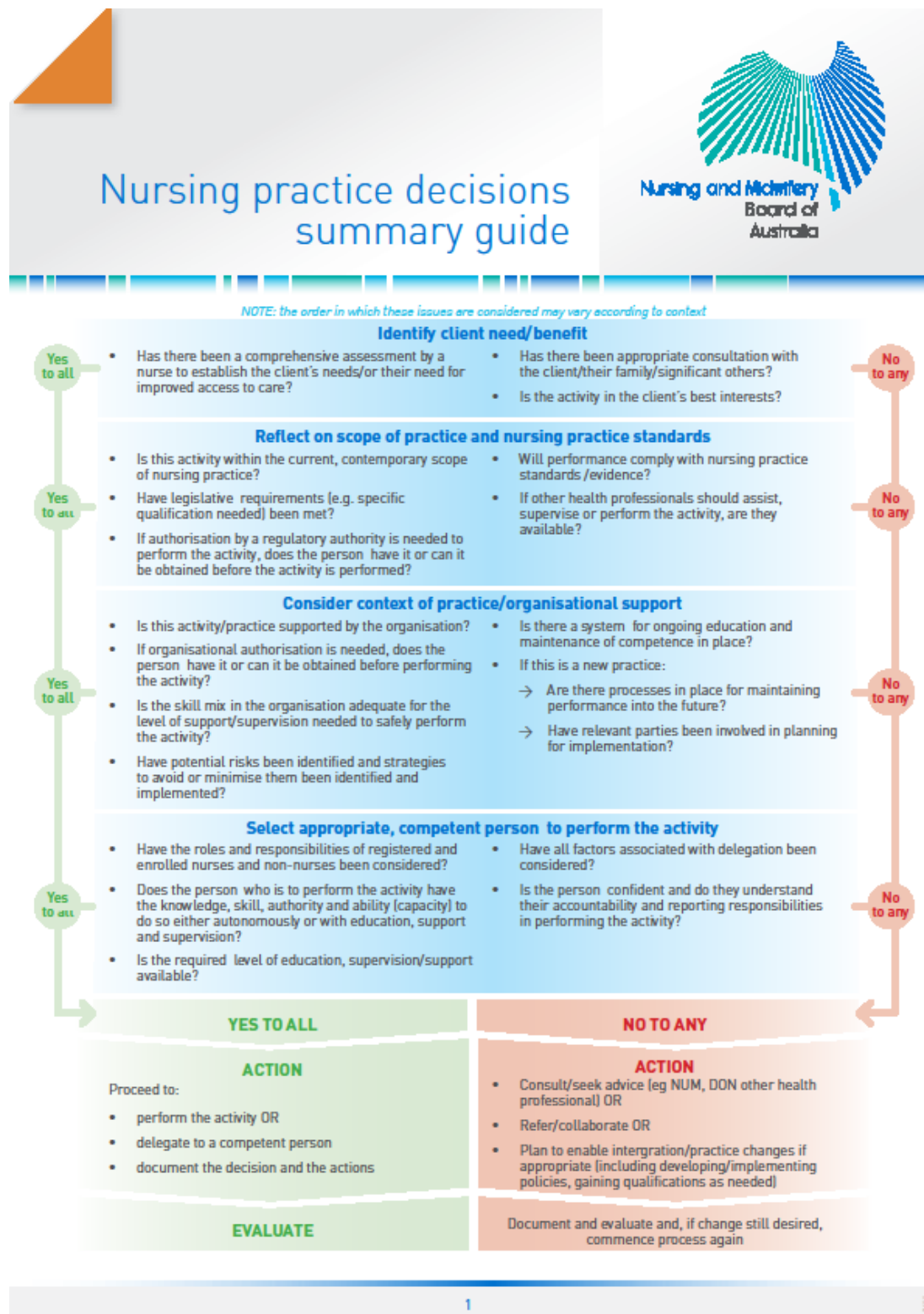
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doi:10.1016/j.ijantimicag.2007.07.033

Appendix B: Literature Review Flowchart



Appendix C Nursing Practice Decision Summary Guide



This is a copy of the *Nursing Practice Decision Summary Guide* (Nursing and Midwifery Board of Australia, 2010), which can be located at:
<https://www.google.com/search?q=Nursing+practice+decision+summary+guide+&ie=utf-8&oe=utf-8>

Appendix D Catheter Compass™

The Catheter Compass™ was designed by the researcher and launched in 2009 at the National Continence Conference. Prior to its launch, the Catheter Compass™ was circulated to specialist clinicians and the Continence Foundation New South Wales for content validation. The Catheter Compass™ is owned by BrightSky Australia. Review of design and content occurs annually at the request of BrightSky Australia to the student researcher; however, to date, no changes in content design have occurred. The researcher continues to be invited by government and non-government organisations to discuss application of catheter features in relation to continence prescription. The education intervention for these sessions is built around the use of the Catheter Compass™. The Catheter Compass™ is available free of charge from ParaQuad NSW as a hardcopy or for a small charge as an Apple iTunes™ app. Since 2009, approximately 10,000 hardcopy tools have been distributed.

What follows is the text of the poster presentation used at the launch of the Catheter Compass™ at the National Continence Conference in 2009.

Introduction

The aim of this poster presentation is to establish the need among registered nurses to develop a clinical tool to assist with catheter selection. Further, it aims to guide the development of such a clinical tool.

A continence assessment conducted by a continence advisor or urologist will help identify the most appropriate continence management plan for an individual. If a catheter is recommended, it may be difficult and labour intensive for the registered nurse to examine and evaluate the many different catheter types, styles, sizes and brands available in the Australian market. The clinical tool will be designed to highlight the clinical features of a catheter that match an individual's needs, as established in the continence assessment.

Market Survey

A market survey was conducted using convenience sampling of catheter-prescribing registered nurses across Australia. The survey focused on the awareness levels and prescription habits of the surveyed clinicians with regard to the different sub-categories of catheters available. Questions were also asked regarding the usefulness of a tool that compares the clinical features of catheters.

Results

The results indicated varying awareness levels among the prescribers, especially in the intermittent catheter categories, where many catheter types do not seem well known. The awareness level was higher across catheter types in the indwelling catheter category. None of the surveyed prescribers indicated complete awareness of the full

range of catheter types in either category. Similarly, only five catheter types of the 19 were known by all the surveyed prescribers.

It was also noted that a significant difference exists between the catheter types of which prescribers are aware, and what they actually prescribe. There were a significant number of catheters that these prescribers never or rarely prescribed. This awareness and prescription pattern may be influenced by which catheter types are available for prescription via government contracts, and/or how accessible education is regarding specialty catheters.

Development of the Clinical Tool

A low level of awareness and/or prescription level regarding catheter types provides an opportunity for improved education among registered nurses, which would allow them to take full advantage of the wide range of catheters available. The aim of the catheter tool is to provide healthcare professionals with a clinical pathway that aids in the selection of a catheter to best meet the needs of individual clients.

Where possible, clinical guidance should always be based on the best possible evidence; however, in the absence of empirical evidence, or where there is poor quality evidence, guidance may offer recommendations based on findings outside the level of evidence hierarchy. The Joanna Briggs Institute acknowledges these limitations and has a broader definition of what constitutes evidence. They have an inclusive approach to developing and grading levels of evidence and implications for practice. For the purpose of developing the clinical catheter tool, relevant product-related literature regarding clinical features of products was sourced and reviewed, and product peer opinion was also taken into account.

The Catheter Compass™

The Catheter Compass™ Product Selection Path helps healthcare professionals select the right catheter for a client, when a urological continence review has resulted in the recommendation of an indwelling or intermittent catheter. The Compass does not replace clinician assessment and treatment. Although these products may be used within the situation of CAUTI, they do not replace traditional physician treatment methods.

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The Catheter Compass™

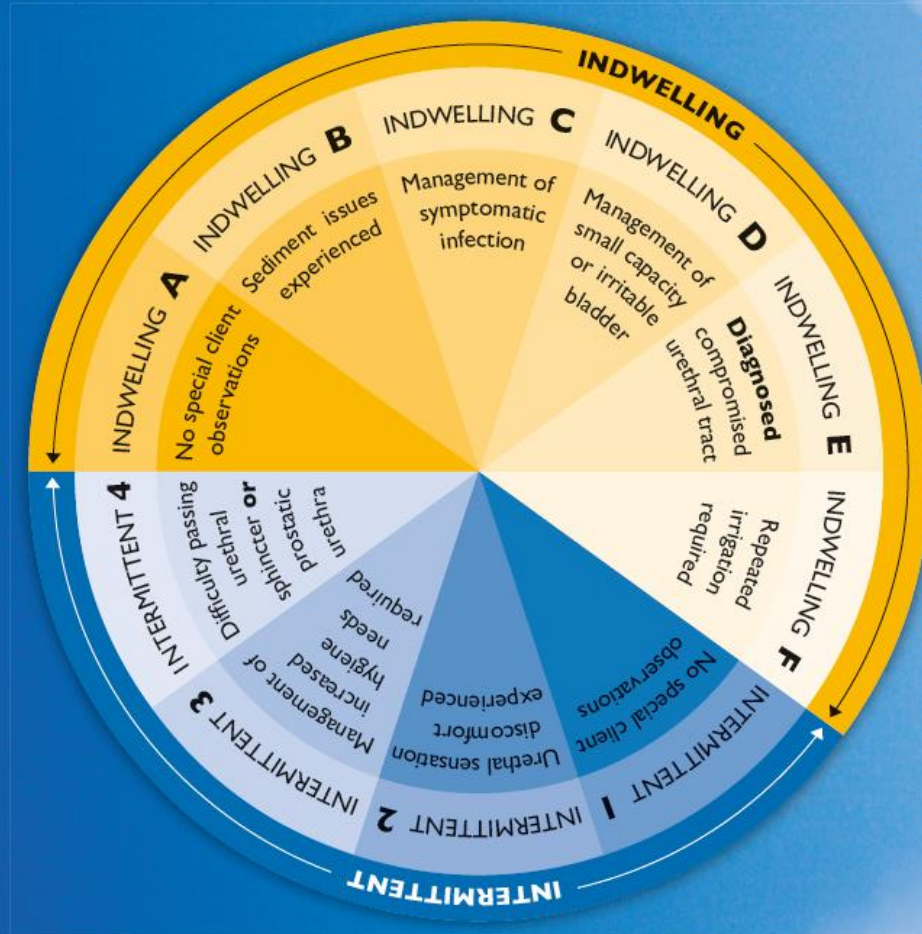
The Catheter Compass™ helps healthcare professionals select the right catheter for a client when a urological or continence review has resulted in the recommendation of an intermittent or indwelling catheter.

Turn the page and follow the Catheter Compass Product Selection Path to identify the type of catheter that best meets the needs of an individual client.

Then refer to the BrightSky Catheter Product Guide to select a product of the required size and preferred brand.

The Catheter Compass on the right summarises the options from the Catheter Compass Product Selection Path.

The Catheter Compass™ has been developed for use by healthcare professionals only. Not intended for consumer use. It has been developed on the basis that products perform as indicated by manufacturers.



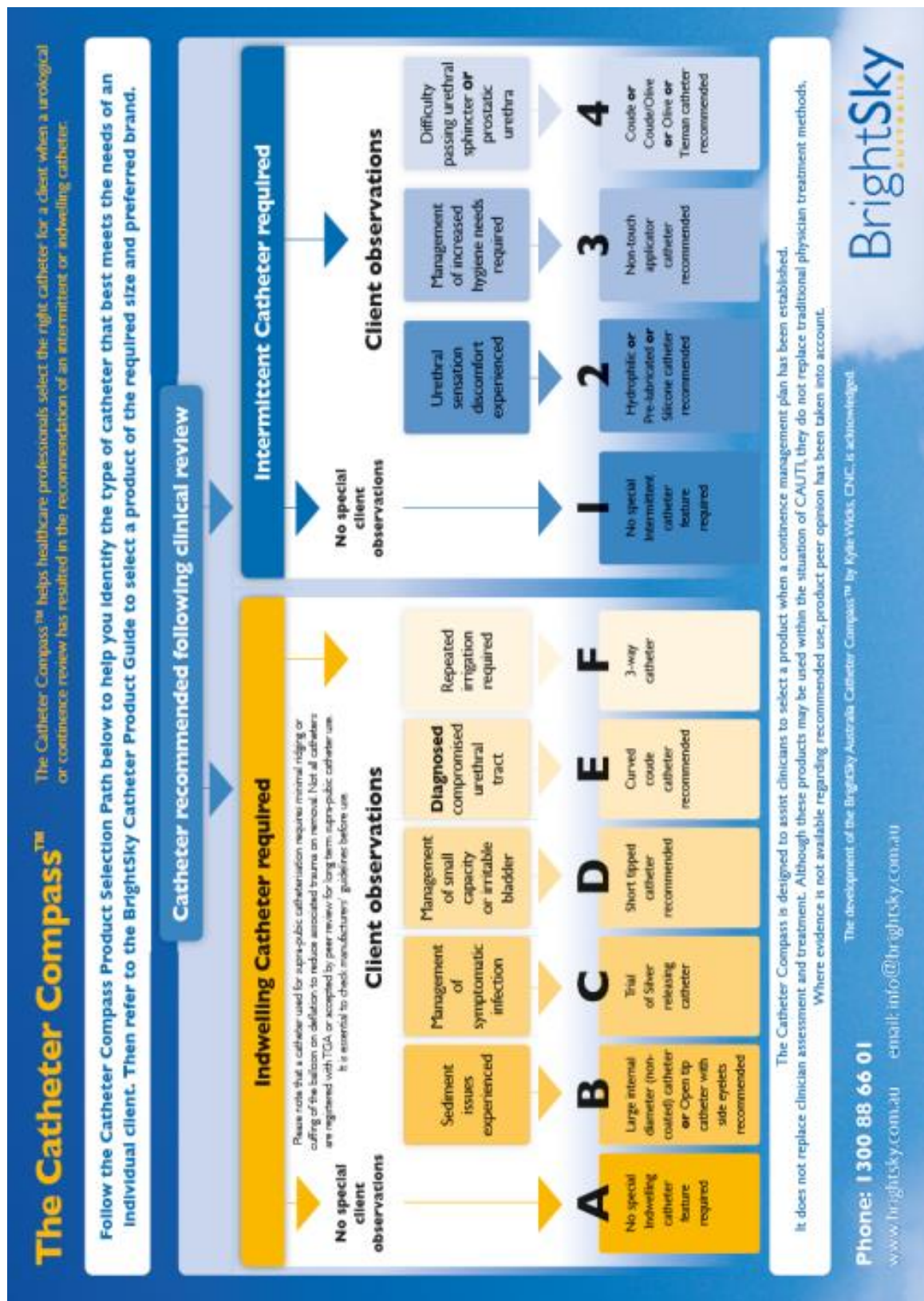
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Appendix E: Knowledge Survey



1. Are all Foley catheters suitable for suprapubic use?
 - a. Yes..... ☐
 - b. No ☐
 - c. Not sure ☐
2. What size should the balloon of the indwelling catheter be inflated to?
 - a. 5 ml ☐
 - b. 10 ml ☐
 - c. 30 ml ☐
 - d. Balloon inflation dependent on balloon size, per manufacture recommendations ☐
3. What length and size catheter is used for an adult male urethral indwelling catheterisation?
 - a. 23 cm Fg 18..... ☐
 - b. 40 cm Fg 14 to Fg 16..... ☐
 - c. 40 cm Fg 10..... ☐
 - d. 23 cm Fg 14 to 16 ☐
4. What length and size catheter is used for an adult female urethral indwelling catheterisation?
 - a. 40 cm Fg 14 to Fg 16..... ☐
 - b. 23 cm Fg 14 ☐
 - c. 40 cm Fg 12 to Fg 10..... ☐
 - d. 23 cm Fg 10..... ☐
5. What length and size catheter is used for adult suprapubic catheterisation?
 - a. Fg 16 to Fg 20 either 23 cm or 40 cm ☐
 - b. Fg 10 to Fg 24 either 23 cm or 40 cm ☐
 - c. Fg 18 40 cm only on males ☐
 - d. Fg 18 23 cm only on females ☐
6. For clients experiencing sediment blockages, which type of catheter should be used?
 - a. Catheter with larger internal lumen or open tip..... ☐
 - b. Keep increasing catheter Fg size until catheter no longer blocking with sediment ☐
 - c. Use a silver-coated catheter..... ☐
 - d. Use a hydrogel-coated catheter ☐
7. For clients experiencing continuous symptomatic infection, which catheter may they benefit from trialling?
 - a. 100% silicon ☐
 - b. Hydrogel-coated catheter ☐
 - c. Silver-coated catheter ☐

- d. Catheter with larger internal lumen or open tip..... ☐
8. For clients experiencing bladder wall irritation, what type of catheter should be trialled?
- a. Catheter with larger balloon size ☐
- b. Catheter with hydrogel coating..... ☐
- c. Short-tipped catheter ☐
- d. Latex-coated catheter ☐
9. For clients with a diagnosed compromised urethral tract, what type of catheter should be trialled?
- a. A firmer catheter ☐
- b. A silver-coated catheter ☐
- c. A coude tip..... ☐
- d. A straight tip ☐
10. For clients requiring repeated irrigation, what should be used?
- a. A new bag after each irrigation ☐
- b. A 60-ml syringe ☐
- c. A three-way catheter..... ☐
- d. A coude-tipped catheter ☐
11. What size intermittent catheter should be used when teaching intermittent self-catheterisation to male adult clients?
- a. Fg 18 40 cm..... ☐
- b. Fg 14 40 cm..... ☐
- c. Fg 18 23 cm..... ☐
- d. Fg 14 40 cm..... ☐
- e. Other..... ☐
12. What size intermittent catheter should be used when teaching intermittent self-catheterisation to adult females?
- a. Fg 12 to 14 ☐
- b. Fg 10 ☐
- c. Fg 18 ☐
- d. other ☐
13. If a client describes urethral discomfort on intermittent self-catheterisation, what would you suggest?
- a. Use a hydrophilic ☐
- b. Use a pre-lubricated catheter ☐
- c. Reduce the size of the catheter..... ☐
- d. Use xylocaine jelly for each catheter..... ☐
14. When should a catheter with a non-touch applicator be used?
- a. On females only ☐
- b. When increased hygiene risk..... ☐
- c. When catheterising in a public toilet ☐
- d. For people with poor dexterity ☐
15. When difficulty passing the urethral sphincter, what type of catheter should be trialled?
- a. A hydrophilic..... ☐
- b. A coude or tieman ☐
- c. A Jacques ☐

- d. A bigger Fg size ☐

Appendix F: Demographic Survey



1. How many years have you been working as a registered nurse?
 - a. 0 to 4 ☐
 - b. 4 to 6 ☐
 - c. 6 to 10 ☐
 - d. 10 or more (please state how many) ☐
2. How many years have you been nursing people with a spinal cord injury or multiple sclerosis?
 - a. Less than 2 ☐
 - b. 2 to 4 ☐
 - c. 4 to 6 ☐
 - d. 6 or more (please state how many) ☐
3. Which title best meets your current job description?
 - a. Registered Nurse ☐
 - b. Clinical Nurse Specialist ☐
 - c. Nurse Educator ☐
 - d. Clinical Nurse Educator ☐
 - e. Clinical Nurse Consultant ☐
 - f. Nurse Unit Manager ☐
 - g. Independent Nurse Practitioner ☐
4. How frequently do you make clinical decisions regarding catheter selection for a patient?
 - a. Daily (several times) ☐
 - b. Weekly (several times) ☐
 - c. Monthly (several times) ☐
 - d. Never ☐
5. What are your nursing qualifications?
 - a. Hospital-trained registered nurse ☐
 - b. College-trained registered nurse ☐
 - c. University-trained registered nurse ☐
6. Please list additional post-registration qualifications (e.g. Spinal Certificate from the College of Nursing, or postgraduate university qualifications, such as Graduate Certificate, Graduate Diploma or Master's Degree in relevant field, such as Rehabilitation Nursing)
 -
 -
7. Have you attended catheter selection training in the past?
 - a. Yes ☐
 - i. If yes, how often have you attended training?
 - ii. In what year was the most recent training?

b. No ☐

Appendix G: University Ethics Approval



Human Research Ethics Committee Committee Approval Form

Principal Investigator: Tracey McDonald
Student Researcher: Ms Kylie Wicks

Ethics approval has been granted for the following project: Investigation of nursing knowledge of catheter selection following the introduction of a catheter decision support tool

for the period: 25/11/2013 – 31/03/2014

Human Research Ethics Committee (HREC) Register Number: 2013 276N

Special Condition/s of Approval

Prior to commencement of your research, the following permissions are required to be submitted to the ACU HREC:


The following standard conditions as stipulated in the *National Statement on Ethical Conduct in Research Involving Humans* (2007) apply:

- (i) that Principal Investigators / Supervisors provide, on the form supplied by the Human Research Ethics Committee, annual reports on matters such as:
 - security of records
 - compliance with approved consent procedures and documentation
 - compliance with special conditions, and
- (ii) that researchers report to the HREC immediately any matter that might affect the ethical acceptability of the protocol, such as:
 - proposed changes to the protocol
 - unforeseen circumstances or events
 - adverse effects on participants

The HREC will conduct an audit each year of all projects deemed to be of more than low risk. There will also be random audits of a sample of projects considered to be of negligible risk and low risk on all campuses each year.

Within one month of the conclusion of the project, researchers are required to complete a *Final Report Form* and submit it to the local Research Services Officer.

If the project continues for more than one year, researchers are required to complete an *Annual Progress Report Form* and submit it to the local Research Services Officer within one month of the anniversary date of the ethics approval.

Signed: 
(Research Services Officer, Melbourne Campus)

Date: 28/11/2013

Appendix H: Participant Information Pack

**CONSENT FORM****NURSE****Copy for Participant**

TITLE OF PROJECT: Catheter selection: Investigation of nursing knowledge of catheter selection following the introduction of a catheter decision support tool

NAMES OF SUPERVISORS Professor Tracey McDonald AM, RSL LifeCare Chair of Ageing Faculty of Health Sciences, Australian Catholic University
Dr Joanne Lawrence, Lecturer Faculty of Health Sciences, Australian Catholic University

NAME OF STUDENT RESEARCHER Ms Kylie Wicks, Master of Nursing
Research student, Australian Catholic University

I (*the participant*) have read (*or, where appropriate, have had read to me*) and understood the information provided to me in the Letter to Participants. Any questions I have asked have been answered to my satisfaction. I agree to complete a 10-minute multiple-choice questionnaire, attend a 40-minute training session on the Catheter Compass™ and, in 3 months, complete another questionnaire. I will not be audio or video recorded, realising that I can withdraw my consent at any time without comment or penalty. I agree that research data collected for the study may be published or may be provided to other researchers in a form that does not identify me in any way.

NAME OF STUDENT RESEARCHER

(block letters)

SIGNATURE DATE / ... /

SIGNATURE OF PRINCIPAL SUPERVISOR DATE / ... /

SIGNATURE OF PARTICIPANT DATE / ... /



CONSENT FORM

NURSE

Copy for Researcher

TITLE OF PROJECT: Catheter selection: Investigation of nursing knowledge of catheter selection following the introduction of a catheter decision support tool

NAMES OF SUPERVISORS Professor Tracey McDonald AM, RSL LifeCare Chair of Ageing Faculty of Health Sciences, Australian Catholic University
Dr Joanne Lawrence, Lecturer Faculty of Health Sciences, Australian Catholic University

NAME OF STUDENT RESEARCHER Ms Kylie Wicks, Master of Nursing
Research student Australian Catholic University

I (*the participant*) have read (*or, where appropriate, have had read to me*) and understood the information provided to me in the Letter to Participants. Any questions I have asked have been answered to my satisfaction. I agree to complete a 10-minute multiple-choice questionnaire, attend a 40-minute training session on the Catheter Compass™ and, in three months, complete another questionnaire. I will not be audio or video recorded, realising that I can withdraw my consent at any time without comment or penalty. I agree that research data collected for the study may be published or may be provided to other researchers in a form that does not identify me in any way.

NAME OF STUDENT RESEARCHER

(block letters)

SIGNATURE DATE / ... /

SIGNATURE OF PRINCIPAL SUPERVISOR DATE / ... /

SIGNATURE OF PARTICIPANT DATE / ... /

PARTICIPANT INFORMATION LETTER

PROJECT TITLE: Catheter selection, investigation of nursing knowledge of catheter selection following the introduction of a catheter decision support tool

PRINCIPAL INVESTIGATOR: Professor Tracey McDonald AM, RSL
LifeCare Chair of Ageing Faculty of health Sciences
Australian Catholic University
Dr Joanne Lawrence Lecturer Faculty of Health Sciences Australian Catholic University

STUDENT RESEARCHER: Kylie Wicks
STUDENT'S DEGREE: Master of Nursing Research

Dear Participant,

You are invited to participate in the research project described below.

What is the project about?

This study will explore current catheter selection knowledge amongst registered nurses who manage clients with neurogenic incontinence. A key concept is not only what their knowledge level is but also confirmation of knowledge transference, that is will education influence the level of registered nurse knowledge in catheter selection.

The research questions that will be explored include

1. What do registered nurses know and understand about urinary catheters and the differences between catheter types?
2. To what extent do participant registered nurses take up and apply new information on catheter types and catheter selection for defined client groups?
3. To what extent can registered nurses knowledge about assessment, catheter selection and use for multiple sclerosis and spinal cord injured be retained by the participants following an education intervention?

Who is undertaking the project?

This project is being conducted by Kylie Wicks and will form the basis for the degree of Master of Nursing Research at Australian Catholic University under the

supervision of Professor Tracey McDonald AM, RSL LifeCare Chair of Ageing Faculty of Health Sciences Australian Catholic University and Ms Joanne Lawrence Lecturer Faculty of Health Sciences Australian Catholic University.

Are there any risks associated with participating in this project?

There are no foreseeable risks.

What will I be asked to do?

You are invited to participate in a study that explores catheter selection knowledge amongst registered nurses who manage clients with neurogenic incontinence. The study will explore your current catheter selection knowledge and your selection knowledge following education in a catheter selection decision support tool. The tool used will be the Catheter Compass™.

If you agree to participate in this study, you will be asked to complete a 10 minute multiple choice questionnaire, attend a 40 minute training session on the Catheter Compass™ and in 3 months, complete another questionnaire. Your responses to the questionnaires will be anonymous. The survey and training session will occur at your place of employment during your work hours.

You will not be audio or video recorded.

How much time will the project take?

The survey will take 10minutes to complete. The training session will take 40minutes. You will then be asked to repeat the survey 3 months after the education intervention.

What are the benefits of the research project?

For people with neurological loss bladder management may be dependent on some form of catheterisation.

In the advancing world of technology, the original Foley catheter and intermittent catheter have evolved into many different designs that need to be considered when selecting a catheter for indwelling or intermittent use. The nurse needs to have a good understanding of the clinical features of such products when catheterising the client or instructing the client in how to perform intermittent catheterisation.

This project is an exploration of registered nurse knowledge of catheter selection for people with neurological loss and will involve an education intervention in catheter selection among a group of nurses whose practice involves providing nursing to patients with neurogenic dysfunction. The results of this project will be used to inform future research into catheter selection and education of nurses who practice in this area.

Can I withdraw from the study?

Participation in this study is completely voluntary. You are not under any obligation to participate. If you agree to participate, you can withdraw from the study at any time without adverse consequences

Will anyone else know the results of the project?

The registered nurses' confidentiality and privacy will be ensured through coding of responses and identities will only be known to the researcher and will not be identified in any publication or report. All confidential information will be stored in a secure password protected computer and held by the researcher. Participants will not be identified in any publications only aggregated data will be published. Publications are yet to be identified but will be derived from the fields of spinal cord injury, multiple sclerosis and general continence.

Will I be able to find out the results of the project?

A summary of results will be posted in your staff room to allow access to the results.

Who do I contact if I have questions about the project?

Should you any questions relating to this project please contact me
Kylie Wicks 0418614765

What if I have a complaint or any concerns?

The study has been approved by the Human Research Ethics Committee at Australian Catholic University (approval number 2013 276N). If you have any complaints or concerns about the conduct of the project, you may write to the Chair of the Human Research Ethics Committee care of the Office of the Deputy Vice Chancellor (Research).

Chair, HREC
c/o Office of the Deputy Vice Chancellor (Research)
Australian Catholic University
Melbourne Campus
Locked Bag 4115
FITZROY, VIC, 3065
Ph: 03 9953 3150
Fax: 03 9953 3315
Email: res.ethics@acu.edu.au

Any complaint or concern will be treated in confidence and fully investigated. You will be informed of the outcome.

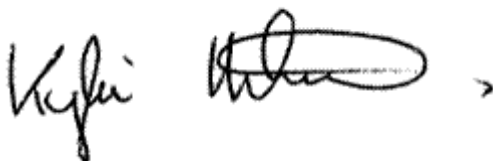
I want to participate! How do I sign up?

An information session about the research will be scheduled on each site enabling the researchers to present the study and what the study hopes to achieve to staff and managers, no staff will be recruited at this session. Any staff interested in participating in the study will be asked to complete a consent form and lodge the completed consent into a sealed box both of which will be left for their convenience in their staff room. This sealed box with will be collected by the researcher one week following the research information session.

Yours sincerely,

RESEARCHER NAME/S AND SIGNATURE/S

Kylie Wicks MNR student 16/10/2013

A handwritten signature in black ink, appearing to read 'Kylie Wicks', followed by a large, stylized circular flourish.

Professor Tracey McDonald

Dr Joanne Lawrence

Appendix I: Calculations—Knowledge translation by Participant

Wilcoxon Signed Rank Test Process

Let N be the sample size—the number of pairs. Thus, there are a total of $2N$ data points. For $i = 1 \dots N$, let $x_{1,i}$ and $x_{2,i}$ denote the measurements.

H_0 : difference between the pairs follows a symmetric distribution around zero.

H_1 : difference between the pairs does not follow a symmetric distribution around zero.

1. For $i = 1 \dots N$, calculate $|x_{2,i} - x_{1,i}|$ and $\text{sgn}(x_{2,i} - x_{1,i})$, where sgn is the sign function.
2. Exclude pairs with $|x_{2,i} - x_{1,i}| = 0$. Let N_r be the reduced sample size.
3. Order the remaining N_r pairs from smallest absolute difference to largest absolute difference, $|x_{2,i} - x_{1,i}|$.
4. Rank the pairs, starting with the smallest as 1. Ties receive a rank equal to the average of the ranks they span. Let R_i denote the rank.
5. Calculate the test statistic, W , by taking the lesser of the sums of the positively and negatively signed ranks.
6. Under null hypothesis, W follows a specific distribution with no simple expression. This distribution has an expected value of 0 and a variance of $\frac{N_r(N_r+1)(2N_r+1)}{6}$. W is compared to a critical value from a reference table. The two-sided test consists in rejecting H_0 if $W \geq W_{critical, N_r}$.

Table 18

Research Question 2—Wilcoxon Signed Rank Test for Null Hypothesis

Pre-intervention	Post-intervention	Sign ²⁷	Absolute ²⁸	Rank ²⁹	Signed rank ³⁰
7	15	1	8	9	9
8	13	1	5	7	7
7	9	1	2	4	4
11	12	1	1	1.5	1.5
11	13	1	2	4	4
8	13	1	5	7	7
7	12	1	5	7	7
9	8	-1	1	1.5	-1.5
9	11	1	2	4	4
Sum of positive ranks					43.5
Sum of negative ranks					-1.5
W-value ³¹					1.5

The critical value of the W statistic at $n = 9$ for a two-sided significance of 0.05 is 5. The calculated W -value is 1.5. Thus, the test is significant at the 0.05 level.

²⁷ The sign of the difference between the post-intervention and pre-intervention scores: 1 if it is positive, -1 if negative, and 0 if zero.

²⁸ The absolute value of the difference between the post-intervention and pre-intervention scores.

²⁹ The ranking of the absolute value of the difference between the post-intervention and pre-intervention scores from lowest to highest, averaging when ranks are equal.

³⁰ The ranking multiplied by the sign.

³¹ The lesser of the absolute value of the sum of the positive and negative signed ranks

Table 19

Research Question 2—Wilcoxon Signed Rank Test for Alternative Hypothesis

Pre-intervention + 3	Post-intervention	Sign	Absolute	Rank	Signed rank
10	15	1	5	9	9
11	13	1	2	5.5	5.5
10	9	-1	1	2	-2
14	12	-1	2	5.5	-5.5
14	13	-1	1	2	-2
11	13	1	2	5.5	5.5
10	12	1	2	5.5	5.5
12	8	-1	4	8	-8
12	11	-1	1	2	-2
Sum of positive ranks					25.5
Sum of negative ranks					-19.5
W-value					19.5

The critical value of the W statistic at $n = 9$ for a two-sided significance of 0.05 is 5. The calculated W -value is 19.5. Thus, the test is not significant at the 0.05 level.

Table 20

Research Question 2—Wilcoxon Signed Rank Test for Null Hypothesis, Excluding Question 13

Pre-intervention	Post-intervention	Sign	Absolute	Rank	Signed rank
7	14	1	7	9	9
8	13	1	5	7.5	7.5
7	9	1	2	4	4
11	12	1	1	1.5	1.5
11	13	1	2	4	4
8	12	1	4	6	6
7	12	1	5	7.5	7.5
9	8	-1	1	1.5	-1.5
9	11	1	2	4	4
Sum of positive ranks					43.5
Sum of negative ranks					-1.5
W-value					1.5

The critical value of the W statistic at $n = 9$ for a two-sided significance of 0.05 is 5. The calculated W -value is 1.5. Thus, the test is significant at the 0.05 level.

Table 21

Research Question 2—Wilcoxon Signed Rank Test for Alternative Hypothesis,

Excluding Question 13

Pre-intervention + 3	Post-intervention	Sign	Absolute	Rank	Signed rank
10	14	1	4	8.5	8.5
11	13	1	2	6	6
10	9	-1	1	2.5	-2.5
14	12	-1	2	6	-6
14	13	-1	1	2.5	-2.5
11	12	1	1	2.5	2.5
10	12	1	2	6	6
12	8	-1	4	8.5	-8.5
12	11	-1	1	2.5	-2.5
Sum of positive ranks					23
Sum of negative ranks					-22
W-value					22

The critical value of the W statistic at $n = 9$ for a two-sided significance of 0.05 is 5. The calculated W -value is 22. Thus, the test is not significant at the 0.05 level.

Appendix J: Calculations—knowledge translation by Question

Exact McNemer Test Process

The test is applied to a 2×2 contingency table, which tabulates the outcomes of two tests on a sample of N subjects, as follows.

	Test 2 positive	Test 2 negative	Row total
Test 1 positive	a	b	a + b
Test 1 negative	c	d	c + d
Column total	a + c	b + d	N

1. The null hypothesis of marginal homogeneity states that the two marginal probabilities for each outcome are the same, i.e. $p_a + p_b = p_a + p_c$ and $p_c + p_d = p_b + p_d$. Thus, the null and alternative hypotheses are:

$$H_0: p_b = p_c$$

$$H_1: p_b \neq p_c$$

2. For small N , this can be compared to a binomial distribution with size parameter $n = b + c$, and $p = 0.5$, allowing direct calculation of the two-sided P-value of:

$$p = \sum_{i=0}^b \binom{n}{i} 0.5^i (1 - 0.5)^{n-i}.$$

Table 22

Research Question 2—Exact McNemer Test for Question 1

Q01		Post-intervention	
		Incorrect	Correct
Pre-intervention	Incorrect	4	4
	Correct	0	1
		$p =$	0.0625

Table 23

Research Question 2—Exact McNemer Test for Question 2

Q02		Post-intervention	
		Incorrect	Correct
Pre-intervention	Incorrect	1	4
	Correct	0	4
		$p =$	0.0625

Table 24

Research Question 2—Exact McNemer Test for Question 3

Q03		Post-intervention	
		Incorrect	Correct
Pre-intervention	Incorrect	1	1
	Correct	1	6
		$P =$	0.75

Table 25

Research Question 2—Exact McNemer Test for Question 4

Q04		Post-intervention	
		Incorrect	Correct
Pre-intervention	Incorrect	1	1
	Correct	3	4
		$p =$	0.3125

Table 26

Research Question 2—Exact McNemer Test for Question 5

Q05		Post-intervention	
		Incorrect	Correct
Pre-intervention	Incorrect	0	2
	Correct	2	5
		$p =$	0.6875

Table 27

Research Question 2—Exact McNemer Test for Question 6

Q06		Post-intervention	
		Incorrect	Correct
Pre-intervention	Incorrect	0	1
	Correct	0	8
		$p =$	0.5

Table 28

Research Question 2—Exact McNemer Test for Question 7

Q07		Post-intervention	
		Incorrect	Correct
Pre-intervention	Incorrect	1	4
	Correct	0	4
		$p =$	0.0625

Table 29

Research Question 2—Exact McNemer Test for Question 8

Q08		Post-intervention	
		Incorrect	Correct
Pre-intervention	Incorrect	0	0
	Correct	1	8
		$p =$	0.5

Table 30

Research Question 2—Exact McNemer Test for Question 9

Q09		Post-intervention	
		Incorrect	Correct
Pre-intervention	Incorrect	2	3
	Correct	1	3
		$p =$	0.3125

Table 31

Research Question 2—Exact McNemer Test for Question 10

Q10		Post-intervention	
		Incorrect	Correct
Pre-intervention	Incorrect	1	7
	Correct	0	1
		$p =$	0.007813

Table 32

Research Question 2—Exact McNemer Test for Question 11

Q11		Post-intervention	
		Incorrect	Correct
Pre-intervention	Incorrect	0	2
	Correct	1	6
		$p =$	0.5

Table 33

Research Question 2—Exact McNemer Test for Question 12

Q12		Post-intervention	
		Incorrect	Correct
Pre-intervention	Incorrect	0	0
	Correct	0	9
		$p =$	1

Table 34

Research Question 2—Exact McNemer Test for Question 13

Q13		Post-intervention	
		Incorrect	Correct
Pre-intervention	Incorrect	7	2
	Correct	0	0
		$p =$	0.25

Table 35

Research Question 2—Exact McNemer Test for Question 14

Q14		Post-intervention	
		Incorrect	Correct
Pre-intervention	Incorrect	1	2
	Correct	0	6
		$p =$	0.25

Table 36

Research Question 2—Exact McNemer Test for Question 15

Q15		Post-intervention	
		Incorrect	Correct
Pre-intervention	Incorrect	0	6
	Correct	1	2
		$p =$	0.0625

Appendix K: Calculations—Knowledge Retention by Participant

Wilcoxon Signed Rank Test Process

Let N be the sample size—the number of pairs. Thus, there are a total of $2N$ data points. For $i = 1 \dots N$, let $x_{1,i}$ and $x_{2,i}$ denote the measurements.

H_0 : difference between the pairs follows a symmetric distribution around zero.

H_1 : difference between the pairs does not follow a symmetric distribution around zero.

1. For $i = 1 \dots N$, calculate $|x_{2,i} - x_{1,i}|$ and $\text{sgn}(x_{2,i} - x_{1,i})$, where sgn is the sign function.
2. Exclude pairs with $|x_{2,i} - x_{1,i}| = 0$. Let N_r be the reduced sample size.
3. Order the remaining N_r pairs from smallest absolute difference to largest absolute difference, $|x_{2,i} - x_{1,i}|$.
4. Rank the pairs, starting with the smallest as 1. Ties receive a rank equal to the average of the ranks they span. Let R_i denote the rank.
5. Calculate the test statistic, W , by taking the lesser of the sums of the positively and negatively signed ranks.
6. Under null hypothesis, W follows a specific distribution with no simple expression. This distribution has an expected value of zero, and a variance of $\frac{N_r(N_r+1)(2N_r+1)}{6}$. W is compared to a critical value from a reference table. The two-sided test consists of rejecting H_0 if $W \geq W_{critical, N_r}$.

Table 37

Research Question 3—Wilcoxon Signed Rank Test for Null Hypothesis

Post-intervention	Six-month follow-up	Sign ³²	Absolute ³³	Rank ³⁴	Signed rank ³⁵
15	13	-1	2	5.5	-5.5
13	14	1	1	2.5	2.5
9	8	-1	1	2.5	-2.5
12	10	-1	2	5.5	-5.5
13	14	1	1	2.5	2.5
13	12	-1	1	2.5	-2.5
12	12	0			
8	13	1	5	7	7
11	11	0			
Sum of positive ranks					12
Sum of negative ranks					-16
W-value ³⁶					12

The critical value of the W statistic at $n = 9$ for a two-sided significance of 0.05 is 5. The calculated W -value is 12. Thus, the test is not significant at the 0.05 level.

³² The sign of the difference between the post-intervention and pre-intervention scores: 1 if it is positive, -1 if negative and 0 if zero.

³³ The absolute value of the difference between the post-intervention and pre-intervention scores.

³⁴ The ranking of the absolute value of the difference between the post-intervention and pre-intervention scores from lowest to highest, averaging when ranks are equal.

³⁵ The ranking multiplied by the sign.

³⁶ The lesser of the absolute value of the sum of the positive and negative signed ranks

Table 38

Research Question 3—Wilcoxon Signed Rank Test for Alternative Hypothesis

Pre-intervention	Six-month follow-up	Sign	Absolute	Rank	Signed rank
7	13	1	6	8.5	8.5
8	14	1	6	8.5	8.5
7	8	1	1	1.5	1.5
11	10	-1	1	1.5	-1.5
11	14	1	3	4	4
8	12	1	4	5.5	5.5
7	12	1	5	7	7
9	13	1	4	5.5	5.5
9	11	1	2	3	3
Sum of positive ranks					43.5
Sum of negative ranks					-1.5
W-value					1.5

The critical value of the W statistic at $n = 9$ for a two-sided significance of 0.05 is 5. The calculated W -value is 1.5. Thus, the test is significant at the 0.05 level.

Table 39

Research Question 3—Wilcoxon Signed Rank Test for Null Hypothesis, Excluding Question 13

Post-intervention	Six-month Follow-up	Sign	Absolute	Rank	Signed rank
14	13	-1	1	2.5	-2.5
13	13	0			
9	8	-1	1	2.5	-2.5
12	10	-1	2	5	-5
13	14	1	1	2.5	2.5
12	12	0			
12	11	-1	1	2.5	-2.5
8	13	1	5	6	6
11	11	0			
Sum of positive ranks					8.5
Sum of negative ranks					-12.5
W-value					8.5

The critical value of the W statistic at $n = 9$ for a two-sided significance of 0.05 is 5. The calculated W -value is 8.5. Thus, the test is not significant at the 0.05 level.

Table 40

Research Question 3—Wilcoxon Signed Rank Test for Alternative Hypothesis,

Excluding Question 13

Pre-intervention	Six-month Follow-up	Sign	Absolute	Rank	Signed rank
7	13	1	6	9	9
8	13	1	5	8	8
7	8	1	1	1.5	1.5
11	10	-1	1	1.5	-1.5
11	14	1	3	4	4
8	12	1	4	6	6
7	11	1	4	6	6
9	13	1	4	6	6
9	11	1	2	3	3
Sum of positive ranks					43.5
Sum of negative ranks					-1.5
W-value					1.5

The critical value of the W statistic at $n = 9$ for a two-sided significance of 0.05 is 5. The calculated W -value is 1.5. Thus, the test is significant at the 0.05 level.

Appendix L: Calculations—Knowledge Retention by Question

Exact McNemer Test Process

The test is applied to a 2×2 contingency table, which tabulates the outcomes of two tests on a sample of N subjects, as follows.

	Test 2 positive	Test 2 negative	Row total
Test 1 positive	a	b	a + b
Test 1 negative	c	d	c + d
Column total	a + c	b + d	N

1. The null hypothesis of marginal homogeneity states that the two marginal probabilities for each outcome are the same, i.e. $p_a + p_b = p_a + p_c$ and $p_c + p_d = p_b + p_d$. Thus, the null and alternative hypotheses are:

$$H_0: p_b = p_c$$

$$H_1: p_b \neq p_c$$

2. For small N , this can be compared to a binomial distribution with size parameter $n = b + c$, and $p = 0.5$, allowing direct calculation of the two-sided P-value of:

$$p = \sum_{i=0}^b \binom{n}{i} 0.5^i (1 - 0.5)^{n-i}.$$

Table 41

Research Question 3—Exact McNemer Test for Question 1

	Pre v. follow-up			Post v. follow-up	
	Incorrect	Correct		Incorrect	Correct
Incorrect	6	2	Incorrect	4	0
Correct	0	1	Correct	2	3
	$p =$	0.25		$p =$	0.25

Table 42

Research Question 3—Exact McNemer Test for Question 2

	Pre v. follow-up			Post v. follow-up	
	Incorrect	Correct		Incorrect	Correct
Incorrect	0	5	Incorrect	0	1
Correct	0	4	Correct	0	8
	$p =$	0.03125		$p =$	0.5

Table 43

Research Question 3—Exact McNemer Test for Question 3

	Pre v. follow-up			Post v. follow-up	
	Incorrect	Correct		Incorrect	Correct
Incorrect	0	2	Incorrect	0	2
Correct	1	6	Correct	1	6
	$p =$	0.5		$p =$	0.5

Table 44

Research Question 3—Exact McNemer Test for Question 4

	Pre v. follow-up			Post v. follow-up	
	Incorrect	Correct		Incorrect	Correct
Incorrect	2	0	Incorrect	3	1
Correct	3	4	Correct	2	3
	$p =$	0.125		$p =$	0.5

Table 45

Research Question 3—Exact McNemer Test for Question 5

	Pre v. follow-up			Post v. follow-up	
	Incorrect	Correct		Incorrect	Correct
Incorrect	0	2	Incorrect	2	0
Correct	3	4	Correct	1	6
	$p =$	0.5		$p =$	0.5

Table 46

Research Question 3—Exact McNemer Test for Question 6

	Pre v. follow-up			Post v. follow-up	
	Incorrect	Correct		Incorrect	Correct
Incorrect	0	1	Incorrect	0	0
Correct	0	8	Correct	0	9
	$p =$	0.5		$p =$	1

Table 47

Research Question 3—Exact McNemer Test for Question 7

	Pre v. follow-up			Post v. follow-up	
	Incorrect	Correct		Incorrect	Correct
Incorrect	1	4	Incorrect	1	0
Correct	0	4	Correct	0	8
	$p =$	0.0625		$p =$	1

Table 48

Research Question 3—Exact McNemer Test for Question 8

	Pre v. follow-up			Post v. follow-up	
	Incorrect	Correct		Incorrect	Correct
Incorrect	0	0	Incorrect	0	1
Correct	0	9	Correct	0	8
	$p =$	1		$p =$	0.5

Table 49

Research Question 3—Exact McNemer Test for Question 9

	Pre v. follow-up			Post v. follow-up	
	Incorrect	Correct		Incorrect	Correct
Incorrect	1	4	Incorrect	1	2
Correct	0	4	Correct	0	6
	$p =$	0.0625		$p =$	0.25

Table 50

Research Question 3—Exact McNemer Test for Question 10

	Pre v. follow-up			Post v. follow-up	
	Incorrect	Correct		Incorrect	Correct
Incorrect	1	7	Incorrect	0	1
Correct	0	1	Correct	1	7
	$p = 0.0078125$			$p = 0.75$	

Table 51

Research Question 3—Exact McNemer Test for Question 11

	Pre v. follow-up			Post v. follow-up	
	Incorrect	Correct		Incorrect	Correct
Incorrect	0	2	Incorrect	1	0
Correct	2	5	Correct	1	7
	$p = 0.6875$			$p = 0.5$	

Table 52

Research Question 3—Exact McNemer Test for Question 12

	Pre v. follow-up			Post v. follow-up	
	Incorrect	Correct		Incorrect	Correct
Incorrect	0	0	Incorrect	0	0
Correct	0	9	Correct	0	9
	$p = 1$			$p = 1$	

Table 53

Research Question 3—Exact McNemer Test for Question 13

	Pre v. follow-up			Post v. follow-up	
	Incorrect	Correct		Incorrect	Correct
Incorrect	7	2	Incorrect	5	2
Correct	0	0	Correct	2	0
	$p = 0.25$			$p = 0.6875$	

Table 54

Research Question 3—Exact McNemer Test for Question 14

	Pre v. follow-up			Post v. follow-up	
	Incorrect	Correct		Incorrect	Correct
Incorrect	0	3	Incorrect	0	1
Correct	0	6	Correct	0	8
	$p =$	0.125		$p =$	0.5

Table 55

Research Question 3—Exact McNemer Test for Question 15

	Pre v. follow-up			Post v. follow-up	
	Incorrect	Correct		Incorrect	Correct
Incorrect	1	5	Incorrect	0	1
Correct	0	3	Correct	1	7
	$p =$	0.03125		$p =$	0.75