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Nursing and midwifery practice for maintenance of vascular access device patency. A cross-sectional survey

Samantha Keogh [a,b,c,*], Julie Flynn [a,b,c], Nicole Marsh [a,b,c], Niall Higgins [a,b,c], Karen Davies [c], Claire M. Rickard [a,b,c]

[a] Alliance for Vascular Access Teaching and Research (AVATAR), Australia
[b] NHMRC Centre of Research Excellence in Nursing Interventions for Hospitalised Patients (NCREN), Centre for Health Practice Innovation – Menzies Heath Institute, Griffith University, Qld, Australia
[c] Centre of Clinical Nursing, Royal Brisbane and Women's Hospital, Qld, Australia

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ABSTRACT

Background: Up to 85% of hospital in-patients will require some form of vascular access device to deliver essential fluids, drug therapy, nutrition and blood products, or facilitate sampling. The failure rate of these devices is unacceptably high, with 20–69% of peripheral intravenous catheters and 15–66% of central venous catheters failing due to occlusion, depending on the device, setting and population. A range of strategies have been developed to maintain device patency, including intermittent flushing. However, there is limited evidence informing flushing practice and little is known about the current flushing practices.

Objective: The aim of the study was to improve our understanding of current flushing practices for vascular access devices through a survey of practice.

Method: A cross-sectional survey of nurses and midwives working in the State of Queensland, Australia was conducted using a 25-item electronic survey that was distributed via the local union membership database.

Results: A total of 1178 surveys were completed and analysed, with $n = 1068$ reporting peripheral device flushing and $n = 584$ reporting central device flushing. The majority of respondents were registered nurses (55%) caring for adult patients (63%). A large proportion of respondents (72% for peripheral, 742/1028; 80% for central, 451/566) were aware of their facility's policy for vascular access device flushing. Most nurses reported using sodium chloride 0.9% for flushing both peripheral (96%, 987/1028) and central devices (75%, 423/566). Some concentration of heparin saline was used by 25% of those flushing central devices. A 10-mL syringe was used by most respondents for flushing; however, 24% of respondents used smaller syringes in the peripheral device group. Use of prefilled syringes (either commercially prepared sterile or prefilled in the workplace) was limited to 10% and 11% respectively for each group. The frequency of flushing varied widely, with the most common response being pro re nata (23% peripheral and 21% central), or 6 hourly (23% peripheral and 22% central). Approximately half of respondents stated that there was no medical order or documentation for either peripheral or central device flushing.

* Corresponding author at: c/ NHMRC Centre of Research Excellence in Nursing, Griffith University, Nathan Campus, 170 Kessels Road, Brisbane, Qld 4111, Australia. Tel.: +61 7 3735 4886; fax: +61 7 3735 3560.
E-mail address: s.keogh@griffith.edu.au (S. Keogh).

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Conclusions: Flushing practices for vascular access device flushing appear to vary widely. Specific areas of practice that warrant further investigation include questions about the efficacy of heparin for central device flushing, increasing adherence to the recommended 10 mL diameter syringe use, increased use of prefilled flush syringes, identifying and standardising optimal volumes and frequency of flushing, and improving documentation of flush orders and administration.

What is already known about the topic?

- Approximately 85% of all hospitalised patients will require some form of intravenous therapy.
- Vascular access device occlusion ranges from 15 to 69% depending on device and setting, with associated costs to the patient, organisation and healthcare system.
- There is a paucity of research and a high degree of practice variation in the maintenance of peripheral and central venous device patency, including the role of flushing to prevent complications.

What this paper adds

- The results of this study have clarified nursing and midwifery practice related to vascular access device flushing.
- The results further highlight the inconsistencies in flushing practice and the need for evidence in this area.
- The results have laid the foundation for an informed protocol development for future intervention and randomised controlled trial work in vascular access device patency and flushing practice.

1. Introduction and background

Venous access via peripheral and central venous catheters is frequently used in hospital care to administer fluids, drugs, blood and nutrition, and to withdraw blood for testing, among other purposes. These devices may need to be left in place for days or even weeks; but they are associated with complications that can be mechanical or infectious. Mechanical complications include occlusion, thrombosis, dislodgement, infiltration, leakage, phlebitis and scar formation. Infectious complications include bacterial or fungal sepsis. Thrombosis or phlebitis at the catheter site can act as a focus for nosocomial infection that is associated with extended admission time, additional costs and increased mortality (Maki et al., 2006; Maki and Ringer, 1991; Mermel et al., 2009).

Each year, approximately 450,000 individuals are admitted to Queensland public hospitals (Australian Bureau of Statistics, 2013). The majority require intravenous catheterisation for the administration of medications or fluid. Based upon this, it is estimated that 150,000 will need a peripheral intravenous catheter in place for more than three days (Tuffaha et al., 2014). A survey from 2003 stated the proportion of central venous catheter use is approximately 29% of the general hospital population, rising up to 80% for patients in critical care settings (Climo et al., 2003). There have been a range of strategies to prevent or reduce intravenous catheter related complications. These include: optimising patency through continuous infusion or intermittent flushes with either normal saline, heparin, antibiotic and/or ethanol locks (Goode et al., 1991; Peterson and Kirchhoff, 1991; Randolph et al., 1998); less frequent catheter and infusion set changes (Bregenzer et al., 1998; Cornely et al., 2002; Homer and Holmes, 1998; Rickard et al., 2012; White, 2001); placement of in-line filters (Chee and Tan, 2002; Roberts et al., 1994); and designated intravenous therapy teams (da Silva et al., 2010; Wenzel and Edmond, 2006). Despite these interventions, catheter failure before the end of treatment is all too common. The failure rate of peripheral intravenous catheters due to occlusion is 20–69% (Bolton, 2010; Rickard et al., 2010, 2012; Royer, 2003). The failure rate of central venous catheters due to occlusion ranges from 15% to 66%, depending on the device, setting and population (Baskin et al., 2009; Raad et al., 2002, 2003; Timsit et al., 2011a). Repeated catheter insertions due to failed catheters require multiple penetrations of the skin barrier, increase patient discomfort and staff time, and predispose patients to infection from skin commensals. Such infections can be life threatening in the acute and critically ill (Maki et al., 2006; Mermel et al., 2009; Raad et al., 2007). Therefore, methods that can prolong the duration of viability of both peripheral and central venous catheters hold significant benefit for patient outcomes and the quality of organisational care delivered.

The USA's Centers for Disease Control (CDC) and the UK's EPIC3 Guidelines for preventing healthcare associated infections (HCAIs) only briefly address the issue of vascular access device patency, and when they do it is in relation to central venous catheters not peripheral intravenous catheters. The Catheter Related Bloodstream Infection (CRBSI) rate in central venous catheters in the USA is approximately 3% (Maki et al., 2006) whereas central venous catheter failure rates due to occlusion or thrombosis range from 15 to 66% (Baskin et al., 2009; Raad et al., 2003, 2002; Timsit et al., 2011a). CRBSI rates in peripheral intravenous catheters are extremely low (0.1% Maki et al., 2006). On the other hand, peripheral intravenous catheter failure rates due to dislodgement, occlusion, infiltration or phlebitis sit at 26% in Australia (Rickard et al., 2012), 38% in Spain (Chico-Padron et al., 2011) and 53% in the USA (Bausone-Gazda et al., 2010). Leading professional Associations include some guidelines for maintaining vascular

access device patency through flushing (Infusion Nurses Society, 2011; Royal Nurses' Association of Ontario, 2005). Levels of evidence informing these recommendations were limited to level IV or V (i.e. single quasi-experimental clinical/lab study or clinical opinion). Recommendations about frequency, volume, syringe size or mode differed. Local guidelines are found to be similarly lacking or inconsistent.

The results of research comparing continuous infusion versus intermittent flushes to maintain catheter patency remain inconclusive, with studies yielding varied findings (Fernandez et al., 2003; Flint et al., 2005). There are no large multi site trials comparing different flushing regimens (i.e. regular versus PRN; 6 hourly versus daily; 3 mL versus 10 mL). Evidence about the use of heparinised flushing solution versus normal saline or other interventions is also inconclusive (Randolph et al., 1998). Indeed, the optimum approach to flushing practice is not known, therefore the inconsistent nature of flushing recommendations in organisational guidelines is not surprising. Consequently, it is timely to survey current flushing practice related to maintenance of peripheral and central venous catheter patency.

2. Aim and objective of study

The aim of this study was to survey a large cohort of nurses and midwives with the objective of increasing our knowledge and understanding of current flushing practices.

2.1. Design

This study employed a descriptive, exploratory design using a large cross-sectional survey to gather information that would address the following research questions:

1. What are the current peripheral intravenous catheter flushing practices among nurses and midwives in Queensland hospitals?
2. What are the current central venous catheter flushing practices among nurses and midwives in Queensland hospitals?

2.2. Sample

The population of registered nurses and midwives in Queensland (Australia) hospitals was accessed through the Queensland Nurses' Union (QNU) database. There are approximately 67,000 nurses and midwives registered in Queensland. Of these 49,806 are QNU members, of whom approximately 70% receive an electronic newsletter. The QNU agreed to pass on the survey invitation and link to these members via the monthly electronic newsletter for two consecutive months.

2.3. Survey

A literature search identified a tool developed specifically for measuring the flushing practices of nurses that cared for patients who had a central venous catheter inserted (Sona et al., 2012). This survey was based upon the original ten-item instrument that was used for a national survey of critical care nurses drawn from the American Association of Critical Care Nurses (Sona et al., 2012). The items and content were based on a literature search that remains current and had input from clinical experts. The authors had also tested face and content validity using a pilot sample and expert panel. Some changes were made to the original tool for the study conducted in Queensland, in order to (a) make it applicable to the Australian population (i.e. vernacular), and (b) be relevant to peripheral intravenous catheter flushing as well as that of central venous catheters. The final Australian survey had 25 items (including demographics). The majority of questions followed a multiple-choice format but did include short response items. It was designed to take approximately 10 min to complete. The survey was conducted using an electronic platform with licensed software (LimeSurvey™). All responses were confidential and anonymous. This survey tool was successfully piloted locally using the electronic method of delivery before implementation.

2.4. Data collection

Following approval by both hospital and university based Human Research Ethics Committees (NRS/19/13/HREC), an invitation to participate in the survey was sent out for July 2013. A reminder message was sent the following month in the newsletter to optimise response rate. Participants were asked to complete the survey online via a web link in the electronically distributed newsletter.

2.5. Data analysis

Survey data were exported and analysed using PASW Statistics v.20 (SPSS Inc.). Descriptive statistics were calculated to summarise demographics and key variables. Data were presented for the overall sample, and then broken down into those who reported peripheral intravenous catheter flushing, and those who reported central venous catheter flushing. There was overlap between the respondents who replied for the peripheral and central venous catheter sections of the survey. Cross tabulation and differences between variables were tested using Pearson's chi-square.

3. Results

A total of 1203 surveys were returned, with 1178 containing complete data for further analysis (see Fig. 1). Of this number, 1068 (91%) respondents cared for patients with peripheral intravenous catheters and 584 (50%) cared for patients with central venous catheters. The majority of respondents were registered nurses (55%) caring for adult patients (63%) in a metropolitan facility (48%). Respondents represented nurses and midwives from a range of settings: primary and acute; metropolitan, regional and remote; neonatal, paediatric, adult. Full occupational details are presented in Table 1. The broad distribution of the survey promoted the opportunity to receive

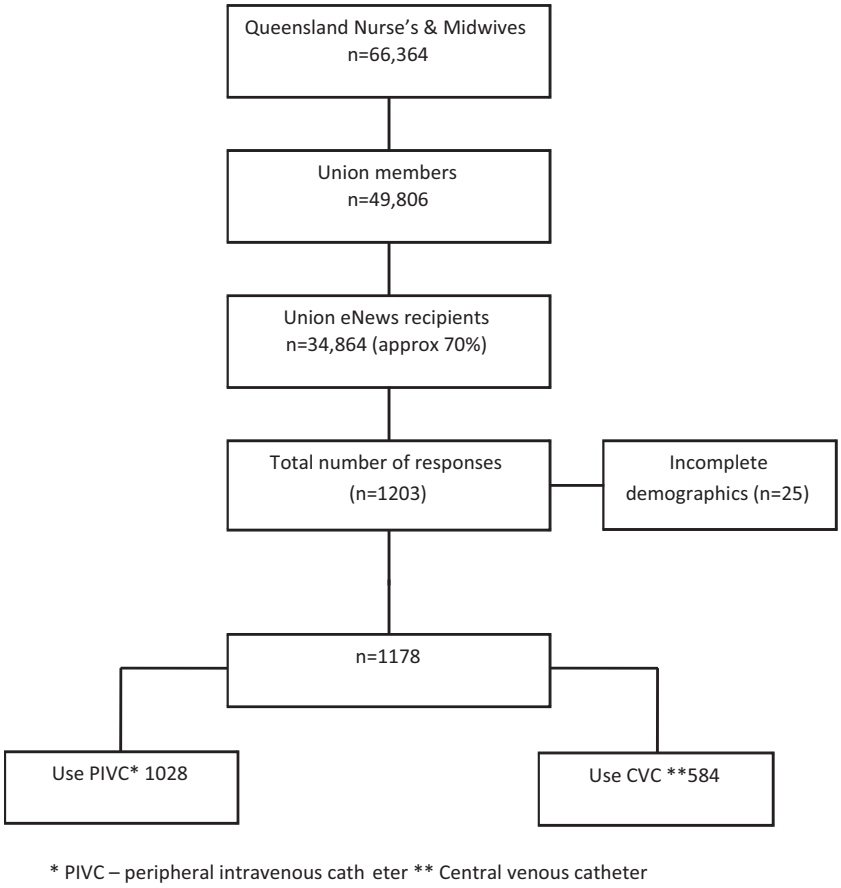

Fig. 1. Sample flow diagram.

responses from nurses and midwives working in regional and rural settings (35% and 17% respectively), as well as across a range of patient populations including paediatric and neonatal (7% and 2% respectively). Respondents had a range of experience but were represented evenly, with 50% of respondents having worked in their clinical domain for more than six years.

3.1. Flushing practice

Data revealed that sodium chloride 0.9% was the most frequent solution used for flushing for both peripheral catheters (96%) and central catheters (75%) devices. Some form of Heparin was used by 25% of respondents in the central venous catheter group. The majority of respondents (approximately 60%) reported 10 mL as the most common volume used to flush both peripheral and central venous catheter, with 5 mL being the next most common amount. Most respondents used a 10 mL size syringe to administer flushes to peripheral catheters (75%) and central catheters (82%). Of respondents using syringes of less than 10 mL volume, there was a higher incidence (23%) in the peripheral catheter group than the central catheter group (8%). Cross tabulation and correlation analysis revealed that clinicians from a paediatric/neonatal setting were more likely to use a smaller syringe (i.e. 2 mL or 5 mL) to administer a peripheral intravenous catheter flush than those working in an adult setting (52% and 89% respectively, $p < 0.0001$). Responses on frequency of flushing were wide and varied, with the most commonly reported timings being pre- and post-drug administration only (Peripheral 23% and Central 21%), and pre- and post-drug plus 6 hourly administration (Peripheral 23% and Central 22%). Full details of all responses are in Table 2.

Most nurses and midwives reported being aware of an institutional flushing policy related to peripheral and central venous catheters (72% and 80% respectively). The vast majority of respondents manually prepared flushes for administration, with only a small percentage using prefilled syringes (Peripheral 10% and Central 11%). It is unknown whether these respondents were referring to commercially available, sterile pre-filled flush syringes, or to manually pre-filled syringes by themselves or another practitioner in their institution. Less than half of the respondents in both groups reported that a medical order was required for flushing. Chi square testing revealed that nurses from a paediatric or neonatal setting were more likely to have an order for flushing and to document administration of flush, compared with practices in adult settings (Peripheral 89% and 82% respectively, $p < 0.001$,

Table 1
Occupational profile of nursing and midwifery respondents.

	Overall $n = 1178$	PIVC[a] $n = 1068$	CVC[b] $n = 584$
Hospital type			
Metropolitan	562 (48%)	523 (49%)	336 (57%)
Regional	414 (35%)	375 (35%)	202 (35%)
Rural/remote	202 (17%)	170 (16%)	46 (8%)
Patient type			
Adult	743 (63%)	670 (63%)	392 (67%)
Combined	329 (28%)	293 (27.4%)	124 (21%)
Paediatric	77 (7%)	76 (7.1%)	59 (10%)
Neonatal	29 (2%)	29 (3%)	9 (2%)
Position			
RN	651 (55%)	602 (56%)	352 (60%)
CN	317 (27%)	297 (28%)	169 (29%)
CNC/NUM	89 (8%)	74 (7%)	42 (7%)
Midwife	59 (5%)	51 (5%)	7 (1%)
EEN	44 (4%)	32 (3%)	8 (1%)
Level 8+	14 (1%)	11 (1%)	5 (1%)
EN	4 (0.3%)	1 (0.1%)	1 (0.2%)
Years in nursing			
<2 years	236 (20%)	210 (20%)	100 (17%)
2–5 years	362 (31%)	332 (30%)	181 (31%)
6–10 years	231 (19%)	211 (20%)	122 (21%)
>10 years	349 (30%)	315 (30%)	181 (31%)

[a] PIVC – peripheral intravenous catheter.
[b] Central venous catheter.

Table 2
Data on IVD flushing practice from nursing and midwifery respondents.

	PIVC[a] $n = 1068$	CVC[b] $n = 584$
Flush solution		
NaCl 0.9%	987 (96%)	423 (75%)
HepSaline	33 (3%)	102 (18%)
Other	8 (1%)	41 (7%)
Incomplete/missing data	40 (4%)	18 (3%)
Flush volume		
2 mL	55 (5%)	23 (4%)
5 mL	324 (31%)	104 (18%)
10 mL	589 (57%)	348 (61%)
20 mL	–	40 (7%)
Other	60 (%)	51 (10%)
Incomplete/missing data	40 (4%)	18 (3)
Syringe size		
2 mL	40 (4%)	12 (2%)
5 mL	192 (19%)	37 (7%)
10 mL	768 (75%)	465 (82%)
20 mL	–	34 (6%)
Other	28 (2%)	18 (3%)
Incomplete/missing data	40 (4%)	18 (3%)
Frequency of flush		
Pre/post drug admin only	237 (23%)	117 (21%)
4/24 only	45 (4%)	18 (3%)
4/24 + pre/post drug admin	94 (9%)	52 (9%)
6/24 only	139 (13%)	65 (11%)
6/24 + pre/post drug admin	238 (23%)	126 (22%)
8/24 only	69 (7%)	28 (5%)
8/24 + pre/post drug admin	129 (13%)	66 (12%)
Daily only	26 (2%)	18 (3%)
Daily + pre/post drug admin	51 (5%)	76 (14%)
Incomplete/missing data	40 (4%)	18 (3%)

[a] PIVC – peripheral intravenous catheter.
[b] Central venous catheter.

and Central 84% and 66% respectively, $p < 0.001$). More than half reported that they document flush administration in either the medication chart or fluid balance chart. A third of all respondents reported that their flush administrations were rarely documented. Details of these characteristics are presented in Table 3.

4. Discussion

The study achieved its aim to generate a cross-sectional snapshot of nursing and midwifery vascular access device flushing practice across Queensland. This is the first systematic investigation undertaken into peripheral intravenous catheter flushing practice anywhere in the world, and only the second study to our knowledge focussing on central venous catheters. Like Sona and colleagues' work from the USA, we found a wide variation in practitioners' responses for flushing solution, frequency and volumes. Their respondents reported a slightly higher use of heparin solution for central venous catheter flushing (33%, 213/632) compared to our finding of 25%, and reported eight hourly standardised flushing as the most common practice, compared to our finding of six hourly plus pre/post-drug administration.

Most respondents in this study reported that their standard flush solution was sodium chloride 0.9% using 10 mL of solution in a 10 mL syringe. Paediatric and neonatal practitioners were more likely to use smaller syringes. Flushing syringes chosen were either 2 mL or 5 mL sizes for 89% of neonatal nurses and 54% of paediatric nurses. This is probably related to the general use of smaller volumes for flushing in these populations. This implies a lack of appreciation for the increase in pressure per square inch (PSI) associated with the properties of smaller size syringes. The use of reduced pressure for flush delivery through a syringe with a larger gauge such as the standard 10 mL syringe is recommended to optimise flush outcomes and minimise damage to the vein (Hadaway, 2006; Macklin, 1999; Perucca, 2010). These recommendations are largely derived from physics principles, and have not been and possibly could not be explicitly tested in clinical trials. In recent times, commercially prepared prefilled flush syringes have become available, which negate the potential for operators to make an incorrect choice of a smaller size syringe, since they are produced in diameters consistent with a 10 mL syringe, but in 3, 5 and 10 mL volumes. A small, single site trial of different flushing frequencies (twice daily versus once daily) demonstrated similar risk of peripheral intravenous catheter failure (12.1% versus 9.5%). However, the sample was a select paediatric population (no infusion therapy or intravenous antibiotics). Additionally, the overall risk of failure was noted to be very low compared to other studies (8.7%, $n = 497$) and this was possibly related to the use of pre-filled flush syringes across both groups (Schreiber et al., 2015). One non-randomised study suggests pre-filled flush syringes can reduce bloodstream infections, over manually filled syringes (Bertoglio et al., 2013).

Table 3
Data on organisational recommendations and flushing practice from nursing and midwifery respondents.

	PIVC[a] $n = 1068$	CVC[b] $n = 584$
Flushing policy		
Yes	742 (72%)	451 (80%)
No	82 (8%)	28 (5%)
Unsure	204 (19%)	87 (15%)
Incomplete/missing	40 (4%)	18 (3%)
Preparation		
Manual	915 (89%)	501 (88%)
Prefilled	108 (10%)	64 (11%)
Incomplete/missing data	45 (4%)	19 (3%)
Flush order		
Yes	396 (38%)	267 (47%)
No	598 (58%)	273 (48%)
Unsure	30 (3%)	24 (5%)
Incomplete/missing data	44 (4%)	20 (3%)
Flush documented		
Medication chart	469 (46%)	282 (50%)
IV Fluid chart	86 (8%)	65 (11%)
Not documented	357 (35%)	164 (29%)
Incomplete/missing data	146 (14%)	75 (12%)

[a] PIVC – peripheral intravenous catheter.
[b] Central venous catheter.

Reported use of prefilled syringes by participants was minimal in this survey (Peripheral 10% and Central 11%). We did not ask respondents who was pre-filling the syringes, which may have been manufacturer-prepared sterile syringes which are clearly labelled as to contents and with 10 mL diameters, or syringes pre-prepared by the nurse/midwife themselves, or by another colleague. The latter practice would be concerning due to the risk of microbial contamination and potential lack of labelling.

A small but substantial number of practitioners caring for central venous catheters (25%) reported using some form of Heparin as a flush solution. The reason for this is not known. Currently the Queensland State policy for central venous catheter flushing recommends Sodium Chloride 0.9% as the preferred flush or infusion solution (Queensland Health, 2011). A number of studies have shown Heparin to support the growth of organisms in solution and in biofilm (Raad et al., 2002, 2003; Shah et al., 2002; Shanks et al., 2005). Both experimental and cohort studies suggest a close relationship between catheter thrombosis and infection, indicating a need for Heparin (Timsit et al., 2011a,b). Other clinical trial results demonstrated that Heparin might reduce CRBSI (Abdelkefi et al., 2005; Birch et al., 2010; Pierce et al., 2000). The latter studies reported that the Heparin solution also contained a preservative with antimicrobial activity, and it is therefore unclear whether the decrease in CRBSI rate would be due to decreased thrombus formation or the preservative, or both (Timsit et al., 2011a). The potential benefits of Heparin flushes and/Heparin-coated catheters must be balanced against the risk of Heparin-induced thrombocytopenia, a rare but serious adverse reaction (Timsit et al., 2011b).

There is currently little evidence informing the recommendations for either the volume or frequency required for a vascular access device flush. Generally, organisational and industry guidelines recommend "a minimum flush volume equal to twice the internal volume of the catheter system, which includes the catheter, extension set, and/or needleless injection system added to the catheter hub" (Infusion Nursing Society, 2011). This usually translates to 1–3 mL for a peripheral intravenous catheter and 5–10 mL for central venous catheter, with a volume of 20 mL preferred after obtaining a blood sample (Infusion Nursing Society, 2011). Such recommendations were generally reflected in the practice reported by participants for central venous catheters, but flush volumes larger than 3 mL were commonly reported for peripheral intravenous catheters in this survey, suggesting a widespread lack of knowledge of these recommendations for these devices. Similar to lack of recommendations regarding flush *volumes*, there are few studies evaluating the effect of flushing *frequency* on patient outcomes, with no rigorous trials to inform practice for either of these two variables (Campbell et al., 2005). This lack of evidence to inform clinicians was apparent from the survey results, which revealed an unacceptable variation in the array of flushing practices amongst respondents caring for patients with these devices.

Respondents in this study were largely aware of their local Queensland Health policy on vascular access device flushing (Peripheral 72% and Central 80%). The policy allows for nurse-initiated flushing without a specific medical order, but there is no recommendation for documentation of these flushes, and respondents reported poor and varied documentation of flushing. A record of vascular access device flushes given would not only demonstrate the evaluation and confirmation of device assessment and patency but also record the patient's fluid balance. An exception was noted, in that respondents from paediatric or neonatal settings were more likely to document flush administration. This reflects the practice of maintaining a strict fluid balance record in these settings.

This study has principally highlighted and confirmed the variation and gaps in vascular access device flushing practice and knowledge. In lieu of much needed trial research, clinicians and organisations could make efforts to standardise and streamline flushing practice in order to minimise inconsistencies and optimise documentation. The USA's Infusion Nursing Society, Canada's Registered Nurses' Association Ontario, and many local guidelines recommend: initial aspiration of blood to ascertain vascular access device patency; a minimum of pre- and post-drug administration flushing; use of single dose prefilled flush syringes to minimise device and solution contamination and incorrect syringe use; volume determined by size of catheter and patient; and use of a pulsatile technique (Infusion Nursing Society, 2011; Registered Nurses' Association Ontario, 2005).

The strengths of this study were its large number of respondents and grounding in the current literature. Generalisability of results is somewhat limited, since the respondents did not include the total workforce of the State of Queensland. Nonetheless, the large absolute numbers and heterogeneous sample does suggest that a

reasonably representative cross-section of this group was sampled. The absolute denominator is not available, but based on the population details, the approximate response rate was 3.5%. Furthermore, observational designs like cross-sectional studies cannot test any direct cause and effect relationship and therefore cannot inform or make firm recommendations for practice. Although cross-sectional designs provide only a "once off" measurement and do not allow for understanding of changes in practice over time, this survey could be repeated some years in the future to assess for practice evolution. The value of the study's results lies in the summary of current practice and its ability to inform future trial work to improve flushing practice and patient care.

5. Conclusion

This survey highlights a number of inconsistencies in practice that reflect the current lack of evidence in the area of vascular access device flushing. Results of the survey have clarified current nursing practice related to peripheral central venous flushing. The study has helped to identify gaps in practice and research, and lay foundations for the conduct of randomised controlled trials to generate evidence related to peripheral central venous flushing. Rigorous research is urgently required to establish the optimal flushing solution, volume, frequency, and mechanism that will prevent vascular access device malfunction, thus optimising patient comfort and clinical outcomes.

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Conflict of interest: None declared.

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