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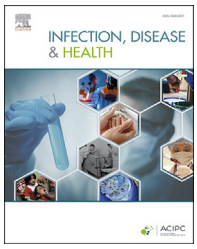

Research paper

Needleless connector nursing care — Current practices, knowledge, and attitudes: An Australian perspective

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Abstract *Background:* Inappropriate needleless connector (NC) care is associated with device failure from catheter occlusion and patient blood stream infections (BSIs). This can be attributed to a lack of knowledge of connector designs and flushing, clamping, and syringe disconnection techniques. This study aimed to assess nurses' practice, knowledge, attitudes, and key influencers on appropriate care of NCs in an Australian facility and compare these with studies undertaken in the United States in 2011.
Methods: A cross-sectional online survey was sent via email with a SurveyMonkey® link to all nurses working in clinical areas (total population sampling approach; approximately 1500 nurses), at an Australian hospital, in 2018. The survey was anonymous and open for 6 weeks. Analysis was with R software.
Results: Response rate was approximately 19% (n = 283). Most (89%) of nurses stated that they clean NCs before each access. Only 25% correctly recognised the negative pressure NC, and 79% correctly identified the correct clamping and disconnection sequence. Positive pressure displacement devices were correctly identified by 44% of respondents, with 34% identifying the correct clamping and disconnecting technique. Nurses reported their behaviour was most influenced by local senior nurses.

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Conclusions: There remains a significant gap in nurses' knowledge of NC device types, as well as the correct clamping and syringe disconnection for both negative and positive displacement NCs. This survey reaffirms that senior nurses are the key influencers of nurses' adherence to best practice guidelines.

Highlights

- Survey of nurses' knowledge and practice of NC care.
- 89% of nurses clean NCs each time before access.
- 25% of nurses correctly recognized negative pressure NCs, 79% chose the correct clamping sequence.
- 44% of nurses correctly recognized positive pressure NCs, 34% chose the correct clamping sequence.
- Nurses reported their behaviour is most influenced by local senior nurses.

Introduction

The introduction of needleless connectors (NCs) was undertaken specifically to remove needles from clinical practice, so as to reduce healthcare worker needlestick injuries [1]. This was successful, with NCs now the access mechanism for administration of fluids and medications for nearly all intravascular devices [2]. Unfortunately, there were many reports of increases in patient blood stream infections (BSI) associated with the introduction of NCs [3—7]. It is likely that device characteristics [8], as well as healthcare worker non-adherence to manufacturer instructions and infection control practices contribute to BSIs and poor patient outcomes [9]. It is likely that these factors also contribute to the significant amount of device failure.

There are a large number of NC manufacturers and several device types. The NC external surfaces vary greatly, as do their internal mechanisms. Jarvis suggests that, in general, a simple design is better [10]. Smooth surfaces, tight seals, minimal dead space and direct fluid pathways are preferred [10]. NCs can have positive, negative, or neutral fluid displacement when syringes or administration sets are disconnected and it is important to know this to correctly sequence the disconnection process [11,12]. Negative pressure NCs require the clinician to clamp the intravenous (IV) catheter and then disconnect from the NC, whereas positive pressure NCs require disconnection, then clamping. If this is not done correctly, blood can reflux into the connector increasing the chance of device occlusion and BSI.

The infection control practices of hand hygiene prior to NC access, disinfection of the NC, and allowing the NC to dry prior to access are all clearly articulated in international guidelines [13—15]. Despite the clear guidelines healthcare worker adherence is often suboptimal.

Lynn Hadaway's 2011, largely US study, on healthcare workers' practice in relation to the care of NCs, identified a significant gap in nurses' knowledge [11]. The most significant findings were lack of recognition and knowledge of: the specific type of device, NC cleaning and drying, and clamping and disconnection sequencing. The lack of recognition of device types and confusion about sequencing of clamping and disconnection was also found in the self-report survey undertaken by Harrold in 2019, with 29% of respondents unaware of the NC used in their facility [16]. This study surveyed health professionals from the British Journal of Nursing database and had a response rate of 20%. To our knowledge there is no published Australian evidence on nurses' knowledge and practice in relation to NC care.

Smith et al. undertook important work in the US in relation to nurses' practices and behavioural influences related to care of NCs [17], developing an instrument called the Smith-Becker Attitudes Toward Disinfection Techniques Scale based on Fishbein and Ajzen's Theories of Reasoned Action and Planned Behaviours. This research identified that nurse peers were the group most likely to influence nurses' behaviour. The personal belief that decontamination of NC prevents BSI was also found to play an important role in nurses' decision to clean NCs.

Research aim and question

The aim of this research was to assess nurses' practice, knowledge, attitudes, and key influencers on, appropriate care of needleless connectors. The research question was 'what are nurses' knowledge and practice in relation to care of NCs in an Australian hospital and how does this compare to the 2011 Hadaway study?

Methods

Study design

This cross-sectional survey used with a web-based electronic tool was developed based largely on the work of Hadaway [11] and Smith et al. [17] There were 9 socio-demographic questions, 30 questions about clinical practice, and 25 questions relating to autonomy, self-efficacy, and behavioural intention using a 5 or 7 point Likert-type

scale (extremely likely to, to extremely unlikely to, a great concern to me or not a concern to me). Images of the NCs currently used in the hospital were provided. SurveyMonkey® was used to collect the data. Five nurses, with 15–20 years of clinical experience were given the survey prior to distribution to ensure readability and content validity with some minor changes undertaken from this feedback.

Setting

The study site is a Magnet® accredited, adult major tertiary teaching hospital with approximately 800 beds. The hospital has an Infection Control Team with 3 full time equivalent (FTE) Clinical Nurse Consultants, and 4 FTE Clinical Nurses which meet the suggested international staffing profile [18]. There is also a Vascular Access and Surveillance Team (VAST) with 1 FTE Clinical Nurse Consultant and 2 FTE Clinical Nurses. Regular multi-disciplinary education and training for peripheral intravenous catheter (PIVC) insertion and care are conducted, and BSIs are reported and followed up regularly.

Recruitment

We used a total population sample approach (probability sampling) whereby all nurses working in clinical roles were sent the survey. Clinical Nursing Directors distributed an email invitation to Nurse Unit Managers to forward a survey link to their clinical nursing staff, asking them to participate in the online survey. It is estimated that 1500 direct care nurses received the survey link. The exact denominator is unknown as some staff would have been on leave, and it relied on the Nurse Unit Manager sending the email link, therefore 1500 is an approximation. Additionally, the Clinical Nursing Directors encouraged participation in divisional meetings. No financial or other incentives were offered to complete the survey.

Data collection

The online survey was voluntary and anonymous, as IP addresses were not collected.

It was compiled in 2018. The survey was open for 6 weeks, with a reminder being sent at week 3. Nurses were the professional group surveyed as they provide the majority of maintenance care of NCs in the clinical environment. There was no check mechanism for multiple entries.

Data analysis

Results were collated by the SurveyMonkey® program. Categorical variables were described using frequencies and percentages. Continuous variables were described either using mean and standard deviation, when a variable was normally distributed, or median and inter-quartile range when normality was not met. Normality was assessed using the Shapiro–Wilk test. Box plots were used to visualise the distribution for demographic characteristics associated with those that always clean NCs (Fig. 1). Two Kendall's Tau correlations were used to screen and exclude variables that had a correlation of less than 0.3 with the two outcome categorical variables. For categorical variables, a Pearson's Chi-square or Fisher's exact test was performed. The analyses were performed using the R software (R version 4.0.2) [19].

Results

All or part of the survey was completed by 19% of staff (n = 283).

Demographics

Of the respondents, 96% were Registered Nurses, with 65% (n = 185) employed within the medical and surgical wards (Table 1). A bachelor's degree or higher qualification was held by 96% (n = 272) of respondents with 3% (n = 8) of respondents' hospital trained. Half (50%, n = 141) of respondents worked full time, 47% (n = 134) part time, and 2% (n = 7) casual, one staff member did not answer. Staff were asked if they believe that they have adequate access to in-service training programs, with 83% (n = 234) answering yes, and 17% (n = 49) answering 'no'.

Nursing practices – NC cleaning and drying

Eighty nine percent (n = 212) of nurses responded that they always clean NCs prior to each use, 6% (n = 15) usually, 2% (n = 4) at times and 3% (n = 7) responding they rarely or never clean the NC. Several demographic characteristics were statistically associated with always cleaning the NC: the area or division in which nurses worked ($p = 0.0003$), the primary shift worked ($p = 0.0012$) and employment type ($p = 0.0139$) (Fig. 1). The cleaning technique most frequently stated was to wrap the antiseptic wipe around the NC and work in a circular motion multiple times (76%, n = 176/233). While 30% (n = 69/231) of nurses reported that they adhere to the current hospital procedure [20] and international recommendations of decontaminating the NC for 15 s or longer [13-15] 23% (n = 53/231) stated that they never timed the procedure.

In terms of allowing NC to dry after decontamination 21% (n = 48) of respondents said they never time it, 42% (n = 96) stating they allow the NC to dry for 3–5 s, 17% (n = 40) allowing 6–10 s to dry, 13% (n = 30) allowing 15 s for drying, 4% (n = 9) at least 30 s, 3% (n = 6) answered in free text mostly stating until it is looks dry.

Types of connectors – knowledge and practice

When asked about the characteristics of devices, 25% (n = 59) correctly identified the negative displacement device, 16% (n = 28) believed it was positive pressure, 26% (n = 63) thought it was neutral, and 33% (n = 79) were unsure. The majority (79%, n = 70) of nurses correctly indicated that they clamp the line and then disconnect the syringe for negative pressure devices. Positive fluid displacement devices were correctly identified by 44% (n = 105) of respondents, with 34% (n = 82) of staff unsure, 15% (n = 37) believed it was negative pressure, and 6% (n = 15) believed it was a neutral displacement device.

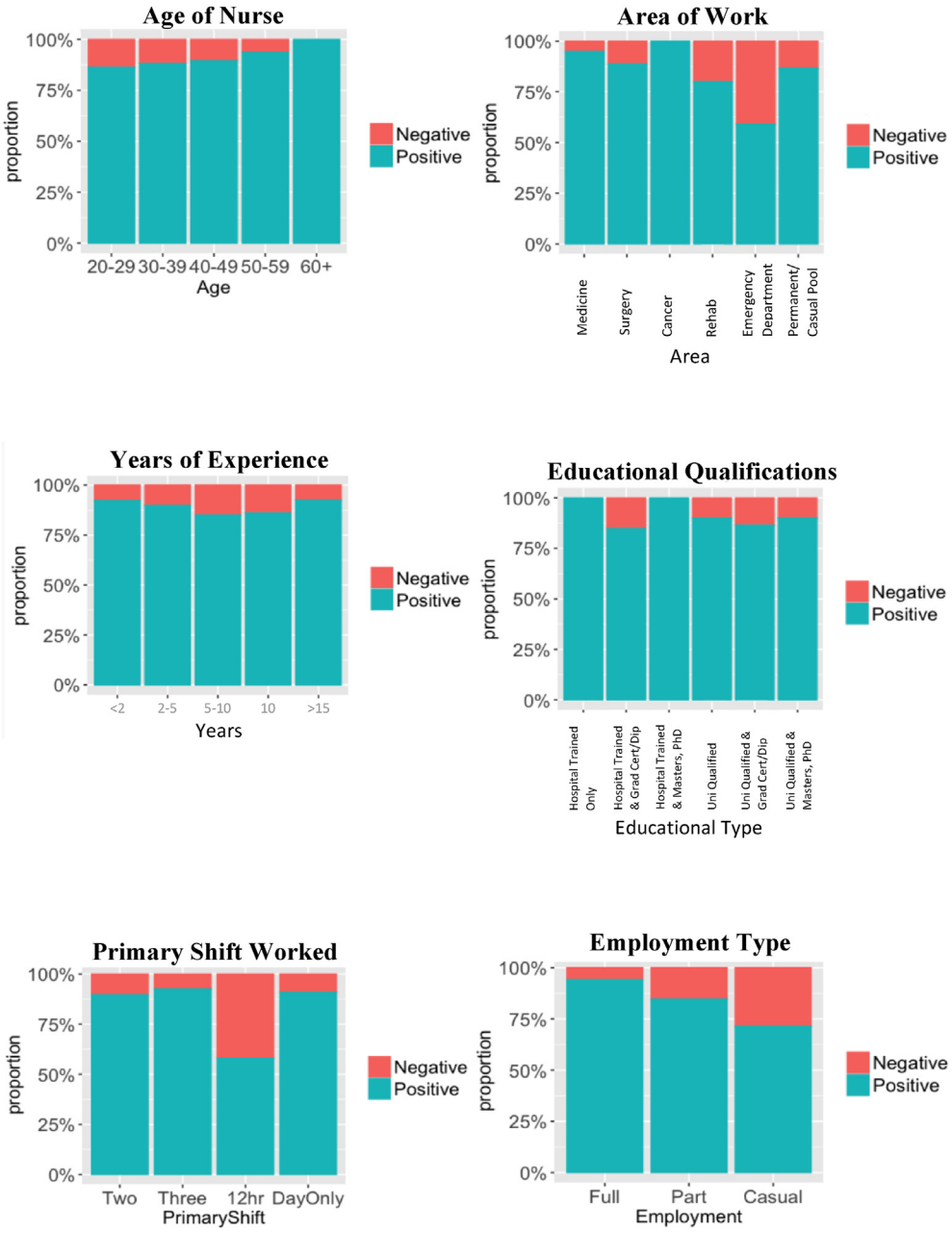

Figure 1 Categorical variables by cleaning NCs prior to access.

Thirty-four percent of staff (n = 30) identified the correct clamping and disconnecting of the syringe for positive displacement devices.

The most common answer for changing peripheral intravenous catheter (PIVC) NCs was when a new PIVC was inserted (55%, n = 106/193), followed by 33% (n = 63) every 72 h, 30% (n = 58) when the NC is visibly dirty, 11% (n = 22) after giving or taking blood, 11% (n = 21) every 96 h, 4% (n = 8) every 48 h, 1% (n = 2) every 24 h, and 1% (n = 2) every 7 days. NCs attached to Central Venous Access Devices (CVADs) were mostly changed every 7 days (52%, n = 97), after giving or taking blood or administering lipids (20%, n = 37), or when visibly dirty (31%, n = 59), multiple answers were possible.

The most frequent system to flush IV catheters was single dose ampoules (85%, n = 175), by prefilled syringes (43%, n = 88) or a bag of IV solution (50%, n = 103). Multiple answers were possible. Ninety eight percent (n = 201) of staff used the syringe either immediately or within 1 h of preparation with 26% (n = 54) stating that they always label the syringe.

Eighty four percent (n = 201/238) of staff stated that they believe that cleaning the NC prevents BSIs, with 2% (n = 5) believing that it does not reduce BSIs, the remaining 13% (n = 32) being uncertain. Alcohol (IPA) was the most common disinfectant used on NCs with 88% (n = 210/240) of staff using IPA, 12% (n = 29) of staff stated their practice was to use chlorhexidine (CHG) in

Table 1 Participant demographic data (n = 283).

	Number	Percentage
Age		
20-29	88	31
30-39	90	32
40-49	56	20
50-59	38	13
≥60 years	11	4
Employment Type		
Enrolled Nurse	12	4
Registered Nurse	180	64
Clinical Nurse	60	21
Clinical Nurse Consultant	12	4
Nurse Unit Manager, Nurse Educator	11	4
Other	8	3
Area of Employment		
Division of Medicine	108	38
Division of Surgery	77	27
Division of Cancer	24	9
Division of Rehabilitation	9	3
Emergency Department	24	9
Permanent Nurse Pool	39	14
Not stated	2	1
Gender		
Female	246	87
Male	35	12
Not Stated	2	1
Year of Practice		
<2 years	38	13
2–5 years	57	20
>5–10 years	61	22
>10–15 years	48	17
>15 years	78	28
Years at Princess Alexandra Hospital		
<2 years	61	22
2–5 years	70	25
>5–10 years	66	23
>10–15 years	42	15
>15 years	43	15
Education Background		
Hospital Trained (no further study)	8	3
Hospital Trained with Bachelor degree, Graduate Certificate, Graduate Diploma	42	15
Hospital Trained with Masters Degree or PhD	7	3
University qualified	142	50
University qualified with Graduate Certificate, Graduate Diploma	59	21
University qualified with Masters Degree or PhD	22	8
Not stated	3	1
Primary Shift Worked		
Two shift worker	31	11
Three shift worker	167	59
12 h day/night	21	7
Day only	63	22
Not Stated	1	0
Employment Status		
Full time	141	50
Part time	134	47
Casual/contract	7	3
Not Stated	1	0

(*continued on next page*)

IPA and 1 staff member reported using both disinfectants (0.4%).

Nursing practices — PIVC versus CVAD decontamination

The majority (58%, n = 139/240) of staff said they used the same practice for disinfecting NC attached to PIVCs and CVADs. The remaining 42% (n = 101) said they did not treat the NCs in the same manner. Of those that stated they treat PIVCs and CVADs differently 61 (61%) stated they use 3 or 4 swabs to clean the CVAD NC, but only one for the PIVC NC. Staff also stated they scrub the hub longer or more thoroughly for CVADs than for PIVCs, use IPA and CHG instead of IPA alone, or use a sterile technique.

Nurses' practices — intermittent infusions

The vast majority of staff (76%, n = 146) discarded IV lines if they needed to be disconnected and re-attached a new line. This is in line with hospital procedure.

Nurses' knowledge — procedures

Nurses' knowledge of the existence of hospital procedures in relation to care of NCs was mixed. Only 59% of staff realised that there was an NC cleaning technique and 38% were aware of the procedure in relation to NC clamping technique. Nurses' knowledge of a policy detailing frequency to change NCs was 51%.

Behavioural intention

Behavioural intention questions were asked using a 5 or 7-point Likert-type scale. Ninety seven percent (n = 192) chose the values one and two (A great concern for me '1' and not a concern for me '7' Likert scale) in relation to preventing the introduction of bacteria into patients' blood stream. Decreasing the risk of an infection in the patient was also of great concern to 91% (n = 180, '1' on the Likert scale) of respondents. The vast majority of respondents 85% (n = 164) indicated they were extremely likely to disinfect the NC every time it was accessed. There was a significant association between those that stated they always clean the NC prior to access and those that indicated they were extremely likely to disinfect the NC every time they access the NC ($p = <0.0001$).

Practice influencers

Those surveyed believed that their Clinical Nurse Consultant (CNC), Nurse Educator, Nurse Unit Manager (NUM) and Infection Control CNC had very high expectations about NC disinfection, with 88% (n = 171) believing that they should definitely disinfect the NC each time before access, and 90% (n = 173) believing the VAST expect that the NC should be disinfected each time before access. Seventy four percent (n = 142) of respondents stated that it was very important to them to do what the VAST expected of them. The belief that NC disinfection was important to medical staff was much less, with 63% (n = 120) of respondents believing that medical staff believe that NCs should definitely be disinfected before each access, with only 41% (n = 78) of respondents saying what medical staff believed was important to them.

Discussion

This study provides comprehensive data on nurses' knowledge, practice, behavioural intentions, and key influencers to practice at an Australian hospital. This Australian study had some findings such as the correct clamping sequence, that are superior results compared to the other comprehensive studies on this topic (both in the USA in 2011) [11,17], other areas such as NC decontamination time compliance are similarly disappointing. Thus, comparison of international and Australian nursing data over the decade indicates consistency of many challenges in achieving best infection prevention nursing practices.

The correct clamping and disconnecting procedures were 79% for negative pressure NCs in this study, and 14.8% in the 2011 Hadaway study [11]. It is interesting to note that although nurses stated that they use the correct clamping sequence, only 25% recognised the PIVC NC as being a negative pressure device. A British survey by Harrold similarly found a lack of recognition of device types (29% of respondents unaware of the type of NC used in their facility) [16]. For positive pressure NCs on CVAD devices, the clamping and disconnecting process was correctly identified by 34% of respondent in this study, it was 20% in the Hadaway study [11]. Nurses' knowledge of written procedures was suboptimal in this study and the Hadaway study, with the lowest results for NC clamping technique [11]. The results suggest a significant knowledge gap existed despite the long-term use of the same products in the site facility including clear policies and procedures.

Slightly less nurses in this study stated that they always clean NCs prior to use (89%), compared to the USA in 2011 (94.3%) [11]. Drying time for NC was not timed by 39.3% of nurses in 2011, as compared to 21% in this study, 3–5 s drying time was the most common response in both studies. Results for NC cleaning time were surprisingly similar, with 27.5% of nurses in 2011 cleaning the NC for 15 s, and 26.4% in this study [11]. The number of staff not timing NC cleaning was also similar, 21.2% [11] compared to 22.9%. A significant opportunity for improvement in both cleaning and allowing NC to dry exists.

Moureau and Flynn suggest NC manufacturers should provide device instructions for use [2]. This should include how the NC should be decontaminated, disinfectant to be used, and drying time. The manufacturer of the NCs used in the facility surveyed provides written directions that the negative pressure NC should be swabbed with 70% isopropyl alcohol (1–2) seconds and allowed to dry (approximately 30 s) [21]. These directions are inconsistent with international guidelines and the hospital procedure of a scrub time of 15 s [13–15,20].

Results of this and the Smith et al. study showed many similarities [17]. Respondents indicated that introducing bacteria in the patients' bloodstream was of 'great concern' to 98% in 2011, and 97% in this study chose '1' or '2' on a 7-point Likert scale, (where '1' signified the greatest concern, and '7' no concern.). The intention of nurses to disinfect the NC was also very similar 78% in 2011 and 85% in this study. Nurses were most influenced by other nurses: this was consistent with the previous study.

Manufacturers should provide regular evidence-based education about correct product use. In our facility, such education was provided on initial product implementation and intermittently since that time. Nursing staff require additional education which is provided in our organisation by experienced, well regarded clinicians such as Infection Control and Vascular Access and Surveillance nurses; this study identified that these staff are the most likely to influence practice. The use of clinical champion or link nurse models to improve clinical practice have proved effective in several settings and may be effective in improving NC care [22,23]. The personal belief that preventing the introduction of bacteria into patients' bloodstream and decreasing the risk of an infection to patients is of great concern to the vast majority of nurses and should therefore be included as reasons to adhere to best practice guidelines.

Limitations of this study include the low response rate of 19%, which may be attributable to direct care nurses being on leave or not accessing work emails. Electronic surveys of nurses usually have a lower response rate than paper surveys [24]. Further, this survey provided no incentive which may have contributed to a reduced response rate [24]. As we did not have a definite denominator, the estimated response rate is likely imprecise. The study was conducted at one Australian hospital and may not reflect other institutions. As there have been limited comprehensive studies reported in the literature we are unable to definitively conclude whether the phenomena studied have improved or worsened over time. Much of the implications of the findings are discussed in relation to work undertaken in the USA, however Hadaway's and Smith's cohort of nurse respondents were largely vascular access 'experts', whereas ours were predominantly bedside clinical nurses. The strength of the study is that it was grounded in prior literature, and clearly identified areas where practice can be enhanced to improve patient outcomes.

Conclusion

Despite the use of NCs for several decades there is still a significant lack of knowledge about NC device types and their care, especially the sequencing of syringe disconnection and line clamping. These results were only slightly

better than those obtained by Hadaway in 2011, suggesting little has changed. Ongoing patient safety issues of device infection and failure highlight the need for more research internationally to identify deficits in clinician knowledge and behaviour.

Regular education congruent with guidelines should be provided by device manufacturers and by local experienced Infection Control and Vascular Access and Surveillance nurses who are the most influential in altering clinician behaviour. Behavioural change theories need to inform educational strategies such as clinical champions or link nurse models. Research is urgently needed into effective models that improve nurses' knowledge and behaviour to achieve evidence-based care of NCs.

Ethics

Ethical approval for this study was obtained from the Princess Alexandra Hospital and Griffith University (HREC/17/QPAH/675, GU Ref No:2017/869).

Authorship statement

Karen Slater — study conception, study design, data collection, interpretation of findings, writing, editing, submission. Marie Cooke — study design, supervision, reviewing and editing, Michael Whitby — supervision, reviewing and editing, Claire M Rickard — study design, supervision, reviewing and editing. All authors provided critical input into the paper, with all authors approving the manuscript.

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Conflict of interest

Dr Cooke reports grants to her employer, Griffith University, on her behalf from Becton, Dickinson and Company. Dr Rickard reports research grants and consultancy payments to her employer, Griffith University, on her behalf from 3M, Cardinal Health, and BD-Bard. Dr Whitby and Karen Slater have no conflicts to declare. No company played any role in the design, analysis, interpretation or presentation of this paper.

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