

Original Article

Vascular access and infection prevention and control: a national survey of routine practices in Irish haemodialysis units

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Abstract

Background. National and international guidelines recommend the use of effective vascular access (VA) and infection prevention and control practices within the haemodialysis environment. Establishing an arterio-venous fistula (AVF) and preventing central venous catheter (CVC)-related infections are ongoing challenges for all dialysis settings. We surveyed VA and routine infection prevention and control practices in dialysis units, to provide national data on these practices in Ireland.

Methods. A descriptive survey was emailed to nurse managers at all adult ($n = 19$) and children ($n = 1$) outpatient haemodialysis units in the Republic of Ireland. Data collected included AVF formation, CVC insertion and maintenance practices, VA use and surveillance of infection and screening protocols. Nineteen of the 20 units responded to the survey.

Results. The AVF prevalence was 49% for 1370 patients in 17 units who provided these data [mean prevalence per unit: 45.7% (SD 16.2)]; the CVC mean prevalence per unit was 52.5% (SD 16.0). Fourteen dialysis units experienced inadequate access to vascular surgical procedures either due to a lack of dedicated theatre time or hospital beds. Six units administered intravenous prophylactic antimicrobials prior to CVC insertion with only two units using a CVC insertion checklist at the time of catheter insertion.

Conclusion. In general, dialysis units in Ireland show a strong adherence to national guidelines. Compared with the 12 countries participating in the Dialysis Outcomes Practice Patterns Study (DOPPS 4), in 2010, AVF prevalence in Irish dialysis units is the second lowest. Recommendations include establishing an AVF national prevalence target rate, discontinuing the administration of intravenous prophylactic antimicrobials prior to CVC insertion and promoting the use of CVC insertion checklists.

Keywords: haemodialysis; infection prevention and control; practice guidelines; survey; vascular access

Introduction

The population of patients with end-stage kidney disease (ESKD) in Ireland is growing with a predicted annual increase of 30–40 patients per million of population (pmp) [1]. In 2011, 80% ($n = 330$) of new ESKD patients in Ireland selected haemodialysis as their treatment modality; during that same year, 1557 patients received haemodialysis (340 pmp) [1].

An essential component of haemodialysis is the establishment of the vascular access (VA) that will enable patients to undergo dialysis treatment. It is acknowledged globally that an arterio-venous fistula (AVF) is the gold standard in VA [2, 3]. There is no National Renal Registry in Ireland; therefore, it is not feasible to compare

prevalence of AVFs with other European countries. The proportion of prevalent haemodialysis patients using an AVF in European countries participating in the Dialysis Outcomes Practice Pattern Study (DOPPS) has decreased between DOPPS 1 (1996–2001) and DOPPS 4 (2010), e.g. during this period AVF prevalence in Italy decreased from 90 to 74% [4, 5]. The DOPPS project, which commenced in 1996, is an international longitudinal observational study of haemodialysis practices. DOPPS 4 collected data from a representative and random sample of 313 units in 12 countries (Australia, Belgium, Canada, France, Germany, Japan, Italy, New Zealand, Spain, Sweden, UK and USA).

Haemodialysis patients and, in particular, patients with central venous catheters (CVCs), are at increased risk of

healthcare-associated infections (HCAIs) [1]. When compared with patients with an AVF, patients with a CVC have greater episodes of VA-related bacteraemia. This is evident in reported episodes, which range from 0.14 to 0.44 episodes per 1000 catheter days and 1.6 to 8.18 per 1000 catheter days for AVF and tunnelled CVCs, respectively [6–11]. These infections have a profound impact on the patient's health, and can lead to serious illness, longer stays in hospital, long-term disability, and death [12]. Recognizing the impact of HCAI on a patient's well-being, national guidelines on the prevention of intravascular catheter-related infection were published in 2009 [13], which include specific recommendations for haemodialysis patients. To minimize HCAI, it is essential that infection prevention and control within the haemodialysis environment take an evidence-based approach [12].

This first ever national survey of routine practice in Irish dialysis units seeks to identify routine care within the haemodialysis environment, with a particular focus on VA and infection prevention and control. It also allows an exploration of the relationship between the current practice and national guidelines.

Materials and methods

Population

One childrens' and all 19 adult outpatient haemodialysis units in the Republic of Ireland were surveyed (12 parent hospital, three satellite and five contracted units).

Survey design

The survey focussed on a number of areas of routine practices in haemodialysis including AVF formation, infection prevention and control, CVC insertion and maintenance and VA use. Survey questions were relevant to recommendations made in national guidelines on the prevention of intravascular catheter-related infection [13].

Experts in survey design and quantitative research, and healthcare professionals with clinical expertise in infection prevention and control, and haemodialysis reviewed the survey to ensure that it captured the sought data appropriately. Two of these experts are co-authors (M.C. and F.F.). Amendments to the survey improved clarity while additional questions on surveillance of infections ensured the collection of more in-depth data on infection prevention and control. The finalized questionnaire consisted of 38 questions.

Survey implementation

In November 2011, the National Renal Office emailed surveys to nurse managers in the 20 dialysis units. Completed surveys were returned to the researcher (MMcC) by post. The Faculty of Health Science, Trinity College Dublin research ethics committee granted ethical approval.

Statistical analysis

Data were analysed using SPSS (Statistical Package for Social Sciences) version 20. Descriptive statistics were used to summarize data, with means and standard deviations (SDs) for continuous variables and frequencies and percentages for categorical data. Fisher's exact test (two-

sided) was used to compare associations between the size of dialysis units and the implementation of guideline recommendations.

Results

By March 2012, 19 completed surveys (18 adult and one paediatric) were returned from 12 parent hospital, two satellite and five contracted units, giving a response rate of 95%. The number of patients attending these units varied (Table 1), ranging from 11 to 185 patients; the mean number of patients per unit was 80 (SD 43.7).

In general, survey responses indicated adherence to national guidelines, the main areas of non-compliance being administration of intravenous prophylactic antimicrobials prior to CVC insertion and non-use of CVC insertion checklists and maintenance care bundles (Table 2).

Prevalence of vascular access

Eighteen units provided data on the number of patients attending their units for dialysis (total of 1450 patients), and 17 provided complete data in relation to VA use. VA prevalence was, therefore, based on the number of patients attending 17 units ($n=1370$) (Table 3). Nine dialysis units had no patients with an arterio-venous graft (AVG); one unit used CVCs for all its 11 patients. Seven dialysis units had a CVC prevalence of >50% (five parent and two contracted units).

Timeline to formation of primary AVF

Only three parent hospital units routinely created a primary AVF, when the eGFR was between 17 and 12 mLs/h; each unit had >60 patients. The AVF prevalence for these units was 42, 49 and 56%.

Seven units did not routinely create early AVFs, while seven other units had alternative routine practices; for two units pre-emptive creation of AVFs was dependent on the available resources such as vascular surgical support, theatre slots and hospital beds. Five units referred patients to a vascular surgeon from pre-dialysis clinics; but, these patients may not have a primary AVF created prior to starting haemodialysis.

Access to vascular surgeon for creation of AVF

Dialysis units used the services of vascular surgeons based at their own hospital or at a variety of other hospitals (Table 4). Only four dialysis units (three parent hospital and one contracted) had access to dedicated theatre

Table 1. Types of haemodialysis units and number of patients attending

Total number of patients	Parent hospital unit, <i>n</i>	Satellite unit, <i>n</i>	Contracted unit, <i>n</i>	Total, <i>n</i>
≤30	1	0	0	1
31–60	0	2	2	4
61–90	8	0	0	8
91–120	1	0	1	2
>120	2	0	1	3
Total	12	2	4	18 ^a

^aEighteen dialysis units provided complete data on the number of patients attending their units.

Table 2. Adherence to national recommendations for the prevention of intravascular catheter-related infection in 19 Irish dialysis units^a

National Guideline Recommendation	Number of dialysis units that meet the recommendation, n (%)
Vascular access	
Create AVF when eGFR 17–12 mL/h	3 (16%)
Access to dedicated vascular surgical theatre time	3 (16%)
Maintain records of VA use	17 (89%)
Infection prevention and control	
Undertake three monthly MRSA screening	17 (89%)
Review bacteraemia rates regularly, for patients with or without CVCs	16 (84%)
Undertake root cause analysis for each episode of HCA CRBSI ^f	9 (47%)
Obtain two sets of blood cultures in suspected cases of HCA CRBSI prior to administration of antibiotics	13 (68%)
Put in place a surveillance programmes for HCA CRBSI	12 (63%)
CVC insertion	
Use interventional radiology department or operating theatre for insertion of CVC	18 (95%)
Use CVC check list at the time of CVC insertion	2 (11%)
Do not administrate intravenous prophylactic antimicrobials prior to CVC insertion	7 (37%)
Use impregnated permanent cuffed CVCs in patient population at high risk of CRBSI	3 (16%)
CVC care and maintenance	
Use antimicrobial locks on patients with long-term CVC, e.g. haemodialysis patients	13 (68%)
Have policies, protocols, guidelines for CVC care and maintenance	19 (100%)
Use CVC care bundles	8 (42%)
Use 2% chlorhexidine gluconate in 70% isopropyl alcohol antiseptic solution to clean the CVC exit site and catheter hubs	14 (74%)
Do not use a topical antimicrobial ointment on the CVC exit site	19 (100%)
Use a transparent semi-permeable polyurethane dressings to cover the CVC exit site	11 (58%)

^aAVF, arterio-venous fistula; eGFR, estimated glomerular filtration rate; VA, vascular access; MRSA, methicillin-resistant *S. aureus*; CVCs, central venous catheters; HCA CRBSI, healthcare-associated catheter-related bloodstream infection.

Table 3. Prevalence of vascular access in 17 outpatient dialysis units^a

	AVF	AVG	CVC	Total
Number	668	18	683	1370
Prevalence (%)	49	1	50	100
Mean (SD)	46% (16.2)	1% (1.3)	53% (16)	–
Range (%)	20–65	1–4	35–100	–

^aArterio-venous fistula; AVG, arterio-venous graft; CVC, central venous catheter.

time for the creation of AVFs; of these, three stated the number of dedicated theatre sessions, which ranged from 1 to 2 h or 1 hour every other week.

Infection prevention and control

Seventeen dialysis units (90%) did 3 monthly methicillin-resistant *Staphylococcus aureus* (MRSA) screening of patients. A majority of units ($n=16$) reviewed bacteraemia rates on a regular basis including: monthly ($n=10$);

Table 4. Location of responsible surgeons for creation of AVF^a

Location of responsible surgeons for creation of AVF	Parent hospital unit, n (%)	Haemodialysis unit surveyed		
		Satellite unit, n (%)	Contracted unit, n (%)	Total, n (%)
In this hospital only	8 (67)	0	0	8 (42)
In other hospitals	4 (33)	2 (100)	5 (100)	11 (58)
Total	12	2	5	19

^aAVF, arterio-venous fistula.

3 monthly ($n=2$) and at other intervals ($n=4$). Two parent hospital units with >60 patients and one satellite unit (<45 patients) never reviewed their bacteraemia rates. Of those units that reviewed bacteraemia rates, 15 reviewed all types of bacteraemias; the remaining unit confined its review to bacteraemias caused by a specific organism.

Half the units ($n=9$) did root cause analysis for each episode of bacteraemia (four parent hospital and five contracted units), with over 50% of these units having ≥ 60 patients. Two parent hospital units informally reviewed each episode of bacteraemia, while five parent hospital (60–90 patients) and two satellite units (<45 patients) never undertook root cause analysis.

The majority of dialysis units ($n=12$; 63%) had a surveillance programme, which monitored the incidence of infection associated with CVC (seven parent hospital and five contracted units). Three of these units (parent hospital) had <60 patients. A majority of the units ($n=5$) that did not have a surveillance programme (five parent hospitals and two satellite units) had >60 patients attending their units. The units that had surveillance programmes used either the Centres for Disease Control and Prevention (CDC) dialysis events protocol ($n=2$), *S. aureus* bacteraemia surveillance ($n=2$), a combination of both ($n=1$) or other tools ($n=6$). There was no significant association between the size of dialysis units and having a surveillance programme in place ($P=0.29$) and undertaking bacteraemia reviews ($P=0.93$) and root cause analysis ($P=0.17$).

CVC insertion

While two parent hospital units used CVC checklists at the time of CVC insertion, three did not. A majority of units ($n=14$) did not know whether a CVC insertion checklist was used (seven parent hospital, two satellite and five contracted units).

In total, seven units did not routinely administer intravenous prophylactic antimicrobials prior to CVC insertion; in contrast, six parent hospital units routinely administered these agents. Furthermore, six units (one parent hospital, four contracted and one satellite) did not know whether such agents were used.

CVC care and maintenance

Antimicrobial/antiseptic impregnated cuffed catheters were used in a minority of units (two parent hospital and one contracted). A majority of units ($n=13$) used trisodium citrate as an antimicrobial locking agent (nine parent hospital, two satellite and two contracted units); two of these units also used urokinase. Six units (three parent hospital and three contracted) used heparin to lock the CVC.

All 19 units had written CVC care and maintenance guidelines; however, over half of the dialysis units ($n=11$) did not use care bundles in CVC maintenance. Those units that used CVC care bundles were either parent hospital ($n=4$) or contracted ($n=4$) with a majority ($n=5$) having >60 patients.

Three quarters of dialysis units ($n=14$) used 2% chlorhexidine gluconate in 70% isopropyl alcohol antiseptic solution to decontaminate catheter hubs before CVC connection and disconnection from dialysis. The remaining units used either 0.5% chlorhexidine gluconate in 70% isopropyl alcohol ($n=3$), 2% aqueous chlorhexidine gluconate ($n=1$) or 0.05% aqueous chlorhexidine gluconate ($n=1$). Similarly, 13 units used 2% chlorhexidine gluconate in 70% isopropyl alcohol to clean the CVC exit site. The other six units used alternative strengths and formulation of chlorhexidine gluconate.

Discussion

National and international guidelines recognize that an AVF is the gold standard for permanent VA [2, 3, 13]. This survey found that AVF prevalence in Irish dialysis units is 49%. When compared with the 12 countries participating in DOPPS 4 (2010), the AVF prevalence in Irish dialysis units is the second lowest, and is lower than the seven participating European countries [5]. None of the Irish dialysis units that completed the survey met the NKF-K/DOQI or UK guideline recommending an AVF prevalence >65 and 85%, respectively [2, 3].

CVCs are considered the last resort for patients due to increased mortality and morbidity risks [3, 14–19]. The Irish CVC prevalence of 50% among the 1370 patients in 17 units who provided the necessary data would make Ireland the second highest users of CVCs when compared with those countries participating in DOPPS 4 (2010), and is much higher than the 10% maximum recommended by NKF-K/DOQI [2]. The National Renal Office found in its annual ESKD Census on 31 November 2012 that 16% of the 1557 patients on dialysis in Ireland who were suitable for, and willing to consent to, AVF creation had not yet had the procedure [1]. In this census survey, 27% of patients without an AVF were adjudged not to be suitable for this on technical grounds, or declined to consent to the procedure. A further 7%, although dialysing via a CVC, had had an AVF created, which had not yet matured to a sufficient degree to be used. As with this study, there was considerable variation between units.

There is general consensus that patients should have, where possible, a functional AVF at the initiation of haemodialysis. Many guidelines recommend creating an AVF during stage 4 CKD (eGFR 15–29 mL/h) [3, 18, 20]. Irish guidelines [13] recommend that patients should have an AVF created when the eGFR is between 17 and 12 mL/h (between stage 4 and 5 CKD). This survey shows that only three units achieve this recommendation. AVF creation was dependent on the available resources such as vascular surgery support, hospital beds and dedicated theatre time, the latter having been identified as a potential barrier to AVF creation [21]. Five units acknowledge that many patients, although referred to the vascular surgeon from pre-dialysis clinics, will not have a primary AVF created prior to starting dialysis. This would support the DOPPS assertion that pre-emptive AVF creation is not being achieved throughout Europe, with a higher

proportion of patients commencing haemodialysis using a permanent cuffed CVC [22].

Inadequate access to vascular surgeons is considered a leading cause for the high use of CVCs [4]. Irish guidelines [13] recommend that all dialysis units should have 'adequate access' to VA procedures; but the definition of 'adequate access' is unclear. Although all dialysis units in our study have access to a vascular surgeon, this access does not meet the needs of those patients in need of AVF creation. This may be due to a number of factors including the current economic difficulties in Ireland, which has resulted in a reduction in healthcare expenditure, leading, in some centres, to a decrease in elective surgical procedures and an increase in waiting lists for outpatient appointments. Another explanation could be that many dialysis units lack a formalized referral programme for AVF formation, given that patients attending seven units in our study did not have the opportunity of pre-emptive AVF creation. Indeed, a lack of policy on referral of patients for AVF creation has been identified as a barrier to access creation [21]. An additional possibility could be that vascular surgeons do not perceive the creation of AVFs to be important, which may account for the lack of dedicated vascular surgical theatre time for AVF formation. Involving vascular surgeons who have a willingness and ability to provide access services is one of the eleven change concepts, put forward by the Fistula First Breakthrough Initiative for increasing AVFs in the USA [23].

It is difficult to identify barriers to pre-emptive creation and use of AVFs within an Irish dialysis setting without information on the following timelines: patients' referral to a nephrologist; their referral to a vascular surgeon and evaluation by the vascular team; admission for AVF creation and the time from AVF creation to cannulation. Using a mixed methods approach in the collection of this data would highlight any differences between perceived timelines and actual timelines. Lopez-Vargas *et al.* note that physicians perceived prolonged waiting times for surgical appointments and VA placement as barriers to AVF formation; yet actual waiting times suggest differently [21]. Overall, there would appear to be inadequate access to VA procedures in Ireland; a major risk for dialysis patients, increasing mortality and morbidity in patients who continue to depend on a CVC while awaiting the creation of an AVF [1, 23].

An important aspect in infection prevention and control in the dialysis setting is the ongoing vigilance in relation to MRSA. The relative risk of MRSA bacteraemia is 100-fold higher in dialysis patients than in the general patient population [24]. Furthermore, 68.9% of MRSA bacteraemias, in the dialysis patient population, occur in haemodialysis patients with CVCs [25]. Dialysis patients are at increased risk of MRSA infection and possible colonization; reducing the number of patients colonized with MRSA will have a positive impact on bloodstream infection rates [26]. Unlike other guidelines [27, 28], which restrict MRSA screening to high-risk patient populations, Irish guidelines [13, 26] recommend three monthly MRSA screening of dialysis patients; our survey found high adherence to this recommendation ($n=17$).

Few renal guidelines make recommendations on surveillance, review of bacteraemia rates and root cause analysis. Renal guidelines suggest auditing *S. aureus* bacteraemias and recording all details regarding catheter-related bloodstream infection (CRBSI), irrespective of the causative organisms, and undertaking root cause analysis in an outbreak of CRBSI [3, 29]. Irish guidelines

recommend that dialysis units review bacteraemia rates for patients with or without CVCs on a regular basis. While the expected frequency of these reviews is not stated, over half ($n = 10$) of the units in our survey undertake monthly reviews.

There is a dearth of studies reporting episodes of VA-related bacteraemia within Irish dialysis units. An Irish pilot of the National Healthcare Safety Network (NHSN) dialysis event protocol reported that dialysis events (which included bloodstream infection) were more common in patients with CVCs when compared with patients with fistulas ($P < 0.001$) [30]. Two other Irish studies report episodes of CVC-related bacteraemia ranging from 0.64 to 1.3 per 1000 catheter days [31, 32]. These episodes are slightly lower than those reported in the literature [9–11]. Using the CDC NHSN, a number of international studies reported episodes of bacteraemia relating to AVF and CVC, which ranged from 0.6 to 1.3 per 100 patient months and 4.4 to 9.8 per 100 patient months, respectively [33, 34]. These studies illustrate that a CVC poses a higher risk of bacteraemia when compared with an AVF. It is interesting to note that these episodes of CVC-related bacteraemia are somewhat higher than the 1.94 episodes per 100 patient months reported by one Irish dialysis unit [32]. While it is beyond the scope of this survey, further studies could explore infection outcome data for this population and correlate it with access provision.

Surveillance is an essential component of infection prevention and control programmes, aimed at preventing and controlling HCA CRBSI [35]. In order to improve the quality and safety of patient care local monitoring of these infections is advocated [12]; dialysis units are expected to put in place surveillance programmes, to determine rates and trends of HCA CRBSI [13]. Twelve dialysis units had a surveillance programme in place; to monitor infections associated with all types of VA. Five parent hospital and two satellite units did not have any surveillance programme in place, even though the parent hospital units have access to onsite infection prevention and control expertise.

The absence of a surveillance programme hinders the identification of gaps in infection prevention and control practices. This absence within dialysis units surveyed may be due to a number of factors including a lack of resources, lack of suitable personnel dedicated to surveillance in the dialysis unit and a lack of suitable surveillance software. An area that needs further exploration is the scope of surveillance programmes within dialysis units, identifying any deficits and resources needed to establish such programmes. Standardizing surveillance methods and programmes across dialysis units will enable national and international comparisons to be made.

It is recommended that each episode of bacteraemia, within the dialysis population, should have a root cause analysis undertaken [13]. This is not reflected across routine practice where more than a third of units are not undertaking such an analysis ($n = 7$), a majority of which were parent hospital units and had over 60 patients. Failing to identify possible sources of infection and gaps in practice may hinder improvements in infection prevention and control. The size of the dialysis unit was not associated with implementing guideline recommendations related to the review of bacteraemia rates, the existence of a surveillance programme or the use of root cause analysis for episodes of bacteraemia.

Both the Infectious Diseases Society of America and the Irish guidelines recommend the use of a CVC

insertion checklist [13, 28]. Such checklists are used to facilitate adherence to infection prevention and control evidence-based practices at the time of CVC insertion. Only two dialysis units used an insertion checklist; fourteen did not know, which may be due, in part at least, to patients presenting to the dialysis unit with their CVC line already in place.

Although not recommended, more than a third of the units surveyed administer intravenous prophylactic antimicrobials prior to catheter insertion [13, 19, 28, 36]. Six dialysis units were not aware whether this was a routine practice; therefore, a substantial number of Irish units practices might not be in keeping with the existing guidelines. Guidelines differ on the use of antimicrobial lock solutions. While Irish [13] and renal-specific guidelines [3] recommend antimicrobial locks for patients who require long-term CVCs, non-renal specific catheter guidelines confine their use to patients with a history of multiple CRBSI [19, 28]. Over two-thirds of units in our study routinely use trisodium citrate as an antimicrobial locking agent ($n = 13$).

The use of maintenance CVC care bundles is not evident in any renal guidelines; but their use is advocated in Irish and CDC guidelines [13, 19]. Maintenance CVC care bundles are evidence-based practices, which have been shown to result in greater improvements in patient outcomes by significantly reducing HCA CRBSI [37–39]. This set of evidence-based practices includes hand hygiene, inspection of insertion site, site care and change of dressing, chlorhexidine skin antiseptic and CVC hub decontamination. The use of CVC care bundles in Irish haemodialysis units has been advocated since 2009; but 11 units have not incorporated them into routine practice. There is a need to explore potential barriers to the implementation of CVC care bundles in dialysis settings.

Another intervention used in the prevention of CVC infection is cleansing the CVC exit site and catheter hubs with an antiseptic solution. Renal guidelines agree on the use of a chlorhexidine gluconate antiseptic solution, but differ in solution strength and formulation. Recent guidelines from the CDC [19] recommend the use of $>0.5\%$ chlorhexidine in 70% isopropyl alcohol solution; while the UK Renal Association [3] suggests 2% chlorhexidine gluconate, but does not stipulate if this should be in 70% isopropyl alcohol or an aqueous solution. A number of guidelines including Irish guidelines recommend 2% chlorhexidine gluconate in 70% isopropyl alcohol [2, 13, 36, 40]. Practice in a majority of Irish units ($n = 14$) is compliant with these recommendations; but some units use alternative strengths and formulations of chlorhexidine gluconate. This reflects uncertainty in the research literature about the most effective ways of cleansing the CVC exit site and catheter hubs [19, 41].

This survey explored the use of effective VA and infection prevention and control practices within haemodialysis units, provided national data on these practices in Ireland and compared these with national guidelines. However, it was beyond the scope of the survey to investigate VA and infection outcomes and link these to the elements of CVC care process. Although such an investigation may allow refinement of the national guidelines, it would require a larger study. Another limitation of this study is that we collected data pertaining to the type of access being used at the time of survey completion and did not seek data on patients whose AVF was maturing. Future surveys of VA prevalence would benefit from including patients with a functioning AVF; functioning AVG;

maturing AVF using CVC, CVC not suitable for AVF or not willing to consent for an AVF, CVC awaiting AVF and other temporary access (as is collected in a less structured fashion by the National Renal Office Annual ESKD Census). Although the survey primarily focussed on CVC care policy and prevention of CRBSI, from a national perspective, it would be interesting if future studies investigated other process measurements in the fashioning of AVF or AVG. Another limitation is the possible difference in how units interpret 'review of bacteraemia rates' and 'root cause analysis' as the survey may not have captured this variability. These issues need to be explored in more depth in future studies, including issues relating to how bacteraemia rates are audited, details of the root cause analysis process and steps taken to decrease bacteraemia rates. In addition, circulating the survey to nurse managers may have resulted in biased responses. We assumed that they would have the necessary knowledge to answer the survey; however, there is a risk that managers may have overestimated their units adherence to practices recommended by national guidelines.

In conclusion, this national survey of routine practices on VA and infection prevention and control is the first of its kind to be undertaken of Irish haemodialysis units. The strength of this survey is its comprehensive nature as it included 19 of the 20 dialysis units in Ireland. This is a study of real clinical practice and shows that haemodialysis routine practices in VA and infection prevention and control are generally underpinned by the best available evidence; but several guideline recommendations still need to be incorporated into routine care. This survey will inform discussions in Ireland about the setting of targets for AVF prevalence, increasing access to vascular surgical procedures, standardizing documentation used in the review of bacteraemias, using root cause analysis, discontinuing the use of intravenous prophylactic antimicrobials before CVC insertion and implementing CVC insertion check lists and maintenance care bundles. Finally, the next iteration of this national survey could explore the relationship between the practices followed in dialysis units and the outcomes for their patients. It could also include a structured series of questions as to 'why' units deviated from the national recommendations. All that we could show was that the 'size of the unit' was not a cause of variation between dialysis units.

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