Rapid evidence review for the RCN infusion therapy standards: a summary
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Introduction

This report summarises a rapid review of the evidence undertaken to support development of an update to the RCN Standards for Infusion Therapy, published in 2010. The standards have proved popular and are widely referenced as an exemplar of best practice. For this reason, following discussions with stakeholders, a decision was taken to update, rather than archive, the 2010 standards document.

The review was underpinned by a robust methodology of rapid evidence assessment (REA); an established research methodology which can be described as a compromise between the requirements of a systematic review (SR) and the need to deliver results within a constrained time period (Thomas et al., 2013).

The evidence review was a collaborative project, managed and conducted by the RCN Research and Innovation (Evidence), Library and professional practice teams, as well as an RCN contractor (Bazian).

Aims and objectives

The primary aim of this review was to support the update of the RCN’s 2010 Standards for Infusion Therapy, with an explicit focus on all settings where infusion therapy is delivered. Specific objectives were to identify areas with robust, promising or no evidence, and evidence identifying harmful practice. The review also included evidence on the patient perspective of infusion therapy, which the authors felt was timely and appropriate in the current health care climate.

The resulting evidence review comprises three strands:

- evidence obtained from randomised controlled trials (RCTs) and SRs (Phase 1)
- evidence obtained from the consideration of the body of evidence from other quantitative study designs (Phase 2)
- evidence relating to the patient perspective of infusion therapy.

Two overarching questions guided the review:

1. What is the latest evidence that can be used to update the previous iteration of the standards for infusion therapy?

2. What are the facilitators and barriers perceived by patients receiving a range of infusion therapies?

The RCN Standards for Infusion Therapy cover a wide cross-speciality area, however the focus of this review was to provide evidence on practice that is relevant to the management of infusion therapy by nurses in a variety of settings, and is linked with clinical effectiveness and patient safety outcomes.

Background

Infusion therapy has historically been associated with hospital care but due to increasing demands it is now delivered in a variety of settings including community and rural settings, as well as self-administration by patients and carers. In light of this changing health care landscape, there is a need to provide standards for infusion therapy that acknowledge and support the delivery of infusion therapy in different settings, whilst also recognising the impact on service provision, nurse workload and patient needs.
Methods

The search strategy

The aim of the literature search was to identify the research evidence, appropriate standards and guidelines on infusion therapy from the UK and other OECD countries, in order to update the 2010 RCN Standards for Infusion Therapy. The search strategy was designed and executed by the RCN Library. Three key bibliographic databases were selected due to their relevance to nursing research and the fact they were immediately and freely available (British Nursing Index, Cumulative Index to Nursing and Allied Health Literature (CINAHL) and MEDLINE). Searches were trialled on these databases during June 2015 to establish appropriate search terms. The general inclusion criteria were agreed with members of the steering board and are detailed below (Table 1).

Table 1: Inclusion criteria

<table>
<thead>
<tr>
<th>Publication date</th>
<th>2010 onwards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographical scope</td>
<td>UK and OECD countries</td>
</tr>
<tr>
<td>Age range</td>
<td>Older adolescents and adults (exclude neonates, infants and children)</td>
</tr>
<tr>
<td>Language</td>
<td>English language</td>
</tr>
<tr>
<td>Study type</td>
<td>RCTs, systematic reviews, meta-analyses and cohort studies</td>
</tr>
</tbody>
</table>

A total of 12 nursing-specific areas of practice were agreed as requiring primary evidence and formed the focus of the clinical aspect of this evidence review (see Table 2).

All three databases were searched during August 2015 using the agreed search strategy. Each of the 121 topics in question were combined with a generic infusion therapy set (where appropriate) and then with each of three additional sets of terms (research designs; standards; complications and adverse events), producing three sets of results per database for each topic. The focus of the search was on primary studies of experimental designs and systematic reviews. In addition, searches were conducted on existing published standards or guidelines to ensure coverage of good or accepted practice.

Sifting

Following the searches, all references were initially sifted for relevance. This was followed by a two-phase review of the clinical evidence.

Phase 1 – RCT and SR evidence

Phase 1 involved undertaking a sift on the basis of design, including only RCTs and SRs and removal of duplicates. The remaining studies were assessed against the predetermined inclusion and exclusion criteria. Full text versions of studies which met all inclusion criteria – or where a decision could not be made based on title and abstract – were obtained where available, and were further assessed for inclusion based on the inclusion and exclusion criteria. The sponsors also provided a number of references, of which four studies were included, resulting in 56 studies being assessed in phase 1 of the review (see Figure 1).

Phase 2 – Non-RCT and SR evidence

In October 2015, a further sift was undertaken to identify any potentially relevant evidence which was originally rejected on the basis of study design. In this phase, RCTs and SRs were removed from the original list of 315 included papers, and the remaining references assessed against the inclusion and exclusion criteria (with the exception that all quantitative research designs were considered), producing 167 studies to be assessed during the second phase of the REA. A similar sifting process was conducted to that discussed above, providing a further 48 studies to be appraised in this phase of the review (see Figure 1).
Additional search: patient experiences

An additional literature review to locate references relating to the patient experience of infusion therapy was carried out during September and October 2015. The databases searched were British Nursing Index, CINAHL and MEDLINE and the inclusion criteria were the same as those identified in the clinical review, with the exception of the research design limitation which was not applied.

Searches were trialled in early September in order to establish appropriate terms for the patient experience element of the search, and to reflect differences in database structure and vocabulary. In addition, supplementary terms were identified from the Warwick Patient Experiences Framework (WaPEF) (Staniszewska et al., 2014); these were included in the search terms and were combined with the infusion set terms from the clinical review to produce an overall picture of patient views.

In addition, a further five areas were investigated using the patient experiences sets (parenteral nutrition; chemotherapy infusions; insulin; blood transfusions; renal infusions (dialysis)), which resulted in a total of six lists of references on patient experiences for each database. This search produced 22 studies for the review of patient perspective literature (see Figure 1).

Quality appraisal, data extraction and synthesis

Appropriate quality appraisal tools and data extraction forms were selected during each phase of the review, based on the type of research that the papers being appraised presented. SRs were appraised using the AMSTAR 11 item checklist (Shea et al., 2007), while the Cochrane risk of bias tool (Higgins et al., 2011) was used to assess RCTs. Other quantitative designs and mixed methods studies were assessed using an in-house critical appraisal tool, adapted from the EPPI Centre REPOSE Guidelines (Newman and Elbourne, 2005). Quantitative evidence was appraised using the Critical Appraisal Skills Programme (CASP) tool for assessing qualitative data (CASP, 2013). All tools resulted in a quality rating of low, medium or high. The number of studies meeting each rating is presented in Table 2. Once relevant data had been extracted and appraised for quality, evidence was mapped to provide an overall picture of the available evidence in each area. Results were then synthesised in order to produce an assessment of the strength and volume of evidence relating to each area. Assessment of strength and volume of evidence was informed by the Infusion Nurses Society (INS) Standards of Evidence (INS, 2016).

The evidence identified in Phase 1 of the process was reviewed and the report was produced by an information specialist in an outsourced contract under the auspices of the RCN. The evidence review for Phase 2 and the patient perspective was conducted directly by the RCN.
Figure 1: Study selection procedure for all phases of review

Phase 1

1,824 studies identified from electronic search

315 retained after first sift for relevance

91 retained after sift on design and duplications (SR and RCT)

73 retained after sift on inclusion and exclusion criteria

4 studies identified from sponsors’ submissions

77 full text retrieved

56 studies included in Phase 1 of review

Phase 2

446 studies identified from electronic search

224 studies considered for Phase 2 of review (non RCT and SR)

167 retained after first sift for relevance

90 retained after first sift on relevance and duplications

68 retained after sift on inclusion and exclusion criteria and duplications

1 study identified from sponsors’ submissions

61 full text retrieved (8 unavailable)

48 studies included in Phase 2 of review

Patient perspective

446 studies identified from electronic search

90 retained after first sift on relevance and duplications

63 retained after sift on inclusion and exclusion criteria

42 full text retrieved (21 unavailable)

22 studies included in patient perspectives review
Key findings and discussion

Findings from each of the reviews were assessed under each of the 12 specific areas (see Table 2) in order to provide an overall appraisal of the strength and volume of the evidence in each area. Detailed findings can be found in Appendix A, while key findings and gaps in the evidence are discussed below.

Table 2: The 12 areas of infusion therapy care and management included in the review of clinical evidence (Phases 1 and 2)

<table>
<thead>
<tr>
<th>Section</th>
<th>Total number of studies</th>
<th>Number of studies per quality category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>High quality</td>
</tr>
<tr>
<td>Add on devices</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Arterial catheters</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Blood sampling</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td>Central venous access devices</td>
<td>21</td>
<td>4</td>
</tr>
<tr>
<td>Flow control devices</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Infusion-related bloodstream infection</td>
<td>34</td>
<td>8</td>
</tr>
<tr>
<td>Infusion therapy phlebitis</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Intraosseous access devices</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Midline catheters</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Parenteral nutrition</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>Peripheral access devices and flushing</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Subcutaneous infusions</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

2 During the first phase of the review, some studies were appraised under more than one area; however, during the overall appraisal, studies were included only once to ensure an accurate reflection of the volume of evidence across all areas of infusion therapy.
The literature search produced a large volume of evidence across a variety of areas relating to infusion therapy; however, some areas appeared more researched than others. Despite limitations in relation to the databases searched, papers actually retrieved and time restrictions, some observations can be made.

The area which received the most research attention is infusion-related bloodstream infections; this is not surprising, given the huge impact of these infections on both an individual patient level and on health service resources. Arterial catheters and subcutaneous infusions produced the lowest volume of literature in the review of clinical evidence, with only four studies found in each of these areas. In the patient perspectives review, the evidence was heavily biased towards experiences of dialysis treatment; with a lack of studies conducted in other settings. In terms of the WaPEF framework, most studies were mapped against the theme of lived experience; with no literature identified relating to the theme of continuity of care and relationships.

After synthesising and analysing the evidence as a whole, several themes emerged relating to various aspects of infusion therapy practice. These themes are discussed below to provide recommendations for practice and for the development of the new standards.

**Flushing and locking of infusion devices**

The largest volume of evidence suggests that there is no difference between flushing central venous catheters (CVCs) with heparin or normal saline (one high quality and one medium quality SR and one low quality RCT). Although one high quality RCT found that flushing peripheral venous catheters (PVCs) with 3ml 100 IU heparin/ml was better than normal saline. There is also no evidence that locking CVCs with heparin is any more effective than normal saline or citrate; however, locking with an antimicrobial solution has been linked with decreased infection rates (two medium quality SRs). There is a need for more research into the effect of flushing and locking using various solutions with regards to PVCs, as well as arterial and midline catheters.

One low quality review aimed to identify connector design features that facilitate scrubbing and flushing and improve outcomes. Identified features include a smooth, tight fitting septum; low intraluminal fluid pathway volume; a straight fluid pathway; no dead space; no reflux with connection or disconnection; and fail-safe back-up systems.

There is weak evidence to suggest that implementing an evidence-based practice intervention relating to flushing and locking may have a positive impact on nurses’ knowledge and flushing technique.

**Infection prevention and control**

Several studies have demonstrated chlorhexidine and silver to be effective antimicrobial agents, when impregnated into catheters, connector devices or securement dressings. Chlorhexidine Gluconate (CHG) bathing has also been demonstrated to be effective at reducing infection risk, as part of a quality improvement intervention.

Pre- and post-insertion care bundles have been shown to reduce infection rates in a variety of settings. A care bundle is a number of interventions that, when performed together, result in improved outcomes. Elements which should be considered for inclusion in a care bundle include hand hygiene, aseptic technique, dressing changes, scrub the hub, daily inspection of insertion site, full barrier precautions on insertion, CHG bathing and removal of unnecessary lines.

Three high quality studies (1 SR and 2 RCTs) found that routine replacement of central or peripheral catheters every three days does not result in decreased infection rates, compared with replacement on clinical indication. However, one medium quality prospective cohort study did find the risk of phlebitis increased with duration of catheter, highest after 96 hours. There is, therefore, a clear rationale for replacement of catheters on clinical indication; however it is vital that
insertion sites are monitored daily for signs of infection and catheters removed promptly whenever infection is suspected.

### Placement of devices

The evidence relating to the best access site in terms of safety and effectiveness is quite sparse. Placement of catheters in the femoral area has been associated with increased risk of infection in studies of both arterial and central venous catheters. In addition, one RCT of low quality did not find that use of radial arterial catheters caused finger or hand ischaemia. Therefore, the evidence available would suggest avoiding the femoral site where possible. In terms of peripheral access devices, placement in the dorsum of the hand was shown to increase the risk of phlebitis in one medium quality cohort study.

Further studies are required in order to determine the most appropriate placement sites. However, in light of the patient perspectives review, any decisions made regarding placement of access devices should take into account patients’ lifestyles and preferences in addition to clinical and research evidence.

### Blood sampling

Several studies have demonstrated that blood samples can safely and effectively be obtained from intravenous (IV) access devices without significantly affecting the results obtained. In addition, similar levels of haemolysis have been observed in blood samples taken from IV starts in the emergency department, compared with venepuncture; and also samples taken from the catheter hub during an IV start, and from the catheter hub via an extension tube. However, several parameters do appear to be affected by sampling using this method including venous blood gases and INR. As patient perspective literature suggests patients can find repeated venepuncture uncomfortable and distressing, sampling from IV starts or existing IV access devices should be considered for routine blood testing. It should be noted, however, that when measuring coagulation parameters in patients receiving continuous heparin infusion, samples should not be taken from the port used to deliver the heparin as this may affect results.

Given the wide reporting of pain and distress in patients undergoing venepuncture and cannulation, there is a need for research into interventions aimed at reducing these outcomes and improving the patient experience.

It is widely accepted that when sampling from IV catheters, a volume of blood must be initially drawn and discarded as waste, in order to produce an undiluted blood sample. The results of one high quality quasi experimental study demonstrate that 1ml is an adequate amount. Therefore, drawing larger volumes of waste is unnecessary and may lead to insufficient samples being obtained where there is a difficulty obtaining blood, or where multiple samples are required and the total volume exceeds the maximum which may safely be extracted.

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In terms of insertion techniques, the only evidence uncovered was of low quality. From the limited evidence available it would appear that using ultrasound guidance is beneficial. A low quality pilot study conducted in the USA reported the success of a novel, resident driven programme for placement of ultrasound-guided midline catheters in critically ill patients; however it is unclear whether this could be replicated in the UK.

### Effectiveness and safety of peripherally inserted central venous catheters (PICCs) and midline catheters compared with central venous catheters

The evidence regarding the safety and effectiveness of PICCs and midline catheters compared with CVCs is limited. One high quality literature review discusses the advantages and disadvantages of midline catheters. Advantages include avoidance of repeated cannulation; increased vessel diameter which reduces the incidence
of complications, such as chemical phlebitis; toleration of isotonic solutions and high flow rates; and reduced infection rate compared with other vascular devices. Disadvantages include a high risk of extravasation; not recommended for dextrose solutions >10%; and an increased risk of mechanical phlebitis.

There is limited evidence to suggest midline catheters may be an acceptable route for the administration of vancomycin. While it is not advised to administer this antibiotic through PVCs due to the risk of various complications, there is evidence to suggest it may be given through midline catheters. Another high quality literature review suggests that pH alone is not an evidence-based indication for the placement of a central line rather than a PICC.

There is evidence to suggest that PICCs have double the risk of deep vein thrombosis (DVT) compared with CVCs. A high quality prospective cohort study found that hypertension, obesity, an increase in PICC arm circumference and oedema are risk factors for upper extremity DVT in patients with PICCs. A high quality RCT demonstrates that proximal valve polyurethane (PVP) PICCs result in half the incidence of phlebitis compared with distal valve silicone (DVS) PICCs.

In addition, one medium quality case-control study explored patient and device-related risk factors for bloodstream infection in patients with PICCs and found congestive heart failure, intra-abdominal perforation, history of Clostridium difficile (C. diff), recent chemotherapy, presence of tracheostomy tube, and use of a multi lumen catheter to be associated with increased infection risk in this population. History of chronic obstructive pulmonary disease and PICC placement in oncology, orthopaedics or surgery appeared to be protective factors although reasons for this are unclear. This highlights the importance of a thorough clinical and vascular assessment of patients prior to insertion of a PICC or midline catheter.

A high quality prospective cohort study carried out amongst palliative care patients showed that the placement of PICCs or midline catheters was associated with very low levels of distress, while their presence resulted in an increased global quality of life for the patients. Therefore midline catheters should be viewed as a viable treatment method in this population for the administration of fluid and nutrition, as well as intravenous medication. However, as with any intervention at end of life, the decision to insert such a device must be made on an individual basis, in partnership with the patient, carers and multidisciplinary team.

**Infusion therapy in the non-acute setting**

There was little research conducted with regards to infusion therapy in the non-acute setting. The above study, which explored levels of pain and distress experienced by palliative care patients during the placement of PICC or midline catheters, was carried out using patients in home and hospice settings. The positive findings of this study, in terms of low levels of distress and the resultant increase in quality of life, provide support for the use of PICCs and midline catheters amongst palliative patients in the community setting.

Evidence for the delivery of antimicrobial therapy in the community is strengthened by a study which found no significant differences in infection rates between self-administered outpatient parenteral antimicrobial therapy compared with administration in a hospital or clinic setting.

Evidence for the delivery of antimicrobial therapy in the community is strengthened by a study which found no significant differences in infection rates between self-administered outpatient parenteral antimicrobial therapy compared with administration in a hospital or clinic setting.

A systematic review concluded that the most common cause of infections in home parenteral nutrition patients is gram positive human skin flora. While this systematic review was of low quality, it highlights the importance of hand hygiene and training for home parenteral nutrition patients, and indeed any patients in the community with indwelling infusion devices.

The patient perspective review found that treatment at home or in the community could be viewed as both a facilitator and a barrier, depending on the characteristics of the individual and the situation. For example, in patients undergoing dialysis, home treatment was viewed as a facilitator as it means...
patients do not have to have a fistula; this enables them to continue working, does not require admission to hospital or travelling for treatment, and was perceived as offering patients greater control over their lives. However, it was also viewed as a barrier as patients described anxieties around the risk of peritonitis and the medicalisation of the home.

Studies exploring patient experiences of other infusion therapies in the home or community suggest that in many cases patients prefer to receive treatment in this setting. However, the research uncovered an increased need for practical, psychological and emotional support for both patients and carers. Nurses would be in an ideal position to provide this additional support. However, it is vital that nurses working in this setting are provided with appropriate education and training; and have sufficient time to provide the range of support required by patients receiving infusion therapy in the home of community setting.

**Limitations**

This review is subject to the limitations associated with carrying out a REA over a full SR. The main difference between a SR and REA is the extent of the search strategy. Specifically, by limiting the search to only three databases and omitting the search for grey literature, there is a risk that not all relevant references have been identified in the current study. To mitigate this risk the expert group and sponsors were invited to also offer papers to assess for inclusion.

The processes of quality assessment and data extraction were conducted by only one researcher, which introduces the potential for reviewer bias; however, a random sample of papers was checked by a second researcher at each stage of the process and no major discrepancies were found. A clear audit trail has been created at all stages to ensure transparency during the entire process.

In terms of the evidence obtained, study designs and research questions were largely heterogeneous, making it difficult to combine results to produce robust conclusions. In addition, the volume of research in some areas was very low, including research carried out outwith the acute hospital setting. However, by synthesising the results of all of the reviews, a picture begins to emerge of where there is strong evidence available and where there is a need for further research or professional consensus.

By including the patient perspective in the review, useful information emerged about the patient experience of infusion therapy; however, the majority of studies identified and included in the review related to the experience of dialysis patients, so there is little evidence relating to other areas of infusion therapy. In addition, the included studies dealt with individual settings of care delivery separately and did not address continuity of care - one of the themes identified in the literature relating to the WaPEF, and which is a key determinant of the patient experience of care. While there was an overlap of the themes and continuity of care may have been covered indirectly, this finding may be an indication for disconnect between what matters to patients and what gets researched and published.

Moreover, a clear path that takes us from understanding the patient experience to understanding how it can influence nursing practice and clinical outcomes is missing. Further research is required in this area; identifying and testing interventions to ensure that patient perspectives are not only acknowledged, but integrated into policy and practice in order to enhance service delivery and improve patients’ experience of receiving infusion therapy.

It should be noted that this review was only part of the evidence considered for the development of the RCN *Infusion therapy standards*. Existing guidance, good practice and expert consensus also informed the work.

**Recommendations for further research**

The findings of the review add to the evidence base in many areas of infusion therapy; however the volume of evidence reviewed was low in some areas (particularly arterial catheters and subcutaneous infusions). Further research should aim to answer the RCN questions
In light of the increased focus on delivering infusion therapy in settings beyond the acute hospital, including references to the patient perspectives literature will allow guidance to be provided which addresses various situations and contexts, and acknowledges the holistic role played by the nurse in the delivery of infusion therapy.

The patient perspectives study offers useful information about patients’ experiences of receiving infusion therapy both in acute and non-acute settings. The studies reviewed provide evidence that in many situations, patients prefer to receive infusion therapy at home or in the community; however several barriers are identified and it is clear that moving towards increased treatment in the non-acute setting will have considerable implications for resource planning and management, and nursing workload management. Further research is required in this area to identify patient and carer needs and how the design of systems and services can best address them. The overall volume of research identified in the patient perspectives study was low and mainly confined to patients receiving dialysis treatment, therefore further research is required to explore patient preferences and experiences in other areas of infusion therapy.

Furthermore, it is not clear from the studies reviewed what the impact of the patient experience is on adherence to, quality, effectiveness and safety of the infusion therapy. More longitudinal, experimental and mixed methods research is required in order to explore this link.

**Recommendations for development of the revised standards**

This review identified a number of studies in a variety of areas of infusion therapy. Due to the heterogeneity of the clinical studies, there are few areas which contain strong evidence. Many high quality studies were identified however, therefore these should be assessed in the context of the existing evidence base in order to add strength to existing standards or challenge areas where new evidence may have emerged. Where ambiguity remains, it is advised that professional consensus be sought.

which remain unaddressed, with a particular focus on the delivery of therapy out with the acute hospital setting.

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Furthermore, it is not clear from the studies reviewed what the impact of the patient experience is on adherence to, quality, effectiveness and safety of the infusion therapy. More longitudinal, experimental and mixed methods research is required in order to explore this link.
Study references


57. Lopez AC (2011) A quality improvement program combining maximal barrier precaution compliance monitoring and daily chlorhexidine gluconate baths resulting in decreased central line bloodstream infections, Dimensions of Critical Care Nursing, 30(5), pp.293-298.


Other references


Appendix A
Detailed findings and gaps in the literature

Add-on devices

While several SRs were identified which looked at the effects of various IV connector devices and methods of reducing contamination, they either produced inconclusive results or identified only low quality evidence. The limited evidence available suggests that closed connector devices for CVCs may reduce the risk of infection as may changing to an intraluminal protection device.

A high quality clinical and laboratory study found that scrubbing the connector hub with a 70% isopropyl alcohol pledget is an effective measure for decreasing bacterial contamination in both the laboratory and also clinical context. Three further studies included scrubbing the connector hub as part of a quality improvement intervention, each of which reported significantly reduced infection rates.

Gaps remain in the evidence base with regards to the effect on patient safety and outcomes of changing add-on devices with each cannula or administration set replacement, or when the integrity of either product is compromised.

Arterial catheters

There is evidence to suggest that the use of radial arterial catheters does not lead to finger or hand ischaemia, however this is the finding of only one low quality RCT. The same RCT found hourly blood glucose monitoring from the catheter did not result in increased infection rates. There is limited evidence that femoral arterial catheters have an increased infection risk compared with radial catheters, therefore more research is required to establish the safest site for arterial catheter placement. The research is inconclusive with regards to the optimum timing of administration set replacement.

There is limited but high quality evidence to suggest that dressing type can influence the success of the arterial catheter, with a bordered polyurethane with standard polyurethane dressing resulting in lower failure rates than standard polyurethane dressing.

High quality evidence demonstrates that arteriovenous fistula cannulation is comparable to CVC for intensive haemodialysis in terms of access loss, failure or complications. However, patient preference data suggests that while professionals tend to favour a fistula over a CVC due to the association with improved clinical outcome, patients may prefer the catheter as they perceive it will offer them a better quality of life.

There was no evidence found relating to the impact of different line flushing frequencies for arterial catheters, or the effect of flushing with saline versus heparinised solutions.

Blood sampling

There is evidence to suggest that routine blood sampling from IV catheters may be justified as similar results are reported in a range of parameters. This is the conclusion from several high quality quasi experimental studies; however, as each study addresses a different aspect of blood sampling, the level of evidence does not exceed Level IV (as per the evidence grading system used in the Infusion Nurses Society standards).

Several RCTs looked at the impact of different methods of blood sampling; however all of these studies were rated as low quality. Results, which should be treated with caution, suggest that sampling speed for taking venous blood from pulmonary artery catheters does not change the level of oxygen and the use of an
extension tube when sampling from the IV catheter hub does not result in reduced levels of haemolysis.\textsuperscript{95}

In terms of device selection, limited evidence suggests that sampling from a non-wire rather than wire hub results in decreased infection rates.\textsuperscript{52} Similarly, there is limited evidence for the 'Holdex' tube holder to reduce risk of erythrocyte injury.\textsuperscript{65}

As patient preference literature suggests many patients find needles uncomfortable and distressing,\textsuperscript{5,80,107} obtaining blood samples from IV devices should be considered, however judgement should be made based on the tests required and taking into account the preferences of the patient. Caution should be applied when measuring venous blood gases or INR as discrepancies have been noted when these samples are taken from IV catheters.\textsuperscript{37,40} Limited evidence suggests that when sampling from a PVC, 1ml is a sufficient waste volume to produce an undiluted blood sample.\textsuperscript{6}

Despite the evidence highlighting that patients often find venepuncture distressing and painful, no evidence was found relating to interventions aiming to reduce fear, pain and anxiety. There are also gaps in the literature reviewed in relation to the effect of site selection for an infusion cannula on patient safety and outcomes. In light of the findings of the patient perspective review, it is suggested the patient’s lifestyle should be taken into account when selecting the most appropriate site. If blood sampling from IV catheter hubs is to be encouraged, then gaps in the literature regarding the impact of different flushing practices before blood sampling must be addressed. Furthermore, with the various devices for blood sampling available, further research is required to identify best practice for different devices.

**Central venous access devices**

There is strong evidence to demonstrate that there is no difference in infection rates when devices are flushed with heparin, sodium chloride or ethanol, or locked with heparin or citrate.\textsuperscript{8,108,109} However locking with citrate plus gentamicin, taurodilone or methylene blue plus methylparaben plus propylparaben may reduce the risk of catheter-related blood stream infection.\textsuperscript{109}

Implementing an evidence-based practice intervention may result in improvements in nurses’ knowledge and flushing technique, however this is the conclusion of only one medium quality quasi-experimental study.\textsuperscript{66}

One high quality prospective cohort study found no significant differences in infection rates between self-administered outpatient parenteral antimicrobial therapy, compared with administration in a hospital or clinic setting.\textsuperscript{7}

There is strong evidence to suggest that PICCs are associated with a higher risk of deep vein thrombosis than CVCs.\textsuperscript{47,70} Further risk factors include hypertension, obesity, an increase in PICC arm circumference and oedema.\textsuperscript{63} Coating or impregnating catheters with antimicrobial substances (including silver, CHG and bismuth) has been demonstrated to protect against infection,\textsuperscript{4,92,105} as has the use of chlorhexidine and silver dressings.\textsuperscript{100,102}

No firm conclusions can be drawn about the most effective insertion technique due to design limitations of the studies identified, and no evidence was found on the effect of different line flushing frequencies on patient safety and outcomes. However there is limited evidence that the femoral area should be avoided where possible when placing CVCs.\textsuperscript{39}

**Flow control devices**

The literature search did not produce any studies relating directly to flow control devices. Two RCTs\textsuperscript{79,104} compared different types of CVCs with relation to flow rates and complications, however the evidence is insufficient to make recommendations regarding the most effective devices.

Two studies were identified in the search, which are not directly related to flow control devices; however they are mentioned as the findings may be of use in the revision of the infusion therapy standards. Limited evidence suggests that local infusion of anaesthetic into the wound following hiatus hernia repair provides no benefit.\textsuperscript{38} However there is evidence to suggest that intrathecal pain relief may be effective in alleviating pain which has not responded to other methods of pain relief.\textsuperscript{38}
No evidence was found for prognostic factors affecting selection of manual flow control device, different frequencies of flow rate monitoring, or the effect of electronic devices which generate flow through positive pressure or low pressure devices.

**Infusion-related bloodstream infections**

There is strong evidence to suggest that locking infusion devices with antimicrobial solutions, in addition to heparin or citrate, is more effective in reducing catheter-related bloodstream infection than heparin or citrate alone.\(^{94,107}\). There is also strong evidence to suggest that chlorhexidine and silver act as effective barriers against bloodstream infection, when used to impregnate catheters, connector devices or dressings.\(^{40,100,102,105}\)

Pre- and post-insertion bundles have been shown to be effective in reducing catheter-related infections.\(^{28,36,39,65}\) Pre-insertion bundles commonly include hand hygiene, chlorhexidine skin preparation, full barrier precautions, aseptic technique and avoidance of femoral line. Post-insertion bundles commonly incorporate hand hygiene, aseptic technique during use of connectors, scrubbing the hub, daily inspection of the insertion site, regular assessment of the need for the catheter and removal of unnecessary lines. Several studies have also shown daily CHG bathing to be an effective prevention control measure alongside other infection prevention practices.\(^{25,48,57,67}\)

In addition, there is evidence to suggest that introducing a lead nurse to standardise and facilitate good practice may result in reduced infection rates.\(^{52,59}\)

One high quality SR\(^{101}\) concluded that administration sets that do not contain lipids, blood or blood products may be left in place for up to 96 hours without increasing the risk of infection. This is in agreement with RCT studies which found replacement of catheters on clinical indication did not result in increased infection compared with those replaced routinely every 2-3 days.\(^{45,86}\)

No evidence was found relating to the management of infusion-related bloodstream infections in this review. While the focus must remain on preventing such infections occurring in the first place, it is unlikely these will be completely eliminated; it would therefore be useful to identify the most effective methods of managing infusion-related bloodstream infections to limit the impact on patient morbidity and mortality, and quality of life.

**Infusion therapy parenteral nutrition**

There is low quality evidence to suggest PN is an effective route for patients with total brain injury.\(^{45}\) However, early initiation of PN on admission to the ICU does not appear to result in improved outcomes.\(^{18,26}\) Various composition of supplements have also not been shown to result in different outcomes for patients.\(^{47,77,91,98,103}\)

In terms of blood sampling, failure to clamp the PN infusion prior to blood collection – or too short a time between clamping and drawing – may lead to spurious bloodwork amongst PN patients.\(^{30}\)

One high quality case control study found the strongest risk factor for candidemia infection in elderly hospitalised adults was duration of PN. Other factors included presence of other invasive devices such as CVC or urinary catheter, and concurrent use of antibiotics.\(^{59}\) In terms of home PN patients, gram positive human skin flora appears to be the most common cause of infections,\(^{27}\) highlighting the importance of hand hygiene and training in this patient group.

In-patients with PN catheter-related bloodstream infections, previous immunosuppressive therapy and patient age have been shown to be independent predictors of 30-day mortality. Catheter removal within 48 hours and appropriate antibiotic therapy appear to be protective factors.\(^{87}\)

No evidence was found for the effect of different frequencies of change of PN administration sets and add-on devices, the performance of nutritional
Intraosseous access

In adults, IV access allows for the delivery of more fluids than intraosseous (IO) routes, with a decreased risk of dislodgement\(^46\). However, when IV access is not possible, IO access has been shown to be more successful and quicker than inserting a central venous catheter\(^12,46,51\). Despite the evidence for IO access, CVC remains the preferred method of access amongst clinicians when IV access is unobtainable\(^12,33\). There is also evidence to suggest that when IO access is obtained, guidance is often not followed\(^33\).

When IO access is performed, the proximal tibia appears to be the site most favoured by clinicians\(^33,83\) but evidence regarding the most effective site remains inconclusive. There is evidence to suggest the humeral head is the most effective site for IO access due to its closer proximity to the central circulation and faster infusion rate\(^33,69\). However, there is also an increased risk of dislodgement if the device is inserted into the humerus during CPR, due to the activity taking place around the torso region\(^33\). The humeral head can also be more difficult to locate, particularly if the patient is obese, and there are reports of decreased first-time success rates when this site is selected. More studies are required to clarify the most effective site; however, it appears site selection should be based on individual patient and situation characteristics.

There are various IO access devices on the market, and there is no evidence to suggest any one device is more successful in terms of placement. However, the EZ-IO battery operated power driver has been reported to be easier to use and was the most commonly used device across all studies reviewed by Garside et al.\(^33\).

No evidence was found on the impact of different phlebitis severity/degrees on patient safety and outcomes. One low quality SR\(^82\) identified 71 different phlebitis scales, therefore it may be useful to identify the most effective scale in order to standardise the grading of phlebitis and simplify the assessment of phlebitis severity.

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Infusion therapy phlebitis

High quality evidence suggests that replacing PVCs on clinical indication, rather than routinely every three days, does not result in increased infection rates\(^85,86\). However one medium quality prospective cohort study\(^23\) found the likelihood of phlebitis increased with duration of catheter, highest after 96 hours.

Proximal valve polyurethane (PVP) PICCS have lower phlebitis rates than distal valve silicone (DVS) PICCS\(^50\). Closed systems also appear to result in fewer incidences of phlebitis than open systems\(^14\). Risk factors for phlebitis include increased duration of catheter and placement in the dorsum of the hand\(^18\). There is evidence to suggest that education and training of staff, as well as a catheter maintenance bundle or ‘catheter care station’ in the operating theatre has a beneficial impact on infection rates\(^56,68\).

Vancomycin does not appear to significantly increase the risk of phlebitis, when administered through a PVC, but this is the conclusion of only one quasi experimental study with a small sample\(^68\). The same study found that while phlebitis incidence was similar amongst those receiving vancomycin and those receiving other antibiotics, vancomycin was associated with several other complications.

No evidence was found on the impact of different phlebitis severity/degrees on patient safety and outcomes. One low quality SR\(^82\) identified 71 different phlebitis scales, therefore it may be useful to identify the most effective scale in order to standardise the grading of phlebitis and simplify the assessment of phlebitis severity.

Midline catheters

One high quality literature review\(^7\) discusses advantages and disadvantages of midline catheters. Advantages include avoidance of repeated cannulation;
increased vessel diameter which reduces the incidence of complications such as chemical phlebitis; toleration of isotonic solutions and high flow rates; and reduced infection rate compared with other vascular devices. Disadvantages include a high risk of extravasation; not recommended for dextrose solutions >10%; and an increased risk of mechanical phlebitis.

Evidence suggests that pH alone is not an evidence-based indication for central line over midline catheter placement53, and that vancomycin can safely be given through midline catheters15.

A study involving palliative care patients at home or in hospice settings, demonstrated low levels of distress during the placement of PICCs or midline catheters. Furthermore, the devices are associated with an improved quality of life13.

No evidence was found on the effect of different flushing frequencies for midline catheters, flushing lines with saline versus heparinised solutions, use of different veins, or site selection.

### Subcutaneous infusions

There is evidence that smaller needles may cause less pain for subcutaneous (SC) injections20, and weak evidence that retractable fixed needles cause less bruising49. Evidence is weak with regards to optimal speed of injection2.

Low quality evidence suggests that SC morphine infusions are less initially effective than IV morphine at controlling post-operative pain64.

The overall volume of evidence was very low in this area, thus no studies were found in relation to electronic devices for SC infusion, site selection, site management, solution tonicity or electrolytes used.

### Patient perspective literature

The articles included in the patient perspectives review were subjected to a thematic analysis using an a priori framework, the WaPEF (Staniszewska et al., 2014). The themes are patient-as-active participant; responsiveness of services (individualised approach); lived experience; continuity of care and relationships; communication; information; and support. The majority of findings were mapped against lived experience, with none mapped against continuity of care and relationships (although there is some overlap between the themes).

A number of facilitators and barriers were extrapolated from the articles reviewed and included reported behaviours, situations, perceptions and other constructs. Some were identified as both facilitator and
barrier, and how they were perceived depended on individual patients and situations.

The key issues which emerged from the patient perspectives literature are that patient experiences and preferences are individual and dependent upon several factors relating to the patient and context. Moreover, patient preferences may differ from those of professionals (for example, focus on quality of life versus focus on clinical outcome).

There is evidence that a paternalistic system dominates in the delivery of infusion therapy and that patients are often dissatisfied with the extent to which they are involved in decisions relating to their care.

It is not clear from the studies reviewed what the impact of the patient experience is on adherence to, quality, effectiveness and safety of infusion therapy. The focus of the studies was on patient and carer perceptions, beliefs and fears and there was only limited exploration of possible ways to improve and alleviate these and their success in achieving that. There appear to be links between the experience of the treatment (clinical and as a service) and psychological state and mental health, but the presence of an effect and its direction were not clear.

It is clear the nurse has a wide ranging, holistic role in the delivery of infusion therapy in a range of contexts, including education of patients and carers, provision of information, emotional support, assistance with self-care, and involvement in nurse-led clinics. However, in functional or operational terms, any move towards delivering infusion therapy services closer to home has implications for resource planning and management and nursing workload management.