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RESEARCH ARTICLE

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Spring-infusors: How a simple and small solution can create king-sized complexity

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Abstract

Aim: The aims of the study were to investigate family and hospital staff views about the use of spring-infusor devices for administration of intravenous antibiotic medications, to examine if the device is acceptable and feasible and to map a process for implementation.

Design: A qualitative study with a pragmatist approach, within a larger, mixed methods knowledge translation study.

Methods: Data were collected by semi-structured interviews with patients who have cystic fibrosis and their parents and focus groups and interviews with hospital staff. Interviews were concluded when no new themes were identified. Thematic analysis and process mapping was undertaken.

Results: Six parents, nine children and 30 staff were interviewed. Families preferred spring-infusors. Staff knowledge, experience and attitudes toward spring-infusor use was varied. All staff acknowledged that their role is to support patient-centred care. Spring-infusors are preferred by families and clinicians above other IV administration devices but misconceptions about spring-infusor use and numerous procedural challenges reduced their use.

KEYWORDS
cystic fibrosis, family centred care, spring-infusor

1 | BACKGROUND

The complexity of healthcare treatments for patients with cystic fibrosis (CF) is high and concerns both patients and their clinicians (Sawicki & Tiddens, 2012). The treatment complexity leads to higher treatment burden for patients (Bell et al., 2020), which in turn can negatively impact (Bell et al., 2020) their ability to complete or adhere to treatments and remain engaged in daily life activities. Any tools or systems to reduce treatment burden for patients may improve both engagement and adherence with treatment plans and therefore health outcomes. Patients with CF experience particularly high burden of care during acute exacerbations when admission to hospital for intravenous (IV) antibiotic therapy is required. Admissions typically take 10–21 days (Bell & Robinson, 2008), with daily and often multiple antibiotic therapies being administered. Hence, selection of an IV administration device that is preferred by patients may minimize treatment burden.

Spring-infusor (Go Medical Industries, Pty Ltd, Perth, Australia) devices are small, mechanical spring-driven syringe pumps used

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for the administration of IV therapies. In comparison to traditional mains electric powered electronic IV infusion devices, spring-infusors are lightweight and portable and allow patients to maintain mobility during the administration of IV therapies, particularly antibiotic medications. Spring-infusors have been demonstrated to be effective and safe for the administration of IV therapy in hospital (Freebairn et al., 1994).

Historically, spring-infusors have been used only at the children's hospital in Western Australia for over two decades. Anecdotally, spring-infusors are preferred by patients with CF due to the improved mobility that spring-infusor use allows. In addition to maintaining patient mobility, user preferences and satisfaction, there may be other advantages in using spring-infusors, such as reduced nurse time administering antibiotic therapy, reduced consumable costs and facilitating earlier patient transition to Hospital-in-the-Home (HiTH) care (i.e. child's ongoing hospital management is provided in the patient's home, with clinical care shared by parent and visiting nurse and physiotherapist) and therefore, possibly reduced patient time in hospital. In contrast, traditional infusion pumps are more restrictive, as patients are connected to a large electronic device, which impedes mobility.

The use of spring-infusors had become ad hoc and sporadic. The reason for the inconsistent use of spring-infusors was not known to the CF team. Given the perceived preference of children with CF and their parents for spring-infusors, reintroducing or increasing the use of spring-infusors represented a potential healthcare improvement opportunity.

Healthcare improvement is a term used to describe a systematic approach to increase the safety, quality and value of healthcare services (Ogrinc et al., 2016). Research approaches to improve healthcare processes within health systems typically incorporate mixed methods designs (Guetterman et al., 2015) and include identification of factors that impact uptake of an intervention (Peters et al., 2013). Also, key is for researchers to work closely with knowledge users and stakeholders (Bowen & Graham, 2013). Given the potential benefits of spring-infusors and the current ad hoc use of the device, we sought to identify key factors that influenced decline in spring-infusor use and explore if re-introduction of the device was feasible. Hence the aims of this study were to investigate family and health staff views about the use of the device, examine if using spring-infusors is acceptable to families and staff, map a process for its use in hospital and to understand if its routine use is feasible.

What does this paper contribute to the wider global clinical community?

- Administration of intravenous antibiotic medication via a manual spring-infusor pump, for children with hospitalised with an exacerbation of cystic fibrosis is largely preferred over standard infusion pumps by patients and their clinicians.
- The use of spring-infusors is reported to improve the patient experience and wellbeing while in hospital.
- Misconceptions about spring-infusor use and numerous procedural challenges reduced their use in the hospital setting.

2 | METHODS

2.1 | Design

The study is the qualitative component within a larger, mixed methods knowledge translation study using a pragmatist approach, that is, (i) emphasis on actionable knowledge, (ii) recognition of connection between experience, knowing and acting and (iii) inquiry (Kelly & Cordeiro, 2020). Pragmatism offers a practical guiding framework for qualitative research to examine organizational processes with the aim to improve practice and policy (Kelly & Cordeiro, 2020). Qualitative data were collected by semi-structured interviews with patients and their parents and focus groups with health staff. One of the interviewers was the CF clinical nurse specialist, who was either known to interviewees or declared her role as part of the informed consent process. Ethical approval was granted by the institutional Human Research Ethics Committee (RGS3880). Reporting the study followed the consolidated criteria for reporting qualitative research checklist (Tong et al., 2007). All participants provided written informed consent.

2.2 | Study setting

The Children's Hospital in Perth, Western Australia is a 298-bed public hospital catering for children aged 0–16 years and is the only specialist CF centre in the state, providing multidisciplinary care for approximately 200 children with CF.

2.3 | Interview guide development

The patient and family perspectives interview guides were developed by two researchers with experience in qualitative methods and the CF clinical nurse specialist and director of CF (respiratory physician) at the hospital. Further details are outlined in the supplement.

2.4 | Selection criteria and recruitment

Children with CF aged 8–18 years and their parents were eligible to participate. All hospital staff involved in the care of children with CF, or whose roles could influence the use of IV administration devices were eligible. Staff participants included any clinical staff who cared for children with CF, including respiratory physicians, nurses, physiotherapists, nurse managers and pharmacists. Other staff included those involved in logistics around purchasing, storage, issuing, cleaning and quality control of equipment.

Children and parents were invited to participate during the child's admission for treatment of an exacerbation of their CF. A clinician researcher approached the family to inform them about the study. Hospital staff involved in caring for children with CF were recruited via verbal or email invitation. Ward nurses who cared for children with CF were recruited via the staff development nurses and clinical nurse managers, who organized focus groups for each relevant ward during regular staff development time slots. Purposive sampling was used with both criterion and snowball sampling (Patton, 2015) techniques to ensure a representative sample of parents and staff were recruited.

Sample size was estimated considering the concept of information power (Malterud et al., 2016), and the impacting dimensions; study aim, sample specificity, use of established theory, anticipated quality of dialogue and the analysis strategy. For child and parent interviews it was anticipated a sample of 10–20 would be sufficient. For staff, interviews and focus groups were planned to enable all key stakeholders an opportunity to contribute. It was planned for approximately four focus groups with four to eight participants in each and up to 10 individual interviews. Recruitment for the child and parents group and the hospital staff group continued until information saturation was achieved for each group, that is, no new information or themes were evident (Braun & Clarke, 2021).

2.5 | Data collection and analysis

The study was conducted between 11 December 2020 and 10 June 2021. Individual parent, child and staff interviews were conducted by experienced paediatric clinicians and researchers. Audio-recorded or notes were taken by hand by two researchers (as preferred by interviewees) (PL, CB and/or FG). Audio-recorded interviews were transcribed verbatim. Interview scripts were written directly after the interview. The data quality between audio-recorded transcriptions and interview scripts have been found to be comparable in the detail captured (Rutakumwa et al., 2020). Issues related to confidentiality, interview bias, role designation, power imbalance and assumptions influencing participants were discussed and resolved within the research team. Focus groups were conducted by at least two researchers (PL, CB and/or FG). One member of the project team facilitated the discussion (FG or CB) and another member wrote notes (PL). Verification of interview back to interviewee for clarification was undertaken when clarification was necessary. Issues were drawn from the claims and concerns discussions, priority issues were established by the focus group consensus and an action plan was identified during each focus group (Guba & Lincoln, 1989).

Thematic analysis was undertaken using Creswell and Creswell's (2018) six-steps. The process of analysis is outlined in the Figure S1.

Initial codes were generated independently by two researchers and verified by two other researchers. The codes were organized into subthemes and then themes were developed, by the researchers, based on the best-fit, to capture succinctly and efficiently the key issues surrounding spring-infusor use.

2.6 | Knowledge mapping

Knowledge mapping was undertaken using a process with four steps based on Vail (Ebener et al., 2006; Vail, 1997) as outlined in Figure S2. The claims and concerns were considered in the planning and organizing of solutions (Damschroder et al., 2009), which will be implemented and evaluated, then reported as part of a larger knowledge translation study. The map included identification of (i) all key people consulted, that is, patient, parents, hospital clinicians, Central Venous Access Device (CVAD) staff, safety committee staff, Medical Technology and Maintenance Unit (MTMU, i.e. biomedical engineering unit) staff, infection prevention and control staff and equipment procurement staff, (ii) key knowledge, (iii) key resources, (iv) process flow from beginning to end to ensure all essential elements were identified and (v) identification and minimization of knowledge gaps.

3 | RESULTS

During the study period, 18 eligible children were admitted to hospital and of these 12 children and their parents were approached. Two children declined to participate and 10 children and 10 parents consented for the interview. Of those who consented, nine children (eight female) and six parents (all female) were interviewed. Characteristics of the patients are presented in Table 1.

Thirty staff (24 female) were approached to participate in an interview or focus group and all consented and were interviewed. Four focus groups were conducted with ward nurses (n = 5,5,5 and 2) and there were 13 individual interviews with nurses (n = 6) and other hospital staff (respiratory physicians (n = 2), physiotherapists (n = 2), pharmacists (n = 2) and biomedical engineer (n = 1)). Nurse roles included ward-based nurses, clinical nurse specialists, staff development educators, clinical nurse managers and HiTH nurses. Experience of staff interviewed ranged from new graduates (nurses) to those with more than 30 years' experience. Duration of interviews and focus groups was between 10–30 min. Table 2 details staff characteristics. About a third of the staff interviewed reported that they had worked in hospitals overseas or elsewhere in Australia. Table 2 outlines characteristics of health staff interviewed.

The key claims and concerns for both families and staff were organized into seven themes; Knowledge, skills, beliefs and attitudes, safety, wellbeing of patient, physical resources, equipment, and process, service efficiency. The themes and their subthemes are outlined in Figure 1.

3.1 | Knowledge

Patient and parent (henceforth called 'families') knowledge about spring-infusors varied from extensive to negligible as explained by Child 1: '*I learnt about them (Spring-infusors) for the first time (this admission), I didn't know what they were before*'. Adolescent 2 demonstrated much more knowledge: '*It (Spring-infusor) slowly releases the*

TABLE 1 Characteristics of patients and parents who were interviewed

Patient ID	Sex	Age (years)	Parent
Adolescent 1	F	13.9	No
Adolescent 2	F	15.7	Mother
Adolescent 3	F	17.3	No
Adolescent 4	F	16	No
Adolescent 5	F	13.1	No
Patient not interviewed	M	18.6	Mother
Adolescent 7	M	14.1	Mother
Child 1	F	12.8	Mother
Child 2	F	12.9	Mother
Child 3	F	12.0	Mother

Note: Key: Children less than 13 years old are referred to as children and children aged 13 years and older are referred to as adolescents. F=female, M = male.

TABLE 2 Characteristics of health staff interviewed

Code	Sex	Designation
FG1	F	Focus group ward nurses
FG2	F	Focus group ward nurses
FG3	F & M	Focus group ward nurses
FG4	F	HiTH nurse and clinical nurse manager
N1	F	CF nurse
N2	M	Ward nurse
N3	F	Respiratory nurse specialist
N4	F	Respiratory equipment & consumables nurse
N5	F	CVAD nurse specialist
N6	F	Ward clinical nurse manager
P1	M	Pharmacist
P2	F	Pharmacist
PT1	F	Respiratory physiotherapist
PT2	F	Respiratory physiotherapist
C1	M	Respiratory physician
C2	M	Respiratory physician
B1	M	Biomedical engineer

Note: Key: F = female, M = male, CF = cystic fibrosis, HiTH = hospital in the home.

medicine through a controlled tubing, which controls the amount of IV fluid thing being pushed through…I use them a lot'.

Amongst nurses, knowledge about spring-infusors was variable. A minority were not aware of the device at all: '*I've never seen one, what is it?'* (Focus Group 1). Nurses who worked on medical wards (where younger children were admitted) were less likely to have knowledge of the device. Some nurses reported that finding information about how to use the device was difficult '*There's no policy available'* (Focus group 2) and '*There was very inconsistent information on their use'* (Nurse 2). There was also a lack of knowledge about device storage, whose role it was to clean it and what cleaning was required to meet infection control requirements: '*…I'm unsure of how to clean inside it?'* (Focus Group 3), '*How are they cleaned in between each patient? That's the other thing 'cause they're not as easy to clean…'* (Nurse 3) and: '*I would think every surface (outside and inside) will need to be cleaned…'* (C2).

In contrast, nurses who worked on the adolescent ward were more knowledgeable and reported frequently using spring-infusors: '*We use spring-infusors … and we have a supply'* (Focus group 4). They were aware of the relevant Clinical Practice Guideline that included cleaning instructions: '*Yeah, there is a policy…it's not complicated'* (Focus group 4).

3.2 | Skills

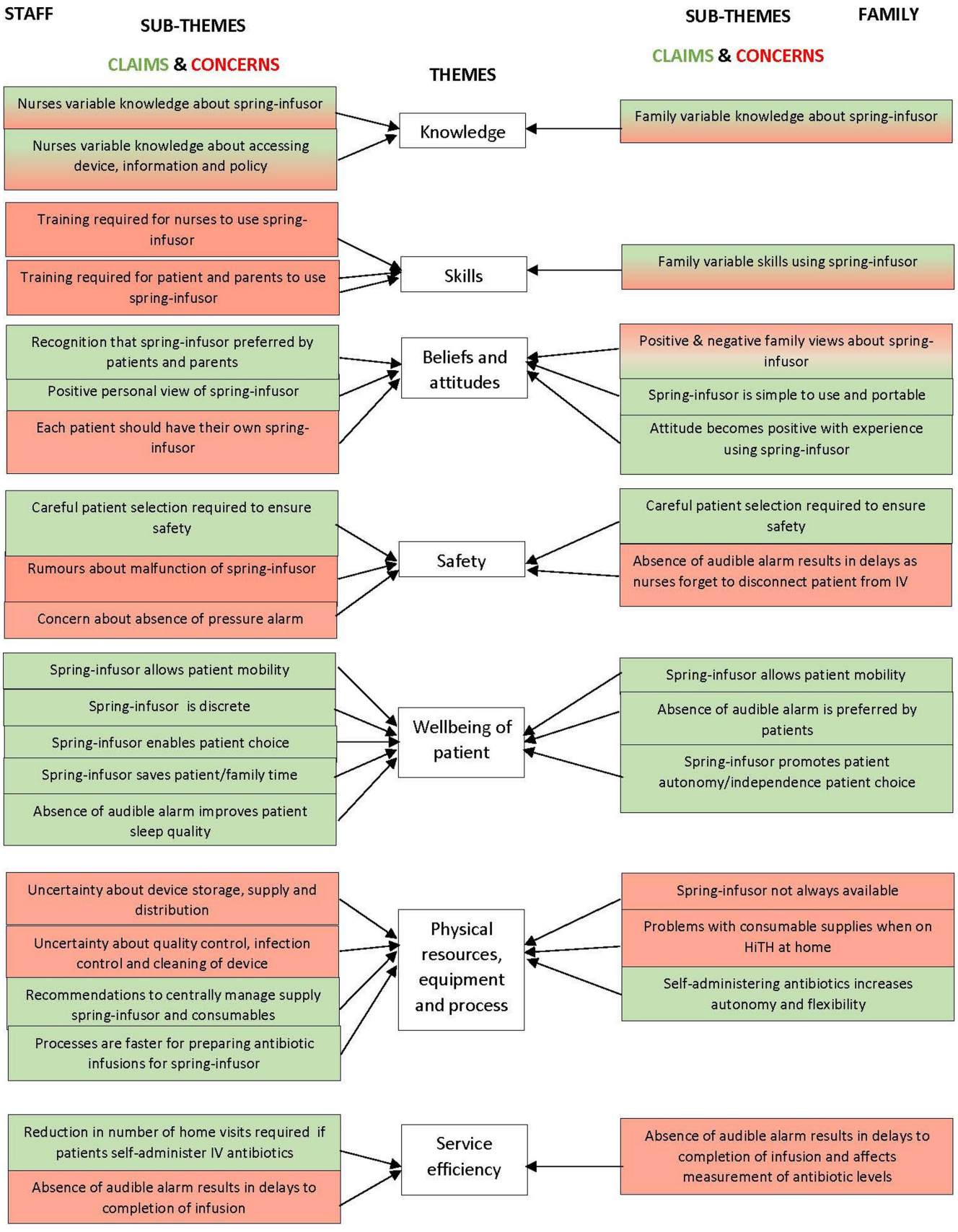
The skills of families using spring-infusors varied from being independent and confident to no skills: '*…we didn't know how to use them or how they worked'* (Parent of child 1). Some patients were trained and independent in administration of IV infusions: '*I have proved to be competent with the nurses. That's why I have the extensions so I can do it myself'*. (Adolescent 2).

There were consistent views that nurses required specific skills. All nurses agreed that training was required to be able to use spring-infusors and was a reason for not using the device: '*No-one has had education…so we don't use spring-infusors…'* (Focus group 1). Nurses recommended two training approaches; by (a) an instructor and (b) by using a train-the-trainer approach supported by the resource of the spring-infusor clinical practice guideline: '*We can easily "train the trainer" for nurses who are competent to use the spring-infusor to train those who don't know how to use'* (Focus group 3). In addition, there was a recognized need for ongoing training for nurses: '*…some nurses don't know how to use them'* (Focus group 1).

Further, nurses agreed that if parents or patients were to become independent users of the device then training and skills assessment would be required: '*The nurse still has to at least watch them (patient/parent) once and sign them off using the family education competency form, which is a part of CVAD'* (competency assessment) (Focus Group 4), and '*If (we) were sending parents' home with it (spring-infusor), it needs to be included with some education with our package of stuff they give… I think it would just be… robustness around making sure we've got the cleaning right; we've got the education right, so parents know we need to flush it straight away…'* (Nurse 5).

3.3 | Beliefs and attitudes

Families who had experience using spring-infusors held positive attitudes and preferred them to electronic infusions pumps or other types of portable infusion pumps such as the Baxter (Baxter International Inc., Illinois, USA); a portable 24-h infusion that is placed in a back-pack and carried by child. The reasons spring-infusors were



Key: Green=claim; re=concern; mixed green/red=both a claim and a concern. HiTH=Hospital in the Home; PICC=Peripherally inserted central catheter, IV=intravenous.

FIGURE 1 Staff and family claims and concerns themes and sub themes

preferred included ease of use, simplicity, portability: '*I like them—they're more portable*' (Child 4), and because they were mechanically more robust: '*The spring-infusors can't malfunction as they are not an electric pump*' (Parent of Adolescent 2) and involve less time: '*They used a Baxter pump (one admission) …it was just annoying having it constantly attached to you. Whereas spring-infusors—it's kind of over and done with quickly*' (Adolescent 2).

In contrast if they had no previous experience using spring-infusors, some families reported how they preferred the standard electronic infusion pumps: '*…the spring-infusor had to have a big, long line attached to me all the time. And it kept like getting in the way and getting pulled and getting caught on things and pressing on my skin. So, it was really, really annoying… I didn't like it.*' (Child 1), and '*…the whole process of having the nurse come in and out (for spring-infusor), like you have to watch when it's done, and it doesn't beep when it's done. You've got to sort of be aware of it for much longer…*' (Parent of Child 1). During a subsequent admission, however, the same parent later reported how her opinion changed: '*She (child) did use them (spring-infusor), and they were great. I think it helps to have some time to get used to them… The first time we didn't know how to use them or how they worked, and we were unsure*'.

Beliefs and attitudes about spring-infusors were mainly positive amongst nurses and doctors. There was widespread agreement that patients with CF preferred the spring-infusor, and that was the chief reason or justification for using them: '*Happy parents and patients make nurses' job more pleasant and spring-infusors are preferred by patients and families*' (Focus group 1) and '*I love them (spring-infusors), (CF) kids love them, families love them*' (Nurse 1). As pointed out by a respiratory physician: '*They (spring-infusors) seem very useful…more portable*' (C1).

Several staff suggested patients with CF could be allocated their own device rather than recycling: '*My preference is to keep them with patient as there are concerns over new infection risks in CF*' (Nurse 6). This would also avoid concerns about infection control risks with multiple users: '*If there is a legitimate concern with not re-issuing the device, and there are not large numbers of patients requiring them, we could potentially supply the family with their own device*' (C2).

3.4 | Safety

The safe use of spring-infusors was reported positively by some of the children: '*Yeah (spring-infusors are safe) …the stat lock (securement dressing) keeps it (the peripherally inserted central catheter, (PICC) line) still…it's not gonna go anywhere as its (the spring-infusor) not heavy enough to pull the line out*' (Adolescent 2) and their parents: '*The spring-infusors can't malfunction as they are not an electrical pump*' (Parent of Adolescent 2). Conversely some families expressed safety concerns: '*I don't think they should be used in very young children as they might pull on the line*' (Parent of child 1) and '*I have recorded having very high platelets, so, a timely flush is important and so if that doesn't happen, that's a bit of an issue*' (increased risk of intravenous access device blockage/thrombosis) (Adolescent 2).

Safe use of spring-infusors related to appropriate patient selection and the mechanical nature of the device. There was staff consensus that the device was safe if used by appropriate patients, that is, their age, understanding, skills and competency: '*In all my years (>15 years), I've never seen them fail, bearing in mind that I'm in there all the time when their having their IVs (antibiotic infusion). I've never seen them fail and I've seen 4-year-olds setting them up under supervision*' (PT2).

However, when staff were asked about why they thought the device was rarely used in the hospital, a perception or rumour was reported that use may have been stopped because of safety concerns, although there was some uncertainty about the basis of the safety concerns. Three staff participants outlined details of the same safety concern rumour: '*…this product doesn't have an inherent design that would allow it to fail safe… but a …robotic infusion pump will monitor the infusion…the pressure…if there's any sort of occlusion in the tubing it will stop, …So, it's more likely to fail-safe …spring-infusor doesn't do that…I have been lobbying the TGA to deregister the device*' (B1).

Another reason reported by staff for reduced use was a perceived high failure rates of CF patients' PICC lines which was thought to be in part related to spring-infusors: '*PICC lines had a really high failure rate…about 50%… And there was a really big thought and thinking around, was it the spring-infusor?… So, the spring-infusors went off to MTMU and had pressure testing and were found to have unreliable and really high pressure*' (Nurse 5). There were also reports of additional device malfunctions that had likely become amplified or embellished over time; '*There was one incident, it was recorded that a spring out of one of the spring-infusors exploded and hit a wall or a window or somewhere in the hospital and then it was like, almost like, shut down. We can't use them, these are too dangerous, it nearly took somebody's head off. And there was a big push back (to not use)*' (Focus Group 4). The above concerns were investigated and found to be inaccurate and unjustified.

3.5 | Wellbeing of patient

Patient wellbeing was a reported positive for all users. The benefits were related to the improved mobility afforded, no alarm noise and the discrete appearance of the device when worn under clothing. Adolescent 3 reported: '*its portable…you're more free with it … I move more when I use the spring-infusor. I move around the room. I wouldn't do that attached to my (infusion) pump*' and greater autonomy and independence: '*Yeah, (don't have to wait for nurses to do IV antibiotics) …I go to school every time now with that 'cause I don't have to lug a pole around I can do my own (IV antibiotics)*' (Adolescent 4). An important benefit using spring-infusor was that there was no alarm noise compared to the electronic infusion pump which did have alarms. This enabled improved sleep quality: '*Yeah I can sleep with it. Instead of it (the electronic alarm) just screaming*' Adolescent 2. An additional benefit reported by children was improved mental wellbeing related to the spring-infusor being less visible and less of an obvious reminder about illness: '*It is less obvious, and I can go to school because I don't*

have to do the IVs at school. The Baxter is embarrassing, and other kids ask questions. I don't go to school with that because of bullying and it is heavy' (Child 3) and: *'Cause if you're…attached to something for too long, you just feel…more sick…you're kind of stuck. A type of sick reality'* (Adolescent 3). There was no reported negative wellbeing impact of using spring-infusors.

For staff, patient wellbeing was also considered the key reason for favouring spring-infusor use: *'I think it makes kids feel less sick if they are not tied up and attached to something…so it's a bit more normal, social interacting and movement…they still look sick if they are carrying around their pole as opposed to their spring-infusor which they can put into their pocket'* (PT2). Almost all staff agreed that most patients with CF preferred the spring-infusor to electronic infusion pumps: *'When they're connected to the IV (electronic infusion pump), particularly these new ones that alarm 5-min before they finish…they alarm every 30 s…it drives the kids nuts, they hate it'* (PT 2). Promoting patient and family centred care was a priority for staff: *'And the most important part is its (spring-infusor) going to save the families and their quality of life'* and *'Spring-infusors help the family out most importantly…it gives them a huge amount of autonomy… spring-infusors give patients another choice'* (Focus Group 4).

3.6 | Physical resources, equipment and processes

Problems with and concerns about device and consumables supply and performance were reported. Lack of availability was a key concern that influenced spring-infusor use: *'Sometimes I have had a (electronic) pump as there are no spring-infusors on the ward. There's sometimes a short supply of them'* (Adolescent 2). Other patient concerns were related to experiences with human error such as use of incorrectly sized control tubing (the tubing required to control flow from the infusion device) *'HiTH is a nightmare with these (control tubing). They (nurses) bring in the wrong ones…which takes 12 h or something stupid…'* (Adolescent 2). Another consumable problem experienced was the control tubing splitting: *'It (control tubing) just split, and the bed got all wet'* (Child 2).

Positive differences in processes of spring-infusors over standard infusion pumps included patients being able to self-administer IV antibiotics with spring-infusors. This benefit was highlighted by one patient who described how self-administering IV antibiotics resulted in increased autonomy and flexibility: *'If, say we're in the car and were doing my IVs, I can do it'* (Adolescent 2).

Further, maintaining the device supply process was through patients returning the spring-infusors following discharge from hospital and then recycling the devices for other patients to use. *'We bring them (spring-infusors) back after (discharge from HiTH) here (to hospital)'* (Adolescent 2).

Concerns about spring-infusors use at the hospital were articulated by nurses related to quality control and availability of the device. There was uncertainty about whose role it was to perform quality control checks: *'We don't know if they're being thrown away when the used by date is finished …And then… there are risk of device fracture and breakage'* (Nurse 5), which department purchased the device, and whose responsibility it was for ordering devices: *'Our manager stopped purchasing as the spring-infusors were not being returned'* (Focus Group 2). There was also a very limited supply: *'Spring-infusors were disappearing as quick as masks are being used here!'* and *'We hide them so that other ward staff don't come and take them'* (Focus group 4).

All nurses agreed that if purchasing and funding for the spring-infusors was enabled, then they would be more likely to be used: *'Our nurse manager orders them, and our ward has to pay. If we could get them well funded and we were not worried about them disappearing, then we would store in equipment bay'* (Focus group 3). There was consensus that if spring-infusor supply was coordinated by a centralized service such as the Equipment and Consumables Services (ECS), then most concerns surrounding quality and infection control and supply could be resolved: *'It would be best managed in ECS for expiry, servicing, cleaning, supply, monitoring and replacement'* (Focus Group 3).

From the perspective of pharmacists who prepared antibiotic infusions, there was an advantage to using spring-infusor infusions compared to electronic infusion pump (Baxter) infusions. Spring-infusor infusions were prepared inhouse and Baxter infusions were externally prepared. The Baxter infusions could take up to 24 h to be delivered and potentially delayed patient discharge to HiTH: *'if an infusion is put through the spring-infusor or whether it's put through a pump—it's the same cost and timing and preparation … the Baxter infusion does take a lot more steps 'cause we do have to do the paperwork, order it from Baxter…if we don't get enough notice, that delays the (patient) discharge'* (P2).

3.7 | Service efficiency

The spring-infusor does not alarm to prompt when an infusion is complete. The absence of an alarm was reported as both a positive and a negative feature. No alarm resulted in patient frustrations and inefficiencies when nurses were not prompted to flush or disconnect lines on completion of an infusion: *'They (nurses) will leave it for ages if they cannot hear (no audible alarm) …It can take an hour or so (once infusion finished before nurse attends to disconnect) …they (nurses) got to do it (tobramycin blood level) on a special time. And if they are forget… because it's not beeping …then you have mucked up timing for your levels'* (Child 2).

Most nurses reported how efficiency was increased when patients participated in their own antibiotic administration. This resulted in nursing time saved in hospital and for HiTH patients, a reduction in the number of home visits by HiTH nurses: *'if we're not going to see the patient with the spring-infusor, we can see another patient out of the hospital that may be needing a dressing or another antibiotic…it gives us capacity for more efficiencies'* (Focus group 4). Conversely in the hospital environment, some nurses reported how for them using spring-infusors negatively impacted efficiency due to the absence of alarm prompts. This could result in nurses forgetting

to complete antibiotic administration: *'The problem is, you got to set them up, then you get caught up doing a thousand other things and you forget'* (Focus group 3).

3.8 | Knowledge mapping

Prior to the mapping process, five hospital level approvals were identified as being required to enable spring-infusor use: (1) Infection Prevention and Control team to stipulate cleaning instructions, (2) Medication Safety Committee to determine appropriate patients and medications approved to use with the device, (3) Product Evaluation and Standardization Committee to test the device to determine if the device performs as expected, (4) MTMU to approve the device following other departmental approvals, (5) Spring-infusor Clinical Practice Guideline to be updated. Each of the approvals involve input from several senior clinical staff across multiple departments. The knowledge mapping was based on these three approvals occurring in a timely manner.

Three key phases were identified for the implementation of spring-infusor use for patients with CF in the hospital setting; preparation, use and return of the device. Within the three phases, a total of 10 individual steps were identified to ensure efficient, safe, and quality controlled use of the device. Figure 2 outlines the process.

4 | DISCUSSION

Spring-infusors were preferred by patients with CF and their families because the relatively small and simple device allowed for greater mobility and reduced exposure to unnecessary alarms. Families who initially had concerns about spring-infusor use generally found that their concerns were allayed after using and becoming more familiar with the devices. Spring-infusors were also preferred by nurses who placed a high priority on patient and family centred care. Reasons for the less-than-routine use of spring-infusors despite patient and clinician preference included misconceptions about the safety of spring-infusors and concerns about the lack of alarms, even though the absence of unnecessary alarms were considered a huge advantage by patients and families. We discovered a complicated intra-hospital process for vetting, procuring, ordering, storing and replacing IV administration (and other medical) devices. This process was generally not known to most clinical staff. Our research highlights the need for hospital clinicians who are involved with direct patient care to have a working knowledge of hospital processes including medical device acquisition and logistics to facilitate use of devices that are preferred by patients and their treating teams.

Most staff reported they were aware that spring-infusors were preferred by patients with CF, and therefore, its use should be promoted. Patient and family centred care in paediatric hospital contexts is accepted as central to the health and wellbeing of children and their families and recognized as contributing to better health outcomes (Shields et al., 2015). Patient and family centred care is a widely used model in paediatrics and is preferred over provider-led care as there is growing evidence of positive patient health outcomes and adherence to healthcare requirements for patients (Gallo et al., 2016). This example of investigating how to increase spring-infusor use highlights how the hospital staff held favourable attitudes toward interventions that are patient and family centred, specifically those that normalize family functioning as much as possible within the healthcare setting. Further, nurses were positive about training patients and their families in self-management of IV infusions to promote a level of autonomy in their child's medical care. These encouraging findings are consistent with the Australian Safety & Quality Standards (Australian Commission on Safety and Quality in Health Care, 2017) outlining how health services should support partnerships with patients and families so that patients can be actively involved in their own care (Australian Commission on Safety and Quality in Health Care, 2011).

Although the spring-infusor device is mechanically simple, user friendly and reportedly promotes wellbeing and mobility for patients, the simplicity and absence of alarm prompts presented some challenges to nurse work practices and impacted attitudes. Spring-infusors do not have a sound alert to notify completion of

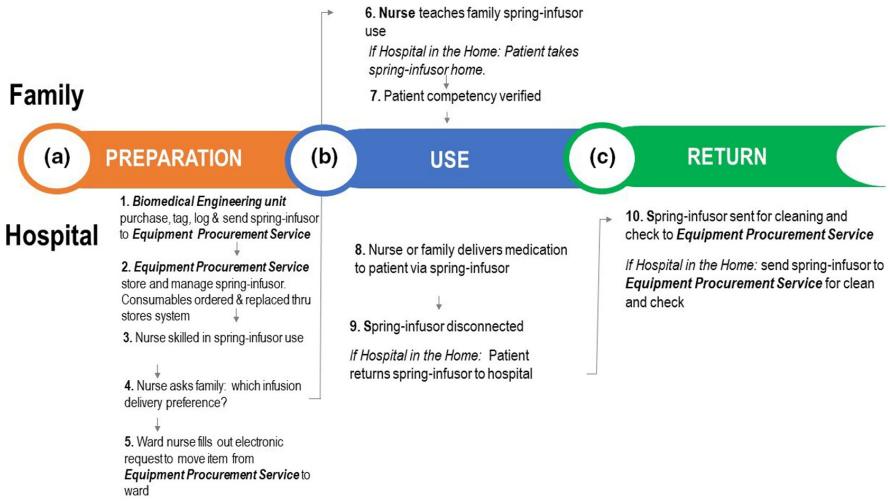


FIGURE 2 Knowledge map of spring-infuser use for patients with cystic fibrosis

an infusion. The absence of alarm was presented with both positive and negative consequences by families and staff. Patients, families, and nurses reported the absence of alarm contributed to nurses not prompted to return to the patient to flush the IV access device on completion of the antibiotic infusion, creating frustration for some families. The purpose of flushing (with 0.9% saline solution) an IV access device is two-fold; to ensure the full dose of the antibiotic therapy is delivered to the patient, and importantly, to reduce IV access device failure due to mechanical occlusion of the lumen by blood clots. If a patient's IV access device becomes occluded, replacement by reinsertion of a new IV access device is required to permit completion of therapy. Ullman and colleagues' systematic review of complications of central venous access devices in children found that, due to occlusion or blockage, PICC lines (commonly used devices for administration of IV antibiotics for this patient population) had a pooled incidence rate of failure per 1000 catheter days of 2.2 (95% CI 1.7–2.8) (Ullman et al., 2015). Reinsertion of an IV access device involves an additional procedure, and in the context of paediatric patients with CF who receive long term IV therapies, the more IV access devices the child has had previously inserted, the more complex the procedure becomes (Ullman et al., 2015).

Avoidance of IV access device failure is clearly important for patients, their families and the health system. In this context the consequence of no alarm to prompt nurses to administer an IV flush was associated with longer spring-infusor connection time, not IV access device failure. The absence of an alarm was reported as a benefit by reducing unnecessary noisy interruptions. Reducing noise may also improve patient safety and wellbeing. By reserving alarms for patient safety conditions there is a reduction of noise/sensory overload and alarm fatigue. Indeed, the Joint Commission Division of Healthcare improvement has warned how excessive alarm sounds can blend into background noise and be ignored (Mitka, 2013).

Despite advantages of using spring-infusors identified by patients, their parents and clinical staff, multiple uncertainties and complexities were revealed through the knowledge mapping process. The complexities included lack of staff knowledge about hospital policy and device safety and perceptions, rumours or myths about previous device malfunctions. We discovered a complicated intra-hospital process for vetting, procuring, ordering, storing, and replacing medical devices including IV administration devices. Similar complexities within the hospital system were reported in a recent Australian study, which identified 12-key steps required to facilitate successful medical follow-up for Aboriginal children hospitalized with acute chest infections (Laird et al., 2021). Mapping and then following the 12-steps was important in ensuring this vulnerable group of patients received timely medical follow-up to prevent serious long-term morbidity.

In our study, one of the main barriers to the use of spring-infusion devices was negative staff attitudes toward the devices, caused by multiple, mainly unsubstantiated concerns. This information now provides us with an understanding of the mechanism of action through which appropriate behaviour change techniques can be selected. Carey and colleagues synthesized the reported links and associations between behaviour change techniques and mechanisms of action (Carey et al., 2018). To target changing staff attitude, it will be critical to include provision of information addressing misinformation about spring-infusor safety and increase knowledge about improved health and social and environmental consequences for patients (Carey et al., 2018). This new information will enable a theory informed approach to designing an intervention to change healthcare staff behaviour.

While our study investigated patient and staff views of spring-infusors, it was limited to one hospital, and focused on patients with CF, rather than patients with other conditions who might also benefit from spring-infusor use. However, many staff had worked at other hospitals and included perspectives from these experiences also. Further, extensive views were gathered from hospital staff who care for patients across a broad spectrum of health conditions, suggesting the findings may have wider application to other patient groups.

5 | CONCLUSION

The use of spring-infusors for IV antibiotic delivery is preferred by paediatric patients with CF and their parents who cite improved mobility, autonomy, and patient wellbeing during the hospital admission as well as HiTH. The absence of an alarm prompt was both a positive and negative device feature. Staff acknowledged that facilitating patient and family centred care was the most important reason to support using spring-infusors. Some misconceptions were held, and numerous procedural challenges contributed to their suboptimal use. Process mapping within the hospital highlighted 10 key steps required to facilitate increased use of spring-infusors. Hospital based clinicians should have a working knowledge of processes around medical device acquisition and logistics to facilitate use of devices that are preferred by patients their treating teams.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICAL APPROVAL

Ethical approval was granted by the institutional Human Research Ethics Committee (RGS3880).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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