Title: Implementing Selective Digestive Decontamination in the intensive care unit: A qualitative analysis of considerations identified by critical care nurses

Abstract (350 words)

Background: Critically ill patients are at increased risk of developing hospital acquired infections such as ventilator-associated pneumonia (VAP). Selective decontamination of the digestive tract (SDD) involves application of topical, non-absorbable antibiotics to the oropharynx and stomach plus the administration of a short course of intravenous antibiotics. SDD is one strategy that has been shown to prevent VAP and improve survival in the critically ill.

Objective: To describe critical care nurses' knowledge of SDD and factors they consider important for implementation of SDD either in the context of a clinical trial or as a component of clinical practice.

Design: In 2011, we conducted a Delphi Study that formed phase two of a multi-methods study undertaken in Canada, the United Kingdom (UK) and Australia/New Zealand (ANZ).

Participants: One hundred and forty one participants provided data for the interview component of the Delphi Study. Data from the twenty senior critical care nurse participants are the focus of this paper.

Methods: We performed a secondary analysis of qualitative data obtained from interviews conducted with senior critical care nurse participants during the Delphi study. Data were obtained during telephone interviews conducted by researchers in each region using a pre-specified topic guide.

Results: Few participants had direct experience with, or detailed knowledge of, SDD. Education about SDD as a strategy to prevent VAP and techniques for administration was highlighted requirement before implantation could be considered. Patient experience was identified as an important consideration with concern expressed for patient comfort during application of antibiotic paste to the buccal cavity and risk of diarrhea. Compatibility of SDD with existing practices, such as mouth care and enteral feeding was considered important if planning an implementation of SDD. At an organisational level, participants highlighted the potential for increased costs associated with SDD consumables and increased work time as a potential factor that might impact implementation.

Conclusions: Despite a lack of direct experience with, or knowledge of, SDD, nurses were able to articulate factors that may influence implementation and delivery of SDD – either in clinical practice or in the context of a clinical trial. Organizations or researchers considering implementation of SDD should include nurses as key members of the implementation team.

Key Words (4-10 in alphabetical order): antibiotic prophylaxis, critical illness, implementation, selective decontamination of the digestive tract, ventilator-associated pneumonia

What is already known about this topic

- Critically ill patients are at risk of developing hospital acquired infections which are associated with increased morbidity, mortality and health care costs
- Selective digestive decontamination can reduce the incidence of hospital acquired infections
- There is limited uptake of SDD in clinical practice internationally

What this paper adds

- In countries with low rates of SDD adoption, nurses require education to ensure accurate knowledge of SDD components and practices
- Compatibility of SDD with existing clinical practices should be considered prior to implementation
- Nurses can make important contributions to the identification of clinical and organizational factors that should be considered to facilitate successful implementation of SDD

1. Background (max 7,000 words)

Hospital acquired infections (HAI) are the most common complication affecting hospitalised patients (Productivity Commission, 2009) with critically ill patients at risk because of advanced age, severity of illness, poor nutritional status (Richards et al., 2003) and the need for invasive devices. (Doyle et al., 2011) It is estimated that more than half of ICU patients would have an infection (Vincent et al., 2009) and most of these will have originated in the respiratory tract. In particular critically ill patients who require intubation and mechanical ventilation are at risk of ventilator-associated pneumonia (VAP). Infection acquisition while in the intensive care unit (ICU) is associated with higher rates of morbidity and mortality (Poissy and Senneville, 2011) emphasising the need to prevent infectious complications during critical illness.

Nurses play an important role in implementing and monitoring the effectiveness of HAI and VAP prevention strategies and thus must demonstrate the requisite knowledge, skills and attributes to ensure relevant evidence-based recommendations are implemented into clinical practice. (Vandijck et al., 2010) Evidence-based guidelines for VAP prevention are widely

available. (Muscedere et al., 2008, National Institute for Health and Clinical Excellence, 2008, American Thoracic Society and Infectious Diseases Society of America, 2005) In some regions, implementation of 'care bundles' for VAP prevention has been strongly supported by professional societies and government agencies and there is some evidence that implementation of VAP bundles reduces VAP rates despite variable compliance with recommendations within the bundles. (Morris et al., 2011)

Selective digestive decontamination (SDD) is a prophylactic strategy which aims to reduce infections and improve mortality in critically ill patients by eradicating potentially pathogenic microorganisms (PPMs) in the oropharynx and digestive tract. (Silvestri and van Saene, 2012) SDD involves four components: 1) a four day course of parenteral antibiotics to control PPMs present on admission; 2) administration non-absorbable antimicrobials (normally polymyxin E, tobramycin and amphotericin B) to the oral cavity and gastrointestinal tract; 3) continuation of standard hygiene measures to control exogenous infections; and 4) cultures of the throat and rectum on admission and then twice weekly to assess the efficacy of SDD and identify emergence of resistant bacteria. (Liberati et al., 2004, Silvestri et al., 2005)

SDD is one intervention that, when fully implemented, has been shown to prevent VAP and improve survival (de Smet et al., 2009, van Essen and de Jonge, 2011), yet uptake into clinical practice is not widespread internationally and only one evidence-based guideline on the prevention of VAP recommends that SDD be considered for patients ventilated for more than 48 hours. (Masterton et al., 2008) Despite some uncertainty about the effectiveness of SDD and perceived risk of increased antimicrobial resistance, it is quite possible that critical care nurses will be required to implement SDD, where implementation includes four overlapping processes of adoption, operationalision, provision and surveillance. There is, however, relatively little collective experience amongst critical care nurses worldwide in

delivering this intervention and a paucity of research that specifically addresses nurses' beliefs and concerns about using SDD. The aim of this paper is to describe factors senior critical care nurses considered identify as important for the implementation of SDD either in the context of a clinical trial or as a component of clinical practice.

2. Methods

2.1. The parent study

In 2010-2012, a multi-methods study was undertaken in Canada, the United Kingdom (UK) and Australia/New Zealand (ANZ) to develop an understanding of issues related to current lack of adoption of SDD and considerations for its implementation into clinical practice. (Cuthbertson et al., 2010) Stage 2 of this study used the Delphi technique to identify stakeholders' (including critical care nurses') self-reported knowledge of SDD as well as their beliefs, views and perceived barriers to adoption and implementation of SDD. The first Delphi round comprised semi-structured qualitative interviews conducted in the three regions. The interview topic guide was based on the Theoretical Domains Framework (Michie et al., 2005) and also incorporated questions to elicit participants' views on the conduct and design of SDD research. The interviews were conducted after establishing a shared understanding of SDD which was the application of topical, nonabsorbable antibiotics to the oropharynx and stomach and a short course of intravenous antibiotics. (Cuthbertson et al., 2010) Ethics approval was obtained from relevant institutional review boards and each participant gave informed consent prior to the conduct of the interviews.

In each region, purposive diversity sampling, with a target sample size of 40 participants in each of the four stakeholder groups, was used to identify stakeholders considered leaders in their clinical areas who were in a position to influence clinical decisions. One hundred and forty one participants completed the interview component of the Delphi study. The four

stakeholder groups were: intensivists, medical microbiologists / infectious disease specialists, critical care pharmacists and ICU clinical leaders which included both medical and nursing clinical leaders. Typically the Delphi technique is used to obtain consensus of *expert* opinion (Hasson et al., 2000). In this study we have used the Delphi technique to measure, rather than determine consensus on SDD. However, as few nurses in these regions had direct SDD experience, we conceptualised expertise more broadly to include nurses in leadership positions who would be likely to contribute to decision making within the ICU with regard to any future implementation of SDD.

2.2 The subgroup study of nurse participants

We conducted a secondary analysis of qualitative data from nurse participants during interviews conducted as part of the Delphi Study (Cuthbertson et al., 2010) to allow for a more in-depth and specific exploration of question(s) different from those posed in the parent study. (Hinds et al., 1997) We specifically analysed a subset of interviews (Thorne, 1998), where the participants were clinical nurse leaders, in order to conduct a similar but more focused analysis than was conducted in the primary study and consequently develop an understanding of issues nurse participants identify as important to consider for the implementation of SDD.

2.2. Data collection

Audio-recorded telephone interviews lasting 20 to 60 minutes were conducted in each region following the pre-specified topic guide. Interviews were transcribed verbatim; all identifying information was removed to maintain privacy and confidentiality.

2.3. Data analysis

In conducting this secondary analysis we employed an inductive approach (Thomas, 2006) where detailed readings of the raw data informed the development of specific concepts and themes. Interviews were read multiple times by and initial themes were developed. Similar to pattern coding but without the determination of causes or explanations, this analytic strategy reflects the general approach to qualitative data analysis proposed by Miles and Huberman (1994) (p. 69-71). Data were coded into themes using NVIVO 9 software**.**

2.4. Participants

Of the 141 participants in this study, 20 were senior critical care nurses. The interview data from these 20 nurse participants are the focus of this paper. Eight participants were from Canada, six from the UK, and six from Australia/New Zealand. Participants are identified by their country of origin (ANZ – Australia and New Zealand; CA – Canada; UK – United Kingdom) and participant number. The majority (ANZ – 5; UK – 5; CA – 7) were female and worked in a tertiary level ICU (ANZ – 4; UK – 4; CA – 8). The mean length of ICU experience was 22.1 years (ANZ=22.5 years; UK=19.8 years; CA=24.4 years).

3. Findings

While many participants were not familiar or did not have experience with SDD they were able to identify issues they felt might impact the implementation of SDD in the clinical setting. Knowledge regarding SDD was low amongst most participants who provided their views on SDD following establishment of a shared understanding of the intervention. Knowledge of SDD was considered essential before implementation into clinical practice. Participants were also able to articulate issues related to the impact of SDD on the patient, nursing practice or the organisation.

3.1. Knowledge

Participant knowledge of SDD was variable. Many participants had no personal knowledge of SDD and reported this lack of SDD knowledge was common amongst their colleagues. One participant commented that "…most of us don't know about it…" (UK4501). Another said that "it would be a completely new idea for the vast majority of Australian intensive care nurses" (ANZ201). There were misconceptions regarding the rationale for SDD. One participant believed it was used to "prevent gut-related infections" (UK4501). Another believed it was "a bowel and gastric stimulant to…expedite the flow or the processes within the gastric system" (CA9) The link between SDD and VAP prevention was also unclear. One participant suggested SDD was primarily a physician responsibility because SDD "wasn't nursing" but "if we were talking about VAP, to me that's all nursing". (CA31) Nevertheless, understanding the rationale underpinning clinical practice was perceived as important. One participant commented nurses like "to know why they're doing things, especially in the critical care area". (CA37) A small number of participants were able to provide an accurate and detailed description of SDD:

> *My understanding of SDD is administration of oral…topical types of antimicrobials and antibiotics parenterally as a prophylactic measure to reduce colonisation…so trying to reduce infection in the intensive care unit by a prophylactic administration of antibiotics in various formats… topical and IV (ANZ 202)*

Many participants were unable to distinguish between SDD and chlorhexidine for mouth care. Canadian participants frequently identified chlorhexidine as a strategy to "decontaminate the oral cavity" illustrating penetration of the Safer Healthcare Now! (Canadian Patient Safety Institute, 2012) care bundles.

> *I consider SDD to be anything to do with the decontamination of the digestive tract …. I would include in that what we'd just classify under mouth care …physical decontamination with a toothbrush, decontamination with chlorhexidine …*ANZ 201

Of the 20 nurse participants in this study, only two explicitly referred to the research on SDD. In recalling SDD as a treatment one participant indicated that it was "a while ago since I read this review from Europe" (ANZ 201) while another described that

> *...there are studies that come out each year, multiple studies coming out each year with regards to [SDD] and then you'll have, you know, there'll be a meta-analysis looking at it...you know you can only be guided by the people who do have experience in it and have researched it far greater than I have and there is still no clear consensus that it is the wonder treatment (*ANZ 203)

3.2. The impact on the patient

All participants expressed concern about the potential for SDD to cause increased bacterial resistance. The participants were also concerned about the possible impact of SDD such as the possibility of the paste "staining the teeth" or having any long term effect on tooth enamel (CA2). Participants expressed concerns related to potential adverse events such as aspirating the oral paste and dislodgement of the endotracheal tube as a result of manipulation that might occur during application of the paste and indicated this was more likely to happen if the patient actively resisted paste application.

The experience of the patient in receiving SDD as a treatment was a key consideration for most nurse participants. The oral component was identified as the one aspect of SDD that had the potential to be unpleasant, with the application of paste to the oral cavity and the taste of the oral paste being frequently identified as concerns. Participants identified the need to consider the patient experience as evidenced by the following comment:

I'm thinking of the patient, you know, having this antibiotic paste in your mouth. You already have the tube in your mouth. Sometimes we forget that these patients at times can still taste, or they have some level of consciousness…. (CA 22)

The risk of diarrhoea was a significant concern for most participants. Some participants perceived the use of SDD might make patients more susceptible to *Clostridium difficile* because "… you're potentially knocking out the flora in their gut, in which case they can get Clostridium, especially if they've had it before. That's not good." (CA37) If SDD resulted in diarrhoea concern for patient comfort and the impact on nursing work was articulated. The potential for increased resource use including laundry, nursing time and consumables, such as faecal management systems was identified.

The potential for antibiotics to increase diarrhoea incidence and then the management of that diarrhea… excoriations…and I would think the likelihood of using faecal management systems will increase because of that and that can be a good thing they they've not been around for a very long time so I suppose there's no known consequences, long term consequences for patients who have had to use them. ANZ 206

3.3. Impact on nursing practice

Participants acknowledged SDD might impact on other aspects of nursing management of the critically ill such as established practices for mouth care and enteral feeding which needed further investigation. Participants identified regular mouth care as fundamental for VAP prevention and elimination of dental plaque. They suggested that there would need to be "a lot of work with ensuring that mouth care is still of a very high standard and it [SDD] is not *instead* of mouth care" (UK1804).

Concern was expressed about the compatibility of SDD and enteral feeding. One participant and considered SDD as possibly being considered a "competing priority" (CA9) with enteral feeding. The potential for food in the stomach to interfere with antibiotics was raised as "some antibiotics aren't good with food…[and] have to be given on an empty stomach" (CA9). Participants also raised the issue of feed tolerance for some, but not all, critically ill patients and queried whether the gastric component of SDD administration was feasible in patients with intolerance to enteral feeds. For those patients where small bowel feeding is required for nutritional therapy, it may be difficult to administer the gastric component of SDD if a nasogastric tube did not remain in place.

Physical tasks and skills associated with SDD administration were not viewed as problematic although some participants acknowledged the amount of time it would take to deliver. Most participants believed critical care nurses have the skills required to administer SDD. However, given many participants were unfamiliar with SDD, questions were raised about ease of administration and the degree of skill required.

3.4. Impact on the organisation

Participants perceived the most significant impact on the organisation was the potential cost of SDD because "money is really tight" (CA31). Participants felt that this was a particular concern to nurses as they are generally responsible for day-to-day management of ICU budgets and are "the ones who pay for all the supplies and medications" (CA22). In addition to the medications and consumables, participants acknowledged laboratory costs associated with surveillance screening may create a further economic impost, especially for those ICUs where routine screening was not in place. (ANZ 206) As few participants' ICUs delivered SDD, the need for additional resources to educate nurses in the use of SDD was identified. Concern was raised that the a number of care improvement initiatives currently in place left

little scope for the introduction of a new practice as "people are saturated [but have] limited resources" and "there is so much in our face that we can't see the wood through the trees." (ANZ212)

A need for balance between costs and perceived benefit was highlighted with some participants questioning whether VAP rates were sufficiently high to warrant the introduction of SDD when other strategies were already established in practice and likely to be cheaper. .

> *Where you've got a high rate of VAP then you need to start with simpler cheaper options… SDD is a much more expensive option so I think you should address the more cost effective, simpler approaches first (ANZ 201)*

While the cost implications were raised as a concern, particularly for those nurses managing a budget, some perceived SDD implementation could be economically sensible if it resulted in improved outcomes for the patient and organisation.

> *…if you were confident that it was effective, well then the cost saved in…a patient not getting VAP and associated [decreased] length of [hospital] stay, length of ICU [stay], length of ventilator hours, all those things would certainly offset it [the cost] I'm sure (AUP 203).*

4. Discussion

SDD is one strategy shown to reduce VAP rates and mortality in critically ill, ventilated patients (Liberati et al., 2004). SDD is not widely practiced (Barends et al., 2008, Bastin and Ryanna, 2009) or even studied outside the European context. (Kollef, 2000, Misset et al., 1996) The lack of wide adoption of SDD within the regions in which this study was conducted may explain the variability in participants' knowledge observed in the data. Many participants stated that they didn't know what SDD was or why it might be used. Others had

misconceptions about what constituted SDD and its purpose suggesting that the primary intent was to either prevent gut infections or to stimulate the gastrointestinal system. Only one participant accurately described the full SDD protocol. (Silvestri et al., 2012) The lack of experience with, and knowledge of SDD, emphasises the need to ensure appropriate education is part of any implementation process for SDD.

The role of SDD in VAP prevention was not well understood by many participants. This is not surprising given few nurse participants had used SDD in current practice. Although currently available guidelines for VAP include SDD as a treatment strategy (American Thoracic Society and Infectious Diseases Society of America, 2005, Dellinger et al., 2008, Muscedere et al., 2008, Rello et al., 2010), only one recommend that SDD be considered for patients expected to be mechanically ventilated for more than 48 hours. (Masterton et al., 2008)

Many participants seemed to confuse the oral component of SDD with routine mouthcare using chlorhexidine. The reference was not to selective oral decontamination (SOD), which is the administration of oral antimicrobials and omitting the intestinal and parenteral components, (Silvestri and van Saene, 2012) but was specifically about the use of chlorhexidine when providing oral care. The use of chlorhexidine in oral care for critically ill patients is not uncommon. All participants working in Canada described the use of chlorhexidine as being part of their routine practice and this is likely influenced by initiatives driven through the Canadian Patient Safety Institute (2012) where oral decontamination with chlorhexidine is a key component of their VAP bundle. Participants from Australia and the UK described greater variability in the routine use of chlorhexidine as a component of oral care. While many VAP guidelines recommend the use of chlorhexidine in oral care it is important to differentiate chlorhexidine as an antiseptic (Koeman et al., 2006, Labeau et al.,

2011) from the use of topical, non-absorbable antibiotics that feature as a component of SDD. (Silvestri and van Saene, 2012)

The primary concern for delivering SDD to critically ill patients was the potential for development of antibiotic resistance. This is likely the most influential factor for the low rates of SDD adoption worldwide with concerns are well debated in the literature. (Kollef, 2000, Silvestri et al., 2011, Wunderink, 2010) While there is some literature suggesting that long-term use of SDD does not contribute to increased acquisition of resistant organisms (Ochoa-Ardila et al., 2011) further research examining the relationship between SDD and the development of antibiotic resistance is required.

Participants also described concerns about the potential for the antibiotic paste to stain the teeth or impact tooth enamel. The antibiotic paste used as part of the SDD regimen contains polymyxin E, tobramycin and amphotericin B. Neither polymyxin E nor tobramycin are readily absorbed by the gastrointestinal tract and are not routinely administered orally. Little data describes the effect of these medications on the teeth or oral cavity although there are reports that the use of amphotericin, in a lozenge form, may results in yellow staining of the teeth however this is easily removed by brushing. (MIMS Online, 2012). The impact of amphotericin as a component of the SDD oral paste is unclear.

Application of antibiotic paste to the oral cavity was identified as potentially unpleasant for patients although one participant with experience administering SDD suggested that very few patients refuse the treatment. Data is not available regarding patient perception of SDD administration however nurses administering SDD suggest that as many as 56% of non-sedated patients found application of paste to the oropharyngeal cavity bothersome and almost half (46%) of patients disliked the flavour of the oral paste. (Jongerden et al., 2010)

Though not identified by our study participants, there is a potential for accumulation of oral antibiotics. Clotted SDD paste has been identified in the oesophagus (2 patients) and the jejunum (one patient), (Smit et al., 2007) leading to recommendations for the removal of residual SDD paste prior to subsequent applications to prevent accumulation.

The risk of diarrhoea as the result of antibiotic administration was another concern. There are few reports of increased rates of diarrhea in patients receiving SDD. In Jongerden et al's (2010) survey of physicians' and nurses' opinions on SDD only three of the 1024 nurse participants identified increased diarrhoea as an effect of SDD. A small study of severely burned children (n=23) receiving SDD, diarrhoea was significantly higher in the SDD group (P=0.003) (Barret et al., 2001). It is possible that the use of broad spectrum antibiotics used in SDD might increase the incidence of diarrhea caused by *Clostridium difficile* however this toxin was identified in fewer than 0.5% of patients receiving SDD. (de Smet et al., 2009)

The introduction of a new treatment, such as SDD, was also considered in light of existing clinical practice such as mouth care and enteral feeding. Mouth care is an important aspect of nursing practice (Feider et al., 2010) and has been shown to reduce plaque biofilm that is a known source of infection. (Heo et al., 2008) Chlorhexidine is also commonly used in the provision of mouth care to critically ill patients. (Canadia Patient Safety Institute, 2012) Those participants regularly using chlorhexidine questioned whether there was the risk of interactions between the oral paste used in SDD and chlorhexidine. To our knowledge, there are no data available on this potential interaction to guide practice. The importance of regular mouth care for patient comfort, reducing plaque and preventing gingivitis was acknowledged. Some participants were concerned that the oral component of SDD might inadvertently lead to a decreased provision of mouth care and emphasized the need to ensure regular mouth care practices were maintained during any implementation of SDD.

The potential for increased nursing work was identified and is consistent with the perception of nurses administering SDD in a research context who consider SDD to be associated with a higher workload. (Jongerden et al., 2010) SDD does require additional nursing time to remove and reapply oral paste, as well as administration of the enteral and parenteral antibiotic components. (Silvestri et al., 2012) In the context of a group-randomized, controlled, cross-over multicenter study of SDD, the estimated median time to deliver the full SDD protocol was five minutes, two minutes longer than either standard oral care or SOD. With administration recommended four times per day (Silvestri and van Saene, 2012) the introduction of SDD could potentially impact existing nursing workload, though not appreciably.

The interaction between the enteral feeding solution and the antimicrobials of the enteral component of SDD was raised as a concern. As such interactions can increase, decrease or cause a delay in the bio-availability of antibiotics. However, this is not a concern given absorption of the antibiotics is not intended with SDD. (Zandstra and Van Saene, 2011) Polymyxin E is a component of SDD and oral does have been associated with increased gastrointestinal side effects (Fraga Fuentes et al., 1997) although these side effects have been reported at doses far exceeding what is used in SDD. (Silvestri and van Saene, 2012) It is possible that the administration of the enteral component of SDD simultaneously with the provision of enteral or oral nutrition might help improve gastrointestinal tolerance.

Administration of SDD to patients experiencing feeding intolerance was concerning. However, the enteral component of SDD comprises 100 mg polymyxin E, 80 mg tobramycin and 500 mg amphotericin in a 10 mL suspension (Silvestri et al., 2012) and is thus unlikely to be a concern even for those patients who might demonstrate reduced tolerance of enteral feeds. It is recommended that this suspension be delivered through the nasogastric tube

(Melsen et al., 2012, de Smet et al., 2009). Some patients experiencing enteral feeding intolerance might have a small bowel feeding tube placed. Recommendations for the delivery of the enteral component of SDD to patients receiving small bowel feeding without a nasogastric tube in situ are not currently available.

Many participants described feeling burdened by the amount of new practices being implemented and monitored in the ICU and questioned if either the organisation or individuals had the capacity to absorb more change. Implementing practice change requires significant effort and needs to be appropriately resourced to be successful. (Weinert and Mann, 2008) The introduction of SDD would require a significant educational component for nurses and their colleagues as well as changes to the way in which established practice (i.e mouth care) is delivered, both which are potentially resource intensive.

Many participants described budgetary responsibilities as a core component of their work and therefore expressed concern about the potential cost of the SDD medications, microbiological surveillance and increased nursing workload. Although estimated costs of SDD are reported at 10€ or $13 USD per day (Silvestri and van Saene, 2012), actual costs are not clearly described and likely to differ by region and product availability. SDD in patients undergoing liver transplantation has been estimated at $3100 USD (1997) per patient, inclusive of medication and surveillance cultures. (van Enckevort et al., 2001)

Concern about costs of SDD needs to be balanced with cost savings from reducing HAIs (Silvestri et al., 2012) At least four randomised controlled trials showing a lower cost per survivor when SDD was used. (Korinek et al., 1993, Rocha et al., 1992, Sanchez Garcia et al., 1998, Stoutenbeek et al., 1996) In a before-after study of antibiotic resistance and costs associated with SDD, no differences were reported in the total of ICU variable costs, microbiological and antibiotic costs between the 12 month period preceding the introduction

of SDD and the 12 months thereafter. (van der Voort et al., 2004) In contrast van Enckenvort et al. (2001) reported that SDD and routine cultures were associated with increased costs when used in patients undergoing liver transplantation highlighting the need for more complete and transparent economic analyses of this treatment.

5. Conclusion

HAIs remain an important issue that impacts on outcomes for critically ill patients. SDD is one strategy that could be used to decrease rates of morbidity and mortality associated with such infections. At present SDD is not widely implemented in ICUs worldwide and many nurses in the UK, Canada and Australia/New Zealand have little or no experience or knowledge of this treatment. Despite lack of direct experience with, or knowledge of SDD, nurses were able to articulate how the delivery of SDD (either in clinical practice or in the context of a clinical trial) might impact the patient, nursing practice or the organisation. Consequently any strategy for the implementation of SDD should include nurses as key members of the implementation team.

References

American Thoracic Society and Infectious Diseases Society of America 2005. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. American Journal of Respiratory and Critical Care Medicine 171 (4), 388-416.

Barends, H., Zandstra, D.F., vand der Voort, P.H., 2008. Current state of affairs: SDD application in Dutch ICUs. The Netherlands Journal of Critical Care 12, 109-112.

Barret, J.P., Jeschke, M.G., Herndon, D.N., 2001. Selective decontamination of the digestive tract in severely burned pediatric patients. Burns 27 (5), 439-445.

Bastin, A.J., Ryanna, K.B., 2009. Use of selective decontamination of the digestive tract in United Kingdom intensive care units. Anaesthesia 64 (1), 46-49.

Cuthbertson, B.H., Francis, J., Campbell, M.K., MacIntyre, L., Seppelt, I., Grimshaw, J., 2010. A study of the perceived risks, benefits and barriers to the use of SDD in adult critical care units (the SuDDICU study). Trials 11, 117.

de Smet, A.M., Kluytmans, J.A., Cooper, B.S., Mascini, E.M., Benus, R.F., van der Werf, T.S., van der Hoeven, J.G., Pickkers, P., Bogaers-Hofman, D., van der Meer, N.J., Bernards, A.T., Kuijper, E.J., Joore, J.C., Leverstein-van Hall, M.A., Bindels, A.J., Jansz, A.R., Wesselink, R.M., de Jongh, B.M., Dennesen, P.J., van Asselt, G.J., te Velde, L.F., Frenay, I.H., Kaasjager, K., Bosch, F.H., van Iterson, M., Thijsen, S.F., Kluge, G.H., Pauw, W., de Vries, J.W., Kaan, J.A., Arends, J.P., Aarts, L.P., Sturm, P.D., Harinck, H.I., Voss, A., Uijtendaal, E.V., Blok, H.E., Thieme Groen, E.S., Pouw, M.E., Kalkman, C.J., Bonten, M.J., 2009. Decontamination of the digestive tract and oropharynx in ICU patients. New England Journal of Medicine 360 (1), 20-31.

Dellinger, R.P., Levy, M.M., Carlet, J.M., Bion, J., Parker, M.M., Jaeschke, R., Reinhart, K., Angus, D.C., Brun-Buisson, C., Beale, R., Calandra, T., Dhainaut, J.F., Gerlach, H., Harvey, M., Marini, J.J., Marshall, J., Ranieri, M., Ramsay, G., Sevransky, J., Thompson, B.T., Townsend, S., Vender, J.S., Zimmerman, J.L., Vincent, J.L., 2008. Surviving Sepsis Campaign: international guidelines for management of severe sepsis and septic shock: 2008. Critical Care Medicine 36 (1), 296-327.

Doyle, J.S., Buising, K.L., Thursky, K.A., Worth, L.J., Richards, M.J., 2011. Epidemiology of infections acquired in intensive care units. Seminars in Respiratory and Critical Care Medicine 32 (2), 115-138.

Feider, L.L., Mitchell, P., Bridges, E., 2010. Oral care practices for orally intubated critically ill adults. American Journal of Critical Care 19 (2), 175-183.

Fraga Fuentes, M.D., Garcia Diaz, B., Dde Juana Velasco, P., Bermejo Vicedo, M.T., 1997. Influence of foods on the absorption of antimicrobial agents. Nutrición Hospitalaria 12 (6), 277-288.

Hasson, F., Keeney, S., McKenna, H., 2000. Research guidelines for the Delphi survey technique. Journal of Advanced Nursing 32 (4), 1008-1015.

Heo, S.M., Haase, E.M., Lesse, A.J., Gill, S.R., Scannapieco, F.A., 2008. Genetic relationships between respiratory pathogens isolated from dental plaque and bronchoalveolar lavage fluid from patients in the intensive care unit undergoing mechanical ventilation. Clinical Infectious Diseases 47 (12), 1562-1570.

Hinds, P.S., Vogel, R.J., Clarke-Seffen, L., 1997. The possibilities and pitfalls of doing a secondary analysis of a qualitative data set. Qualitative Health Research 7 (3), 408-424.

Canadian Patient Safety Institute, 2012. Ventilator-associated pneumonia. Safer Healthcare Now! Retrieved 12 December 2012 from http://www.saferhealthcarenow.ca/EN/Interventions/VAP/Pages/default.aspx Edmonton, Alberta.

Jongerden, I.P., de Smet, A.M., Kluytmans, J.A., te Velde, L.F., Dennesen, P.J., Wesselink, R.M., Bouw, M.P., Spanjersberg, R., Bogaers-Hofman, D., van der Meer, N.J., de Vries, J.W., Kaasjager, K., van Iterson, M., Kluge, G.H., van der Werf, T.S., Harinck, H.I., Bindels, A.J., Pickkers, P., Bonten, M.J., 2010. Physicians' and nurses' opinions on selective decontamination of the digestive tract and selective oropharyngeal decontamination: a survey. Critical Care 14 (4), R132.

Koeman, M., van der Ven, A.J., Hak, E., Joore, H.C., Kaasjager, K., de Smet, A.G., Ramsay, G., Dormans, T.P., Aarts, L.P., de Bel, E.E., Hustinx, W.N., van der Tweel, I., Hoepelman, A.M., Bonten, M.J., 2006. Oral decontamination with chlorhexidine reduces the incidence of ventilator-associated pneumonia. American Journal of Respiratory and Critical Care Medicine 173 (12), 1348-1355.

Kollef, M.H., 2000. Opinion: the clinical use of selective digestive decontamination. Critical Care 4 (6), 327-332.

Korinek, A.M., Laisne, M.J., Nicolas, M.H., Raskine, L., Deroin, V., Sanson-Lepors, M.J., 1993. Selective decontamination of the digestive tract in neurosurgical intensive care unit patients: a double-blind, randomized, placebo-controlled study. Critical Care Medicine 21 (10), 1466-1473.

Labeau, S.O., Van de Vyver, K., Brusselaers, N., Vogelaers, D., Blot, S.I., 2011. Prevention of ventilator-associated pneumonia with oral antiseptics: a systematic review and meta-analysis. Lancet Infectious Diseases 11 (11), 845-854.

Liberati, A., D'Amico, R., Pifferi, Torri, V., Brazzi, L., 2004. Antibiotic prophylaxis to reduce respiratory tract infections and mortality in adults receiving intensive care. Cochrane Database of Systematic Reviews (1), CD000022.

Masterton, R.G., Galloway, A., French, G., Street, M., Armstrong, J., Brown, E., Cleverley, J., Dilworth, P., Fry, C., Gascoigne, A.D., Knox, A., Nathwani, D., Spencer, R., Wilcox, M., 2008. Guidelines for the management of hospital-acquired pneumonia in the UK: report of the working party on hospital-acquired pneumonia of the British Society for Antimicrobial Chemotherapy. Journal of Antimicrobial Chemotherapy 62 (1), 5-34.

Melsen, W.G., de Smet, A.M., Kluytmans, J.A., Bonten, M.J., 2012. Selective decontamination of the oral and digestive tract in surgical versus non-surgical patients in intensive care in a cluster-randomized trial. British Journal of Surgery 99 (2), 232-237.

Michie, S., Johnston, M., Abraham, C., Lawton, R., Parker, D., Walker, A., 2005. Making psychological theory useful for implementing evidence based practice: a consensus approach. Quality and Safety in Health Care 14 (1), 26-33.

Miles, M.B., Huberman, A.M., 1994. Qualitative data analysis: An expanded sourcebook. Sage, Thousand Oaks.

MIMS ONLINE, 2012. Funilin Lozenges Complete Product Information. Retrieved 12 December 2012 from https://www-mimsonline-com-au.cknservices.dotsec.com/Search/FullPI.aspx?ModuleName=CMI&searchKeyword=Fungilin+Lozenges&PreviousPage=~/Search/CMISummary.aspx&SearchType=&ID=9140003_2

Misset, B., Artigas, A., Bihari, D., Carlet, J., Durocher, A., Hemmer, M., Langer, M., Nicolas, F., de Rohan-Chabot, P., Schuster, H.P., Tensillon, A., 1996. Short-term impact of the European Consensus Conference on the use of selective decontamination of the digestive tract with antibiotics in ICU patients. Intensive Care Medicine 22 (9), 981-984.

Morris, A.C., Hay, A.W., Swann, D.G., Everingham, K., McCulloch, C., McNulty, J., Brooks, O., Laurenson, I.F., Cook, B., Walsh, T.S., 2011. Reducing ventilator-associated pneumonia in intensive care: impact of implementing a care bundle. Critical Care Medicine 39 (10), 2218-2224.

Muscedere, J., Dodek, P., Keenan, S., Fowler, R., Cook, D., Heyland, D., 2008. Comprehensive evidence-based clinical practice guidelines for ventilator-associated pneumonia: diagnosis and treatment. Journal of Critical Care 23 (1), 138-147.

National Institute for Health and Clinical Excellence, 2008. Technical patient safety solutions for ventilator-associated pneumonia in adults. National Institute for Health and Clinical Excellence.

Ochoa-Ardila, M.E., Garcia-Canas, A., Gomez-Mediavilla, K., Gonzalez-Torralba, A., Alia, I., Garcia-Hierro, P., Taylor, N., van Saene, H.K., de la Cal, M.A., 2011. Long-term use of selective decontamination of the digestive tract does not increase antibiotic resistance: a 5-year prospective cohort study. Intensive Care Medicine 37 (9), 1458-1465.

Poissy, J., Senneville, E., 2011. New antibiotics for severe ICU-aquired bacterial infections. Infectious Disorders - Drug Targets 11 (4), 401-412.

Productivity Commission, 2009. Public and Private Hospitals. Commonwealth of Australia, Canberra, ACT.

Rello, J., Lode, H., Cornaglia, G., Masterton, R., 2010. A European care bundle for prevention of ventilator-associated pneumonia. Intensive Care Medicine 36 (5), 773-780.

Richards, M., Thursky, K., Buising, K., 2003. Epidemiology, prevalence, and sites of infections in intensive care units. Semininars in Respiratory and Critical Care Medicine 24 (1), 3-22.

Rocha, L.A., Martin, M.J., Pita, S., Paz, J., Seco, C., Margusino, L., Villanueva, R., Duran, M.T., 1992. Prevention of nosocomial infection in critically ill patients by selective decontamination of the digestive tract. A randomized, double blind, placebo-controlled study. Intensive Care Medicine 18 (7), 398-404.

Sanchez Garcia, M., Cambronero Galache, J.A., Lopez Diaz, J., Cerdá, C.E., Rubio, B.J., Gómez, A.M.A., Núnez, R.A., Rogero, M.S., Onoro, C.J.J., Sacristán del Castillo, J.A., 1998. Effectiveness and cost of selective decontamination of the digestive tract in critically ill intubated patients. A randomized, double-blind, placebo-controlled, multicenter trial. American Journal of Respiratory and Critical Care Medicine 158, 908-916.

Silvestri, L., Petros, A.J., De La Cal, M.A., Visintin, S., 2011. Selective digestive decontamination. Why are intensivists more "resistant" than microorganisms? Minerva Anestesiologica 77 (6), 658-659.

Silvestri, L., van Saene, H.K., Milanese, M., Gregori, D., 2005. Impact of selective decontamination of the digestive tract on fungal carriage and infection: systematic review of randomized controlled trials. Intensive Care Medicine 31 (7), 898-910.

Silvestri, L., van Saene, H.K., Petros, A.J., 2012. Selective digestive tract decontamination in critically ill patients. Expert Opinions in Pharmacotherapy 13 (8), 1113-1129.

Silvestri, L., van Saene, H.K.F., 2012. Selective decontamination of the digestive tract: an update of the evidence. HSR Proceedings in Intensive Care and Cardiovascular Anesthesia 4 (1), 21-29.

Smit, M.J., van der Spoel, J.I., de Smet, A.M., de Jonge, E., Kuiper, R.A., van Lieshout, E.J., 2007. Accumulation of oral antibiotics as an adverse effect of selective decontamination of the digestive tract: a series of three cases. Intensive Care Medicine 33 (11), 2025-2026.

Stoutenbeek, C.P., van Saene, H.K.F., Zandstra, D.F., 1996. Prevention of multiple organ failure by selective decontamination of the digestive tract in multiple trauma patients. In: Faist, E., Baue, A.E., Schildberg, F.W. (Eds.), The Immune Consequences of Trauma, Shock and Sepsis - Mechanisms and Therapeutic Approaches. Pabst Science Publishers, Lengerich, pp. 1055-1066.

Thomas, D.R., 2006. An inductive approach for analyzing qualitative evaluation data. American Journal of Evaluation 27 (2), 237-246.

Thorne, S., 1998. Ethical and representational issues in qualitative secondary analysis. Qualitative Health Research 8 (4), 547-555.

van der Voort, P.H., van Roon, E.N., Kampinga, G.A., Boerma, E.C., Gerritsen, R.T., Egbers, P.H., Kuiper, M.A., 2004. A before-after study of multi-resistance and cost of selective decontamination of the digestive tract. Infection 32 (5), 271-277.

van Enckevort, P.J., Zwaveling, J.H., Bottema, J.T., Maring, J.K., Klompmaker, I.J., Slooff, M.J., TenVergert, E.M., 2001. Cost effectiveness of selective decontamination of the digestive tract in liver transplant patients. Pharmacoeconomics 19 (5 Pt 1), 523-530.

van Essen, E.H., de Jonge, E., 2011. Selective decontamination of the digestive tract (SDD): is the game worth the candle? Semininars in Respiratory and Critical Care Medicine 32 (2), 236-242.

Vandijck, D.M., Labeau, S.O., Vogelaers, D.P., Blot, S.I., 2010. Prevention of nosocomial infections in intensive care patients. Nursing in Critical Care 15 (5), 251-256.

Vincent, J.L., Rello, J., Marshall, J., Silva, E., Anzueto, A., Martin, C.D., Moreno, R., Lipman, J., Gomersall, C., Sakr, Y., Reinhart, K., 2009. International study of the prevalence and outcomes of infection in intensive care units. JAMA 302 (21), 2323-2329.

Weinert, C.R., Mann, H.J., 2008. The science of implementation: changing the practice of critical care. Current Opinions in Critical Care 14 (4), 460-465.

Wunderink, R.G., 2010. Welkommen to our world. Emergence of antibiotic resistance with selective decontamination of the digestive tract. American Journal of Respiratory and Critical Care Medicine 181 (5), 426-427.

Zandstra, D.F., Van Saene, H.K., 2011. Selective decontamination of the digestive tract as infection prevention in the critically ill. A level 1 evidence-based strategy. Minerva Anestesiologica 77 (2), 212-219.