

1 **Title Page**

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3 **Non-contact vital sign monitoring of patients in an**
4 **Intensive Care Unit: A Human Factors analysis of staff**
5 **expectations.**

6

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14 PW co-developed the System for Electronic Notification and Documentation (SEND), for which Sensyne
15 Health has purchased a sole licence. The company has a research agreement with the University of
16 Oxford and royalty agreements with Oxford University Hospitals NHS Trust and the University of Oxford.
17 Sensyne Health (previously Drayson Health) pay a proportion of PW personal fees. LT reported receiving
18 grants and personal fees from Sensyne Health and Oxehealth Ltd (of which he is a founder and stock
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32

Abstract (157)

Background: Infra-red and thermal imaging enable wireless systems to monitor patients' vital signs and absence of wires may improve patient experiences. No studies have explored staff perceptions of this specific type of technology in the adult population. Understanding existing working systems before introducing technology could improve adoption.

Methods: We conducted semi-structured interviews with Intensive Care Unit (ICU) staff exploring perceptions of wireless patient monitoring. We used the Systems Engineering Initiative for Patient Safety (SEIPS) model to guide thematic analysis.

Results: We identified usability themes relating to staff perceptions of current patient monitoring experiences, staff perceptions of patient/relative expectations of ICU care, troubleshooting, hierarchy of monitoring, and consensus of trust.

Conclusion: The concept of wireless monitoring has perceived benefits for patients and staff. The Systems Engineering Initiative for Patient Safety model guided a rigorous systems-based evaluation of the technology. The results highlight social and environmental factors which may influence usability, adoption, or abandonment of wireless technology in the ICU.

There is a prevalent belief that health innovation will improve care, efficiency and productivity (1) and that new healthcare technologies are essential in a climate of increasing care costs, life expectancy and complex medical conditions (2). Widespread technological or biomedical innovation adoption can be challenging despite good evidence of benefit (3). Reasons for this have been explored recently through the Non-adoption and Abandonment of technologies by individuals (staff and patients) and problems with Scale-up, Spread and Sustainability framework (NASSS) (4). This framework was designed to explore the wider organisational impacts and effects when new technology is introduced. Results suggest that when real-world implementation is considered, rather than small-scale controlled situations, it becomes easier to recognise failure points that may lead to eventual non-adoption or abandonment of new technology in healthcare. Key reasons for non-adoption or abandonment of introduced technology include limited shared understanding between stakeholders (5) and socio-cultural factors (6). These factors affect perceived and actual usability and have a direct impact on likelihood of technological adoption (7). Exploring an existing operational system and designing new technology to work specifically with current processes can improve diffusion rates (8).

Vital signs (such as heart rate and peripheral oxygen saturations) can be monitored non-invasively (9) with contact sensors (10–12), or invasively via intravenous catheters or direct cardiac output monitoring (13). Whilst ward ambulatory monitoring can be more conducive to rehabilitation during the hospital admission than static wired vital signs systems, complications associated with adhesive sensors such as damaging fragile skin remain an issue (10). Monitoring in the intensive care unit (ICU) can be more complex than in other healthcare environments, incurring additional risks (14,15,16,17). The effect of this intensive monitoring can be significant with family members stating restriction by wires as one of the highest ranking stressors in the ICU (15,16). It has been recommended that efficient, sensitive, and better tolerated monitoring systems need to be developed (13,17,18).

There is a spread of digital visual systems to collect organisational data, including social interactions, within the corporate industry (19). It is now feasible for camera-based systems within healthcare to derive blood pressure, oxygen levels and respiratory rate. These non-contact monitoring systems use algorithms to derive physiological values from infra-red and thermal data (10,20,21). A limited number of studies have tested this technology, primarily in the paediatric population (10,20,21). One study explored the efficacy of camera-based photoplethysmography technology in the ICU (22), but did not explore experiences of the users, specifically the staff, patients or patient relatives. This limited evaluation therefore cannot explain why this technology may work or fail. This is likely to have significant implications for adoption or abandonment (23).

Primary factors influencing staff experiences of monitoring systems are usability, reliability, accuracy, and integration within existing care delivery pathways (14,24,25). Qualitative research into the use of vital signs monitoring has to date been limited to alarm fatigue, alarm management, and usability of cardiac monitoring systems (13,25,26). There is a significant gap in the literature exploring perception of monitoring vital signs in the ICU, and no studies have explored staff perceptions of technologies using non-contact methods of monitoring in the adult population.

The aim of this qualitative study was to explore staff expectations of wireless non-contact patient vital signs monitoring, how staff think this type of technology could be utilised in the ICU, and how staff believed patients and relatives would respond to its introduction.

Methods

We undertook a qualitative exploration of a patient wireless vital signs monitoring system undergoing feasibility testing between September 2016 and March 2017 in a general adult ICU, within a major teaching hospital in the UK. The study (REC ref: 16/WA/0024, approved by Wales Research Ethics Committee 5, Bangor, January 2016) was designed to assess the feasibility of non-contact patient monitoring of vital signs in the ICU environment. Monitoring data from the research equipment were collected concurrently with wired monitoring as per usual patient clinical care in the ICU. Usual care monitoring included a Philips Intellivue™ patient monitoring system (Philips Healthcare Intellivue MP70™), ECG electrodes, and a pulse oximetry finger probe (Phillips M1941A™). Blood pressure was measured using oscillometry, or an invasive arterial blood pressure (ABP) line, and temperature was measured using a Covidien Tympanic Thermometer Genius 2™.



Picture 1. The non-contact monitoring “Stack”

The research equipment was mounted on a bespoke “stack” designed specifically for the study (see Picture 1). A hard drive locked in the base cabinet was physically connected to a screen mounted to the vertical bars. The screen was only activated to confirm data collection and was ‘off’ for the majority of the time. No results from the system (heart rate, breathing rate, oxygen saturation, blood pressure, and temperature) were visible in real time. Staff therefore did not have any information to make clinical decisions based on data not part of usual care monitoring. Two cameras (one thermal, one digital) faced the patient. Above these was a blind that could be pulled down to protect the patient’s dignity. Staff had limited direct interaction with the equipment. Equipment contact ranged from directly caring for a patient receiving non-contact vital signs monitoring but being unable to view wireless data, to being on shift whilst monitoring was occurring within an open plan ICU unit. All unit staff received information about the study either through direct training or exposure to study promotional posters. The feasibility study exposed staff to the concept of non-contact monitoring, its implications for practice, and how this technology may be experienced by staff, patients or relatives.

Semi-structured interviews were conducted using a topic guide (see Appendix. 1) to explore ICU nurses’ expectations of non-contact monitoring in the ICU, how this could be utilised in ICU, and the effects that this type of monitoring may have on the patient or relative’s experience. Interviews were undertaken concurrently with the feasibility study, with participants selected from the host ICU. We used the ISSM COREQ 32 item checklist (27) (see Appendix. 2) for reporting qualitative studies to guide our approach,

ensuring methodological rigor. Nurses were approached directly by the research team and no-one refused to be interviewed. Interviews lasted between 15 and 35 minutes and were conducted by a single researcher with a background in critical care nursing (JE). No-one else was present during the interviews. Interviews were focussed on perceptions and expectations of vital signs monitoring technology in general and more specifically the concept of non-contact vital sign monitoring. Staff gave informed consent to take part, having first read the information leaflet. Interviews were conducted in a quiet room in the ICU.

Interviews were digitally recorded, transcribed verbatim and coded using NVivo 11 for Windows software (QSR International, United States). Two researchers (JE, SV), both with a professional background in critical care nursing, coded the transcripts. We used the thematic analysis (28) structured around the Systems Engineering Initiative for Patient Safety (SEIPS) model (29–31), to allocate data into broad categories. We then split these broad categories into smaller more informative themes within the domains of the SEIPS model and identified the primary user group affected. This approach ensured the analysis considered the ICU and wider organisation as a complete and inter-connected working system. Definitions of the domains as used in this study are presented in Table 1. Coding rigor was strengthened by regular team meetings, discussing codes and ensuring there was a consensus of themes.

Results

Table 1. SEIPS domains as used in this study, and how identified themes relate to SEIPS domains

Domain	Definition	Themes	User Group
Person	Patient, family or ICU staff	Staff perception of current patient monitoring experiences	Patient
		Staff perception of patient and relative expectations of ICU care	Patient and Relative
Task	Vital sign monitoring	Troubleshooting	Staff
Tools and Technology	Wireless and wired vital signs monitoring systems	Hierarchy of monitoring	Staff
Organisation	NHS trust	Consensus of trust	Staff
Environment	ICU department	Staff expectations of continuous monitoring in the ICU	Staff

Demographics

Nine (one male, eight female) nurses were interviewed. No-one withdrew from the study during or after they had been interviewed. Median (IQR) duration of ICU nursing experience was 2(10) years .

160 Themes

161 Six themes were identified from the interviews relating to the five SEIPS domains (see Table 1 and
 162 Figure.3). Overall these focused on staff expectations of the usability of the non-contact vital sign
 163 monitoring system and how this system may be experienced by relatives and patients. Three main non-
 164 contact vital signs user groups were identified (staff, patients, and relatives) during the interviews and
 165 data analysis.

166

167 *Staff perception of current patient monitoring experiences:*

168 Staff perceptions, expectations, and experiences of current patient monitoring mapped to the SEIPS
 169 domain Person. Staff evaluated the wireless technology as part of the patient experience and were
 170 mostly positive. Staff describe staff, patient and relative dissatisfaction with current (wired) monitoring
 171 equipment in ICU believing it contributes to anxiety in patients and relatives. Reasons for this belief
 172 originate from the restrictive nature of wired monitoring and how wires are perceived to limit physical
 173 contact between patients and their relatives. Staff described patients as becoming agitated during times
 174 of delirium and that this caused them to remove wires or lines that had been placed for monitoring
 175 purposes. Staff proposed that ICU-acquired delirium may be less common with the use of the wireless
 176 monitoring systems, and that monitoring would not be interrupted as a result of physical
 177 disconnections. It was also felt that existing wired monitoring systems impair mobilisation during the
 178 recovery process and therefore wireless monitoring may facilitate ICU rehabilitation.

179

Staff perception of current patient monitoring experiences
<i>'It's [wired monitoring] very restrictive and gets in the way of patients' care in terms of what they can and can't do and how far they can move from the bedside' (interview 5)</i>
<i>'One guy I was looking after just like kept pulling off his 3 lead monitoring and he was a bit confused but he just wanted it all off of him. He just felt stuff all over him and he couldn't move and he got really frustrated and had to have his sats monitoring off' (interview 7)</i>
<i>'I think hospital can be very, very daunting so the least amount of equipment and lines and wires I think would be better for them ITU can be incredibly daunting and so I think the more normal we can make it for the relatives the better' (interview 4)</i>
<i>'It's [wired monitoring] just a hindranceI think relatives get a bit frightened of it. They don't want to go near it and if anything goes wrong they don't want to touch it, I think it puts them off actually and physically engaging with the patient as well if they want to hug them or give them a kiss or hold their hand.....' (interview 5)</i>

180

181 *Staff perception of patient and relative expectations of ICU care:*

182

183 Staff perception of patient and relative expectations of ICU care mapped to the SEIPS domain Person.
 184 Staff commented that vital signs monitoring can be a source of anxiety and discomfort for patients and
 185 relatives. For others, the presence of monitoring equipment is a source of comfort. The opacity of non-

contact monitoring, compared with the very obvious wires associated with current monitoring systems, was therefore perceived as both a positive and a negative feature of the system. Subsequently, there were concerns an ICU without overt patient monitoring may not meet the care expectations of some relatives and patients, resulting in scrutiny and criticism of care. Staff also suggested some patients may find non-contact monitoring reassuring as part of an ICU step-down care programme which currently consists of a binary monitored/not monitored approach.

Staff perception of patient and relative monitoring expectations

'There could be a possibility that they [relatives] may query whether something's actually working if it's being monitored and they can't see itneed a bit of reassurance that we are monitoring your relative' (interview 4)

'Relatives get transfixed on the monitors, .. it'sall about the experience of the nurse to manage that situation.... If you take a monitor away.. so there is no monitoring visible, do patient's relatives think that we are not monitoring them?' (interview 3)

'There are patients who feel some sense of comfort that we have got them connected because it [wired monitoring] means that we can see what is going on the whole time and they can sense that' (interview 2)

Troubleshooting:

The theme of troubleshooting mapped to the SEIPS model of Task. Staff talked about spending large amounts of time troubleshooting current ICU vital signs monitoring systems. Causes of current vital sign monitoring failures were patient disconnection, poor vital sign readings, and equipment malfunction. Despite these usability problems, staff were confident in their ability to troubleshoot and fix faults as they occur. Staff were concerned that the newer and apparently more complex non-contact technology would mean they would have low confidence in being able to troubleshoot it. Being able to maintain monitoring functionality, without support from the manufacturer or on-site engineers seemed to lead to a feeling of control in this cohort of ICU nurses.

Troubleshooting

'I feel confident using them [wired monitoring devices], and I think it's easy to kind of troubleshoot when things aren't reading properly because you have wires, you can check that they are plugged in, or if they are not connected in the right places..... it is easy to see your traces.....I feel confident in using it' (interview 2)

'The arterial line if it's pressed up against the artery or the vessel wall itself then it can give a bit of a damp trace or if it's kinked or anything like that then it can give a strange trace and so we then had to revert to a non-invasive just to double check.....we are taught how to troubleshoot it [wired monitoring], more often than not we can get it to work again, as we can educate on how to troubleshoot any issues, that would be a good thing.' (interview 4)

'The concept sounds very good but as a nurse within critical care we like to be in control of how we monitor things and where things are and if that's all taken away, it's like its taking away a role from us' (Interview 5)

204

205 *Hierarchy of Monitoring:*

206 The theme of hierarchy of monitoring mapped to the SEIPS model of Tools and Technology and was a
 207 significant theme which spanned several staff interviews. ICU staff hold embedded models of the
 208 hierarchy of monitoring strategies used in ICU. These range from simple use of the senses (physical
 209 visual assessment), through basic non-invasive options (for example blood pressure monitoring), up to
 210 more complex invasive monitoring such as intra-cranial pressure monitoring and pulmonary artery
 211 catheters. These complex techniques were universally believed to be the most accurate and staff
 212 frequently defined the acuity of patients by the type of equipment used to monitor their condition. It
 213 was commonly stated that patients require more invasive monitoring as their condition worsens (and
 214 vice versa). The hierarchy of monitoring may have implications for the acceptance or abandonment of
 215 non-contact monitoring technology within the ICU environment.

216

Hierarchy of monitoring

'So have got your normal basic which is your five senses, looking at the patient, looking at how they look, colour.....you have got that, the bit that technology can't do.....you've got the standard monitoring like ECG, pulse oximetry, BP non-invasive and invasive) sats. You have also got the monitoring on the ventilator as well. The invasive ventilation, the temperature probes that sort of thing that you can insert into patients.' (interview 8)

'... the invasive one [wired monitoring] goes straight into the vessel itself and therefore it's a lot closer to the pressure and therefore it can give a lot more accurate reading than the non-invasive,it's not in direct contact with the vessel and therefore it's more of a guesstimate rather than actual accuracy. So I guess the theory is the more invasive the monitoring is the more accurate it should be.' (interview 4)

'With us [ITU] the patients are more acutely unwell so they should really have continuous monitoring so we can pick up deteriorations in them as they happen or before they happen. Intermittent monitoring is more for ward based patients whonever been to an acute are in the first place.' (interview 7)

217

218 *Consensus of Trust:*

219 The theme of consensus of trust mapped to the SEIPS domain of Organisation. When considering the
 220 organisation as a whole, it was clear that widely conflicting opinions of innovation can be destructive,
 221 and that these are an influencing factor in mainstream clinical perceptions and achieving a consensus
 222 of trust with new technology. Staff felt a consensus of opinion that newly introduced technology
 223 provides clinical and patient benefits is essential for successful adoption. They expressed the view that
 224 this would be physically demonstrated through consistent use of a technology throughout an

225 establishment and that pervasive visibility would be significant in the success of continued use of new
226 technology.

Consensus of trust

'.... you need more than one doctor to say do you know that is really good. You need to have, it has to be through the establishment....have to feel the same way about it otherwise you'll get a doctor who wants you to do manual BP' (interview 3)

227

228 *Staff expectation of monitoring in ICU:*

229 The theme staff expectation of monitoring in ICU was mapped to the SEIPS domain Environment. ICU
230 staff had clear expectations of the continuous monitoring required for patients in a critical care
231 environment, but acknowledged that this was not always achievable. Staff described being reassured
232 by reliable, accurate, and continuous patient monitoring because of patient physiological instability. It
233 was noted that the current (wired) continuous monitoring systems were prone to interruptions due to
234 faults, patient discomfort or medical intervention. This could cause staff anxiety, causing them to assign
235 high levels of risk to very short periods of monitoring absence. There was a common opinion that
236 existing monitoring systems often require a conscious balance to be made between continuous
237 monitoring and patient comfort.

238

Staff expectation of monitoring in ICU

'I do feel a lot safer having the constant [wired monitoring] monitoring there again because of the demographic of our patients' (interview 4)

'That's always a bit of a nightmare [wired monitoring] and, then you end up losing your trace. It takes you five minutes to set it all back up, by which time your patient probably changed in some way' (interview 2)

'.....it's [wired monitoring] obviously more of an issues of the patient is a bit confused....and taking it all off...most of the time we end up just taking off their monitoring and not having anything if it going to aggravate them more' (interview 1)

239

240 Discussion

241 This is the first qualitative study exploring ICU staff expectations of non-contact monitoring and how it
242 may affect the patient/relative experiences. We identified themes relating to non-contact monitoring
243 usability and acceptance, and mapped each of these to a SEIPS domain. This ensured a comprehensive
244 analysis of the technology in a real working environment, allowing us to address a wide range of factors
245 that could affect acceptance, adoption, and possible abandonment.

246 There is a dearth of literature exploring perceptions of monitoring specifically in ICU. Research to date
247 has been limited to ward based devices on a small number of monitoring types (telemetry or cardiac
248 devices) (12) or alarm fatigue (25,26). As the choice of monitoring methods expand due to technology

innovation and advances, it is essential to understand how these fit user requirements and their working systems as per the NASSS framework (23). Assessment should therefore examine how technology facilitates current working patterns or intrinsically changes them in unanticipated ways. This study offered an opportunity to add to the limited body of literature by using an established HF framework to explore staff perceptions of current systems together with expectations of a novel concept of non-contact technology to monitor patients in the ICU.

It is clear there are significant limitations to current monitoring technology in the ICU environment, and that this justifies the need to improve monitoring systems (17,18). During their interviews, nursing staff described usability issues with wired monitoring systems such as high maintenance, hampering of family contact, patient discomfort, limited mobilisation and mostly not being conducive to long-term wear (32). Literature also highlights fears of infection with monitoring wires being used by multiple patients consecutively (33). The non-contact system used in this study was perceived by staff to address these limitations.

As anticipated the non-contact system was perceived to improve the overall patient experience by reducing physical restrictions and aiding the mobilisation process which wired monitoring inhibits (34). It is likely that non-contact monitoring could improve rehabilitation by making the process less time consuming through eliminating the need to disconnect and reconnect equipment. This may make rehabilitation both more effective and more efficient, and may increase the frequency of rehabilitation sessions. Reduced restriction may also enable patients to experience a greater sense of control, an essential component for motivation and adherence to rehabilitation programmes (35).

A number of unanticipated themes were identified. Staff recognised a gap in current clinical systems that this new technology may fill. It is understood that delirious patients should be monitored closely due to a high risk of complications (36). Nurses in this study however reported that delirious patients become more agitated as a result of the wires required for monitoring. This has also been recognised within critical care delirium research (34). As a result, the wires are frequently removed to improve patient comfort. A non-contact system may allow nursing staff to maintain an expected level of ICU monitoring and improve the acceptability of long term monitoring for agitated patients. Staff also proposed that fewer wires may encourage physical contact between relatives and patients. Physical contact has been linked to reduced anxiety in ICU patients (37) and could be easier to achieve with non-contact monitoring.

Another unexpected theme was that staff spoke about the high workload due to troubleshooting current wired equipment systems. There is limited research detailing the time ICU staff spend troubleshooting technology in their environment, or how this forms an integral aspect to their specialised role (14). These results therefore highlight a little understood element to ICU nursing. An important aspect of professional thriving is 'coping self-efficacy' where staff need to be able to manage challenges (38). During the interviews staff indicated that continuous monitoring is a basic expectation in the ICU and that control of monitoring systems was linked to a sense of control in the workplace. There were concerns that advances in technology may result in a higher burden. The non-contact monitoring system trialled in this study has limited physical hardware. Nurses felt they would be less able to resolve system failures without external assistance. Failures may occur anywhere in the system from remote sensors (hardware failure), algorithms used to transpose vital sign data (software failure) to hospital IT infrastructure problems (for example Wi-Fi dropouts). This relates to the usability of technology and ability of the user to recover from errors (39). The non-contact vital signs system was perceived by staff as potentially having failures that could only be managed through an engineering or IT department which could result in significant time delays, affecting patient care. It is clear that any monitoring technology introduced to the critical care environment needs to allow staff to maintain an element of control of monitoring during periods of failure.

ICU staff hold a clearly perceived hierarchy of monitoring techniques used in the ICU (see Figure 1). It was believed the more invasive the technology, the more accurate it was, and that the sickest patients needed the most invasive (accurate) monitoring. On further analysis, this hierarchy whilst described by staff as relating to accuracy, may also feasibly be related to frequency of required monitoring whereby invasive monitoring affords a greater level of patient surveillance without a significant increase in nursing workload. It may also relate to the fact that invasive monitoring can focus in on very specific areas of physiology ranging from cerebral perfusion pressures, pulmonary artery pressures to global arterial pressures giving staff very precise measures and control over patients illness responses. It is likely that this perception for the need for “accuracy” is also related to trust in the specific technology. This poses a significant adoption barrier for non-contact systems in general as staff may view this technology as inherently less effective simply because it is contradictory to their (perceived) ‘Gold Standard’ invasive monitoring equipment. To combat this cultural bias within this specialised area, trust in the new system needs to be earned. The reliability and accuracy of new technology needs to be emphasised during implementation, ideally with supporting data to provide an evidence base for new systems.

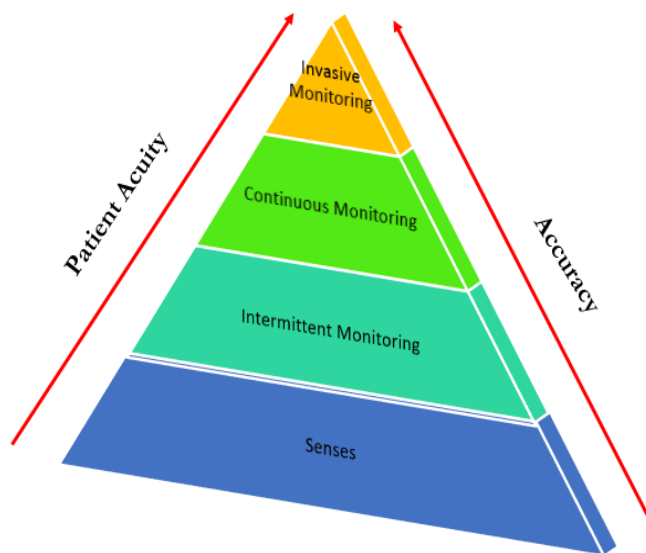


Figure.1 ICU Staff Hierarchy of monitoring effectiveness

There was a suggestion by staff that lack of visible monitoring (40) may leave clinical practice open to criticism. In particular there were concerns that the technology may not meet expectations of care from some patients and relatives. A previous study describes patients equating wired monitoring with ‘safety’, with removal causing anxiety (16). Other studies have highlighted the reassurance that patients gain from the monitoring process and staff interaction (41). Nurses also thought that patients monitored via non-contact systems may not realise they are being monitored. A key function which future non-contact vital signs equipment should achieve would be an observable function confirming ‘connectivity’.

Finally, successful adoption of new technology in the healthcare environment was thought to be facilitated by a consensus of trust and satisfaction. It was believed this was more influenced by informal interactions than through formal ‘opinion leaders’ (40,42) and that widespread visibility of new technology would reinforce positive messages of support.

Limitations

There are some limitations to this study. Staff had limited interaction with this novel, non-contact vital signs monitoring technology. Further study into staff expectations and interactions with this technology are required to fully understand how these systems may integrate into a specialist ICU environment. ICU nurses are very familiar with patient monitoring and use a variety of systems in routine clinical practice. This may influence their perceptions leading to a more positive opinion of new technology than might be seen outside of the ICU. Non-ICU staff may also not hold the same hierarchical views of monitoring systems. The results are therefore unlikely to be generalisable to other clinical areas, although some points raised may be valid across disciplines.

The interviewer was known to the interviewees which may have caused some response bias although staff may also have been more open for this reason. The staff were mostly female, but the male/female ratio for this study is representative of the population where approximately 10% of nursing staff are male. Participant numbers were low and saturation of themes were not felt to be met. This would be mitigated through further research into this area, potentially with higher and more profession-diverse participants. We did not explore patient, relative or non-nursing staff groups about their perceptions of wireless technology. Whilst ICU nurses are the primary users of continuous bedside monitoring, further exploration of the multidisciplinary team and patient perspective would contribute to a richer understanding of monitoring expectations in the ICU.

Conclusion

This study is the first to explore staff perceptions of a novel, non-contact vital signs monitoring technology in the ICU environment. The SEIPS model guided rigorous systems-based evaluation of this technology in clinical practice. We found that the concept of non-contact monitoring is acceptable to ICU staff and has perceived usability benefits for patients and staff alike. Non-contact monitoring may provide a sustainable continuous monitoring solution which sits well with expectations of patient monitoring in the ICU but may need overt indication that monitoring is taking place. It is clear that the ability to troubleshoot technology to maintain appropriate patient monitoring is a key feature of the ICU nurse identity. This means that successful adoption of new technology is only likely when the workforce is comfortable and familiar with the system, enabling independent manipulation of equipment.

In conclusion, it is clear that there could be significant benefits to using a non-contact system to monitor patients in the ICU however there are key barriers of trust that need to be overcome. This study highlights the need for a co-ordinated systems-based approach to implementation of new technology as social and environmental contexts have a direct influence on perceived or actual usability and, ultimately, adoption or abandonment.

Contributions

PW is the guarantor. LT and PW were investigators on the original feasibility study. OG conducted the feasibility study and collected data. JE and SV were responsible for the overall design and content of the paper. JD provided draft content feedback and editing. All authors read, provided feedback and approved the final manuscript.

Figure 2

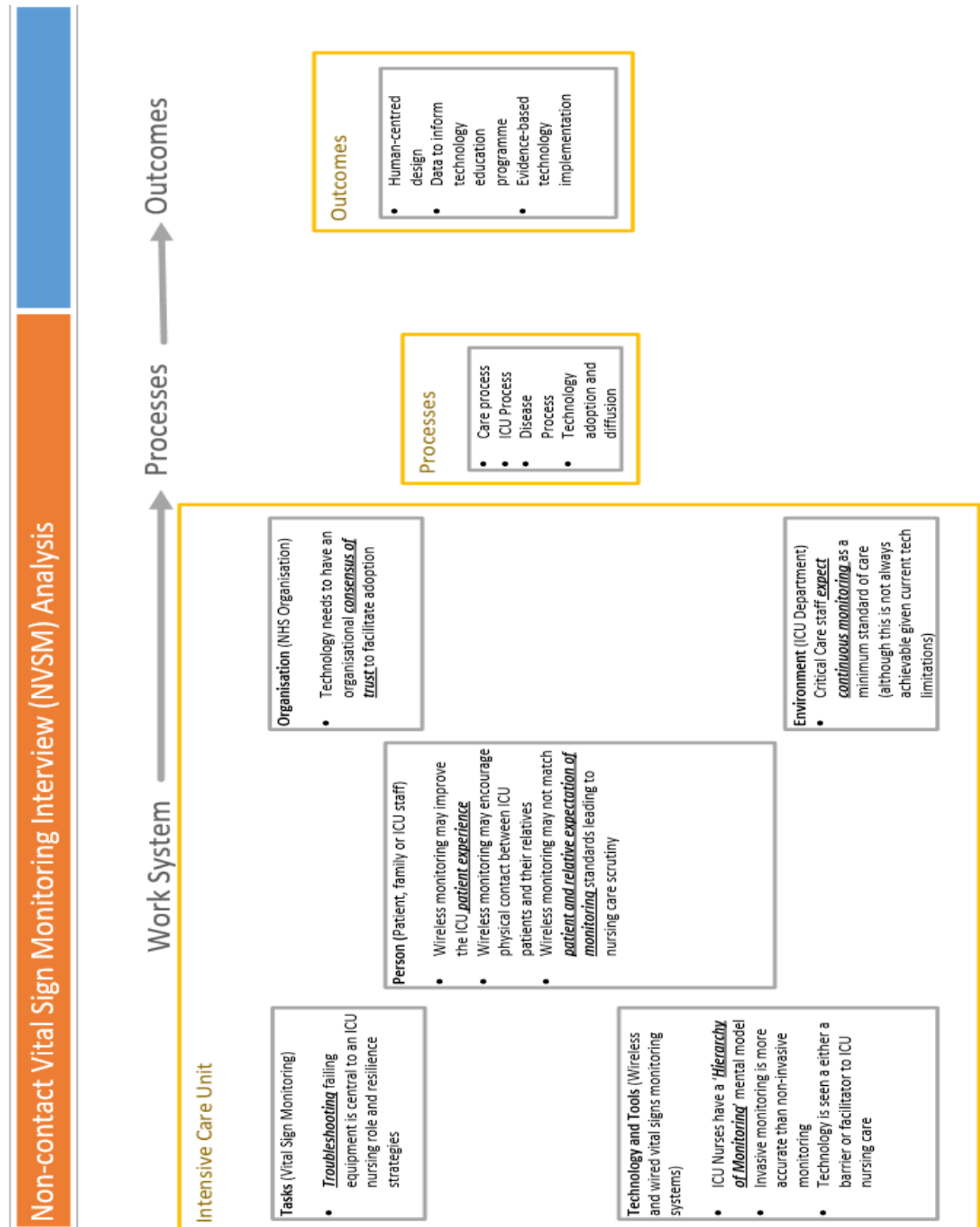


Figure 3. SEIPS representation of non-contact vital sign monitoring technology interview themes.

References

1. Brewster L, Mountain G, Wessels B, Kelly C, Hawley M. Factors affecting front line staff acceptance of telehealth technologies: A mixed-method systematic review. *J Adv Nurs.* 2014;70(1):21–33.
2. Coye M, Aubry W, Yu W. The "tipping point" and health care innovations: Advancing the adoption of beneficial technologies. *Accel Qual Improv Heal Care Strateg to Speed teh Diffus Evidence-Based Innov* [Internet]. 2003; Available from: <http://www.nihcm.org/pdf/Coye.pdf>
3. Haines A, Kuruvilla S, Borchert M. Bridging the implementation gap between knowledge and action for health. *Bull World Health Organ.* 2004;82(10):724–31.
4. Greenhalgh T, Wherton J, Papoutsis C, Lynch J, Hughes G, A'Court C, et al. Beyond adoption: A new framework for theorizing and evaluating nonadoption, abandonment, and challenges to the scale-up, spread, and sustainability of health and care technologies. *J Med Internet Res.* 2017;19(11).
5. Kent B, Redley B, Wickramasinghe N, Nguyen L, Taylor NJ, Moghimi H, et al. Exploring nurses' reactions to a novel technology to support acute health care delivery. *J Clin Nurs.* 2015;24(15–16):2340–51.
6. Rogers EM. Diffusion of preventive innovations. *Addict Behav.* 2002;27(6):989–93.
7. International Organization for Standardization. ISO 9241-210: Ergonomics of human–system interaction - Human-centred design for interactive systems. *Int Organ Stand.* 2010;2010:32.
8. McGinn TG, McCullagh L, Kannry J, Knaus M, Sofianou A, Wisnivesky JP, et al. Efficacy of an Evidence-Based Clinical Decision Support in Primary Care Practices. *JAMA Intern Med.* 2013;173(17):1584.
9. Elliott M, Coventry A. Critical care: the eight vital signs of patient monitoring. *Br J Nurs* [Internet]. 2012;21(10):621–5. Available from: <http://www.magonlinelibrary.com/doi/abs/10.12968/bjon.2012.21.10.621>
10. Davis S, Watkinson P, Guazzi A, McCormick K, Tarassenko L, Jorge J, et al. Continuous non-contact vital sign monitoring in neonatal intensive care unit. *Healthc Technol Lett* [Internet]. 2014;1(3):87–91. Available from: <http://digital-library.theiet.org/content/journals/10.1049/htl.2014.0077>
11. Jeskey M, Card E, Nelson D, Mercaldo ND, Sanders N, Higgins MS, et al. Nurse adoption of continuous patient monitoring on acute post-surgical units: Managing technology implementation. *J Nurs Manag.* 2011;19(7):863–75.
12. Orphanidou C, Clifton D, Khan S, Smith M, Feldmar J, Tarassenko L. Telemetry-based vital sign monitoring for ambulatory hospital patients. *Proc 31st Annu Int Conf IEEE Eng Med Biol Soc Eng Futur Biomed EMBC 2009.* 2009;4650–3.
13. Prgomet M, Cardona-Morrell M, Nicholson M, Lake R, Long J, Westbrook J, et al. Vital signs monitoring on general wards: Clinical staff perceptions of current practices and the planned introduction of continuous monitoring technology. *Int J Qual Heal Care.* 2016;28(4):515–21.
14. Tunlind A, Granstrom J, Engstrom A. Nursing care in a high-technological environment:

- 411 Experiences of critical care nurses. *Intensive Crit Care Nurs* [Internet]. Elsevier Ltd;
412 2015;31(2):116–23. Available from: <http://dx.doi.org/10.1016/j.iccn.2014.07.005>
- 413 15. Novaes MAFP, Knobel E, Bork AM, Pavão OF, Nogueira-Martins LA, Ferraz MB. Stressors in ICU:
414 Perception of the patient, relatives and health care team. *Intensive Care Med*.
415 1999;25(12):1421–6.
- 416 16. Gustad LT, Chaboyer W, Wallis M. ICU patient's transfer anxiety: A prospective cohort study.
417 *Aust Crit Care*. 2008;21(4):181–9.
- 418 17. NICE Clinical Guidelines. Acutely ill adults in hospital: recognising and responding to
419 deterioration. 2007;(July):1–30. Available from: <https://www.nice.org.uk/guidance/CG50>
- 420 18. Mok W, Wang W, Cooper S, Ang ENK, Liaw SY. Attitudes towards vital signs monitoring in the
421 detection of clinical deterioration: Scale development and survey of ward nurses. *Int J Qual*
422 *Heal Care*. 2015;27(3):207–13.
- 423 19. Olguín-Olguín D, Pentland A. Sensor-based organisational design and engineering [Internet].
424 Vol. 1, *Int. J. Organisational Design and Engineering*. 2010 [cited 2019 May 23]. Available from:
425 <https://vismod.media.mit.edu/pub/tech-reports/TR-647.pdf>
- 426 20. Aarts LAM, Jeanne V, Cleary JP, Lieber C, Nelson JS, Bambang Oetomo S, et al. Non-contact
427 heart rate monitoring utilizing camera photoplethysmography in the neonatal intensive care
428 unit - A pilot study. *Early Hum Dev* [Internet]. Elsevier Ltd; 2013;89(12):943–8. Available from:
429 <http://dx.doi.org/10.1016/j.earlhumdev.2013.09.016>
- 430 21. Blanik N, Blazek V, Abbas AK, Venema B, Leonhardt S. Hybrid optical imaging technology for
431 long-term remote monitoring of skin perfusion and temperature behavior remote monitoring
432 of skin perfusion and temperature behavior. *J Biomed Opt*. 2013;19:016012-1-016012-10.
- 433 22. Rasche S, Trumpp A, Waldow T, Gaetjen F, Plotze K, Wedekind D, et al. Camera-based
434 photoplethysmography in critical care patients. *Clin Hemorheol Microcirc*. 2016;64(1):77–90.
- 435 23. Greenhalgh T, Wherton J, Papoutsis C, Lynch J, Hughes G, A'Court C, et al. Beyond Adoption: A
436 New Framework for Theorizing and Evaluating Nonadoption, Abandonment, and Challenges to
437 the Scale-Up, Spread, and Sustainability of Health and Care Technologies. *J Med Internet Res*
438 [Internet]. JMIR Publications Inc.; 2017 Nov 1 [cited 2018 Jul 1];19(11):e367. Available from:
439 <http://www.ncbi.nlm.nih.gov/pubmed/29092808>
- 440 24. Bitan Y, Meyer J, Shinar D, Zmora E. Nurses' reactions to alarms in a neonatal intensive care
441 unit. 2004 [cited 2017 Jun 20]; Available from:
442 <http://www.tau.ac.il/law/cegl3/Meyerpaper.pdf>
- 443 25. Christensen M, Dodds A, Sauer J, Watts N. Alarm setting for the critically ill patient: A
444 descriptive pilot survey of nurses' perceptions of current practice in an Australian Regional
445 Critical Care Unit. *Intensive Crit Care Nurs* [Internet]. 2014 Aug [cited 2017 Jun 19];30(4):204–
446 10. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/24703797>
- 447 26. Sowon AK, Tarriela AF, Gomez TM, Reed CC, Rapp KM. Nurses' Perceptions and Practices
448 Toward Clinical Alarms in a Transplant Cardiac Intensive Care Unit: Exploring Key Issues Leading
449 to Alarm Fatigue. *JMIR Hum Factors* [Internet]. 2015;2(1):e3. Available from:
450 <http://humanfactors.jmir.org/2015/1/e3/>

- 451 27. Barbour R. Checklists for improving rigour in qualitative research. *Bmj*. 2001;323(7311):514.
- 452 28. Charmaz K. Constructing grounded theory: a practical guide through qualitative analysis. Vol.
453 10, Book. 2006. 208 p.
- 454 29. Carayon P. Emerging role of human factors and ergonomics in healthcare delivery - A new field
455 of application and influence for the IEA. *Work*. 2012;41(SUPPL.1):5037–40.
- 456 30. Wooldridge AR, Carayon P, Hundt AS, Hoonakker PLT. SEIPS-based process modeling in primary
457 care. *Appl Ergon* [Internet]. 2017 [cited 2017 May 8];60:240–54. Available from: [http://ac.els-](http://ac.els-cdn.com/S000368701630254X/1-s2.0-S000368701630254X-main.pdf?_tid=e573bf02-33d2-11e7-800f-00000aacb35f&acdnat=1494236834_992f28332972684034262c7ce9bedbb4)
458 [cdn.com/S000368701630254X/1-s2.0-S000368701630254X-main.pdf?_tid=e573bf02-33d2-](http://ac.els-cdn.com/S000368701630254X/1-s2.0-S000368701630254X-main.pdf?_tid=e573bf02-33d2-11e7-800f-00000aacb35f&acdnat=1494236834_992f28332972684034262c7ce9bedbb4)
459 [11e7-800f-00000aacb35f&acdnat=1494236834_992f28332972684034262c7ce9bedbb4](http://ac.els-cdn.com/S000368701630254X/1-s2.0-S000368701630254X-main.pdf?_tid=e573bf02-33d2-11e7-800f-00000aacb35f&acdnat=1494236834_992f28332972684034262c7ce9bedbb4)
- 460 31. Barker AK, Brown K, Siraj D, Ahsan M, Sengupta S, Safdar N. Barriers and facilitators to infection
461 control at a hospital in northern India: a qualitative study. *Antimicrob Resist Infect Control*
462 [Internet]. 2017 Dec 8 [cited 2017 May 2];6(1):35. Available from:
463 <http://www.ncbi.nlm.nih.gov/pubmed/28405312>
- 464 32. Jeffs E, Vollam S, Young JD, Horsington L, Lynch B, Watkinson PJ. Wearable monitors for
465 patients following discharge from an intensive care unit: practical lessons learnt from an
466 observational study. *J Adv Nurs*. 2016;72(8):1851–62.
- 467 33. Lankiewicz JD, Wong T, Moucharite M. The relationship between a single-patient-use
468 electrocardiograph cable and lead system and coronary artery bypass graft surgical site
469 infection within a Medicare population. *Am J Infect Control*. Elsevier Inc.; 2018;1–3.
- 470 34. King J, Gratrix A. Delirium in intensive care. *Contin Educ Anaesthesia, Crit Care Pain*.
471 2009;9(5):144–7.
- 472 35. Parry SM, Knight LD, Connolly B, Baldwin C, Puthuchery Z, Morris P, et al. Factors influencing
473 physical activity and rehabilitation in survivors of critical illness: a systematic review of
474 quantitative and qualitative studies. *Intensive Care Med*. Springer Berlin Heidelberg;
475 2017;43(4):531–42.
- 476 36. Kim S, Kim J-J, Oh J, Park J, Park JY. Delirium characteristics and outcomes in medical and
477 surgical inpatients: A subgroup analysis. *J Crit Care* [Internet]. Elsevier Inc.; 2018;43:156–62.
478 Available from: <http://linkinghub.elsevier.com/retrieve/pii/S0883944117306056>
- 479 37. Henricson M, Ersson A, Määttä S, Segesten K, Berglund AL. The outcome of tactile touch on
480 stress parameters in intensive care: A randomized controlled trial. *Complement Ther Clin Pract*.
481 2008;14(4):244–54.
- 482 38. Koen MP, Van Eeden C, Wissing MP. The prevalence of resilience in a group of professional
483 nurses. *Heal SA Gesondheid* [Internet]. 2011 Feb 23 [cited 2017 Aug 21];16(1):11 pages.
484 Available from: <http://www.hsag.co.za/index.php/HSAG/article/view/576>
- 485 39. Nielsen J, Mack RL. Usability inspection methods [Internet]. *Usability inspection methods*.
486 Wiley; 1994 [cited 2017 Jul 11]. 413 p. Available from:
487 <http://dl.acm.org/citation.cfm?id=189209>
- 488 40. Rogers EM. Diffusion of innovations [Internet]. Macmillan Publishing Co. 1995. 3rd Edition.
489 Available from: <http://hollis.harvard.edu/?itemid=%7Clibrary/m/aleph%7C006256656>

41. Downey CL, Brown JM, Jayne DG, Randell R. Patient attitudes towards remote continuous vital signs monitoring on general surgery wards: An interview study. *Int J Med Inform* [Internet]. 2018 Jun [cited 2019 Apr 30];114:52–6. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S1386505618302508>
42. Hendy J, Reeves BC, Fulop N, Hutchings A, Masseria C. Challenges to implementing the national programme for information technology (NPfIT): a qualitative study. *BMJ* [Internet]. 2005;331(7512):331–6. Available from: <http://www.bmj.com/content/331/7512/331.short>

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Appendix 1

Staff Interview Topic Guide v1.0 01/08/2016

REC Ref No: 16/WA/0024

Chief Investigator: Dr Peter Watkinson

Title of project: Assessing the feasibility of non-contact vital sign monitoring.

Introduction

This topic guide is to give an overview of possible outcomes of the semi-structured interview in relation to the feasibility study of the use of wireless monitoring in a critical care area.

Objectives

-Current vital signs monitoring standards (how is this done/compatibility/advantages/disadvantages)

-Staff's attitude toward current monitoring and how this affects patients (positively/negatively)

-Perceptions of wireless monitoring technology (compatibility/relative advantages/disadvantages/observability/complexity)

-Feelings of staff using contactless vital signs monitoring (compatibility/relative advantage/observability/complexity)

-Staff's attitudes toward contactless vital signs monitoring (compatibility/relative advantage/observability/trialability/complexity)

-Clinical staff's attitudes towards ethical considerations (Compatibility)

-New areas for consideration that new technology brings to healthcare

-Ideas surrounding staff's perceptions of patient/relative experience of monitoring within healthcare

Can I just start by asking you a little about your nursing experience please?



547

548

549 **Opening questions designed to explore staff participants' experience with and**
550 **knowledge of patient**

551 **monitoring in hospitals:**

552 • **Talk to me about the types of monitoring that you are used to or**
553 **aware of? (eg. Transfer monitoring, minimal monitoring SpO2**
554 **and HR only, visual monitoring only, invasive monitoring such**
555 **as ABG/Oesophageal doppler/CO, blood results monitoring)**

556

557 • **Can you talk me through the rationale for using different types**
558 **of monitoring?**

559 • *Why do you use certain monitors for different tasks? CT scan, Transfer,*

560 • *Could you explain what you mean by that?*

561 • *Could you explain that in more detail?*

562 • *How do you think that could be achieved?*

563 • *How do you think other people might view that?*

564

565

- 566 • **What effect do you think that current monitoring systems have**
567 **on the patient experience or healthcare journey?**
568 • *Could you explain what you mean by that?*
569 • *Could you explain that in more detail?*
570 • *How do you think that could be achieved?*
571 • *How do you think other people might view that?*

572

573 **Specific questions to explore the staff participants' experiences during the study:**

- 574 • **How do you feel using the existing wired monitoring systems?**
575
576 • *Could you explain what you mean by that?*
577 • *Could you explain that in more detail?*
578 • *How do you think that could be achieved?*
579 • *How do you think other people might view that?*
580
581 • **Wireless monitoring is a new concept, what were/are your**
582 **feelings towards it?**
583
584 • *What would increase user comfort?*
585
586 • *Did you find any of the equipment intrusive?*
587 • *Could you explain what you mean by that?*
588 • *Could you explain that in more detail?*
589 • *How do you think that could be achieved?*
590 • *How do you think other people might view that?*

591

592

- 593 • **How did the presence of the camera change your practice?**
594
595 • *Could you explain what you mean by that?*
596 • *Could you explain that in more detail?*
597 • *How do you think that could be achieved?*
598 • *How do you think other people might view that?*
599
600 • **Was there anything about the study equipment that was**
601 **unexpected?**
602 • *Could you explain what you mean by that?*
603 • *Could you explain that in more detail?*
604 • *How do you think that could be achieved?*
605 • *How do you think other people might view that?*
606
607

608 • **(if have used any of the standard medical equipment before)**
609 **Have you had any problems using <piece of equipment> in your**
610 **professional working life?**

- 611 • *Could you explain what you mean by that?*
- 612 • *Could you explain that in more detail?*
- 613 • *How do you think that could be achieved?*
- 614 • *How do you think other people might view that?*
- 615

616 **Exploratory follow-up questions to probe for further details:**

- 617 • *Could you explain what you mean by that?*
- 618 • *Could you explain that in more detail?*
- 619 • *How do you think that could be achieved?*
- 620 • *How do you think other people might view that?*
- 621

622 **More detailed questions to explore participants' thoughts on automatic visual monitoring**
623 **(in general):**

- 624 • **How do you think visual monitoring could be used in the future?**
- 625 • *Could you explain what you mean by that?*
- 626 • *Could you explain that in more detail?*
- 627 • *How do you think that could be achieved?*
- 628 • *How do you think other people might view that?*
- 629

630 • **Do you think there is a place for visual monitoring in the**
631 **hospital?**

- 632
- 633 • *Could you explain what you mean by that?*
- 634 • *Could you explain that in more detail?*
- 635 • *How do you think that could be achieved?*
- 636 • *How do you think other people might view that?*
- 637

638 • **Do you think there is a place for visual monitoring in the home?**

- 639 • *Could you explain what you mean by that?*
- 640 • *Could you explain that in more detail?*
- 641 • *How do you think that could be achieved?*
- 642 • *How do you think other people might view that?*
- 643

644 • **Would there be any additional information which you would like**
645 **to be obtained from the camera equipment? (Thermal**
646 **discrepancies in limbs/skin grafts, depth of respiration,**
647 **perfusion grading)**

- 648
- 649 • *Could you explain what you mean by that?*
- 650 • *Could you explain that in more detail?*
- 651 • *How do you think that could be achieved?*

- 652 • *How do you think other people might view that?*
- 653
- 654 • **Are there other areas of life where you think visual monitoring**
- 655 **might be useful?**
- 656
- 657 • *Could you explain what you mean by that?*
- 658 • *Could you explain that in more detail?*
- 659 • *How do you think that could be achieved?*
- 660 • *How do you think other people might view that?*
- 661
- 662 • **What benefits can you see with the visual monitoring system?**
- 663 • *Could you explain what you mean by that?*
- 664 • *Could you explain that in more detail?*
- 665 • *How do you think that could be achieved?*
- 666 • *How do you think other people might view that?*
- 667
- 668 • **How do you think wired monitoring is experienced by patients**
- 669 **and relatives?**
- 670
- 671 • *Could you explain what you mean by that?*
- 672 • *Could you explain that in more detail?*
- 673 • *How do you think that could be achieved?*
- 674 • *How do you think other people might view that?*
- 675
- 676 • **How do think wireless monitoring is experienced by patients and**
- 677 **relatives?**
- 678 • *Could you explain what you mean by that?*
- 679 • *Could you explain that in more detail?*
- 680 • *How do you think that could be achieved?*
- 681 • *How do you think other people might view that?*
- 682
- 683 • **How is wired monitoring experienced by staff?**
- 684
- 685 • *Could you explain what you mean by that?*
- 686 • *Could you explain that in more detail?*
- 687 • *How do you think that could be achieved?*
- 688 • *How do you think other people might view that?*
- 689
- 690 • **How was the wireless monitoring experienced by the staff?**
- 691 • *Could you explain what you mean by that?*
- 692 • *Could you explain that in more detail?*
- 693 • *How do you think that could be achieved?*
- 694 • *How do you think other people might view that?*
- 695

696 • **What concerns do you think people might have with visual**
697 **monitoring (in hospital/at home)?**

698

699 • *Could you explain what you mean by that?*

700 • *Could you explain that in more detail?*

701 • *How do you think that could be achieved?*

702 • *How do you think other people might view that?*

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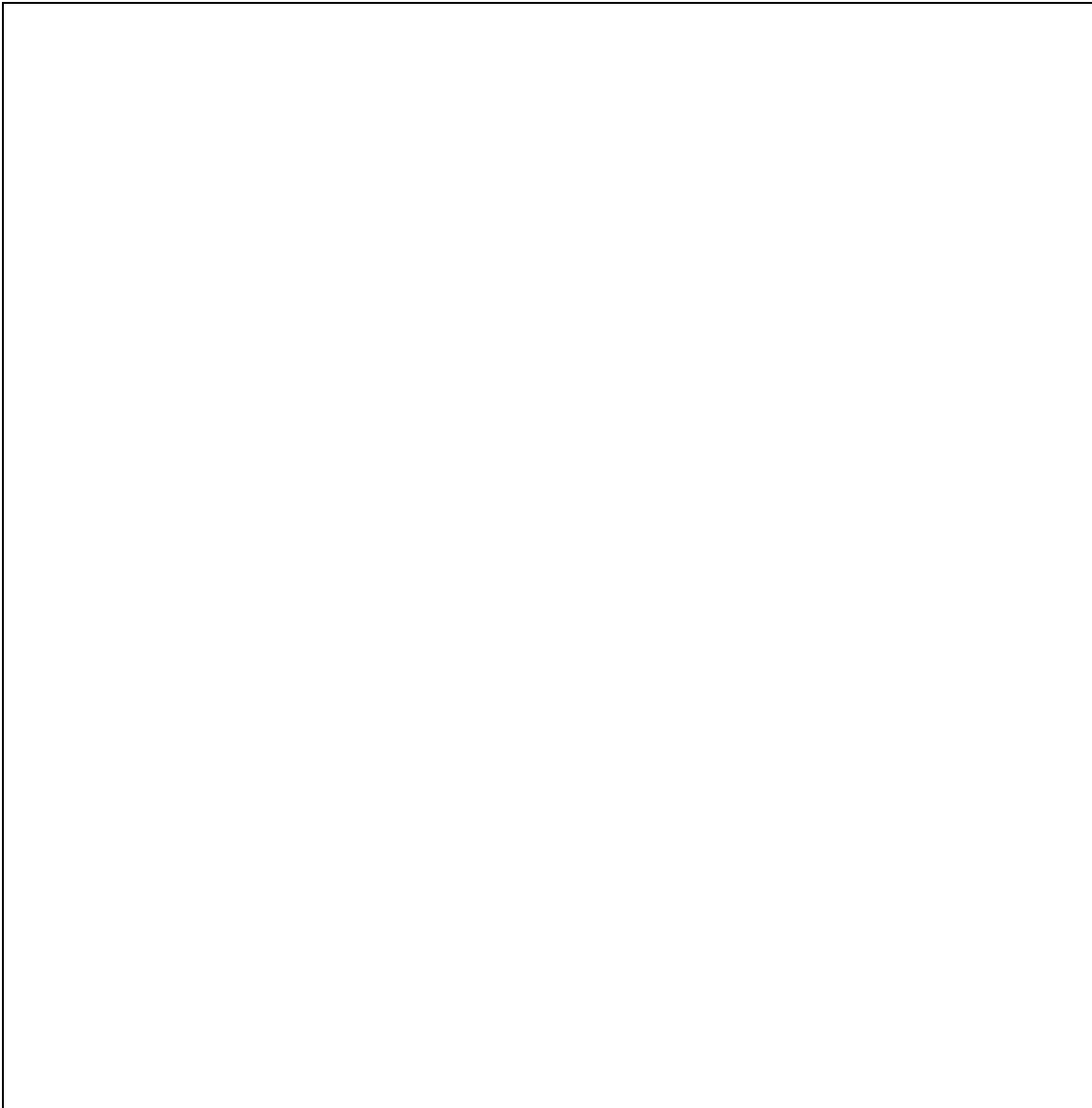
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715 **Interview notes**



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721 Appendix 2

722 **Consolidated criteria for reporting qualitative studies (COREQ): 32-**
723 **item checklist**

724

No.	Item	Guide questions/description	Reported on Page #
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Domain 1: Research team and reflexivity		
<i>Personal Characteristics</i>		
1. Interviewer/facilitator	Which author/s conducted the interview or focus group?	J.E.Ede
2. Credentials	What were the researcher's credentials? E.g. PhD, MD	MSc in Clinical Healthcare Practice
3. Occupation	What was their occupation at the time of the study?	Research Nurse
4. Gender	Was the researcher male or female?	F
5. Experience and training	What experience or training did the researcher have?	-GCP -3 years Research experience -Qualitative Research Methods Course
<i>Relationship with participants</i>		
6. Relationship established	Was a relationship established prior to study commencement?	Pg16
7. Participant knowledge of the interviewer	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	Pg16
8. Interviewer characteristics	What characteristics were reported about the interviewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	Pg5 Pg16
Domain 2: study design		
<i>Theoretical framework</i>		

9. Methodological orientation and Theory	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	Pg5
<i>Participant selection</i>		
10. Sampling	How were participants selected? e.g. purposive, convenience, consecutive, snowball	Pg5
11. Method of approach	How were participants approached? e.g. face-to-face, telephone, mail, email	Pg5
12. Sample size	How many participants were in the study?	Pg6
13. Non-participation	How many people refused to participate or dropped out? Reasons?	Pg5
<i>Setting</i>		
14. Setting of data collection	Where was the data collected? e.g. home, clinic, workplace	Pg5
15. Presence of non-participants	Was anyone else present besides the participants and researchers?	Pg5
16. Description of sample	What are the important characteristics of the sample? e.g. demographic data, date	Pg6
<i>Data collection</i>		
17. Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	Pg5 Appendix 1-Topic Guide Pg 29
18. Repeat interviews	Were repeat inter views carried out? If yes, how many?	No
19. Audio/visual recording	Did the research use audio or visual recording to collect the data?	Pg5
20. Field notes	Were field notes made during and/or after the interview or focus group?	Yes Pg 29
21. Duration	What was the duration of the inter views or	Pg5

	focus group?	
22. Data saturation	Was data saturation discussed?	Pg16-Not achieved
23. Transcripts returned	Were transcripts returned to participants for comment and/or correction?	No
Domain 3: analysis and findings		
<i>Data analysis</i>		
24. Number of data coders	How many data coders coded the data?	Pg5
25. Description of the coding tree	Did authors provide a description of the coding tree?	
26. Derivation of themes	Were themes identified in advance or derived from the data?	Pg5-Pg6
27. Software	What software, if applicable, was used to manage the data?	Pg5
28. Participant checking	Did participants provide feedback on the findings?	No
<i>Reporting</i>		
29. Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	Pg7-13
30. Data and findings consistent	Was there consistency between the data presented and the findings?	Yes
31. Clarity of major themes	Were major themes clearly presented in the findings?	Yes Pg6 Pg19
32. Clarity of minor themes	Is there a description of diverse cases or	Yes Pg 7-13

	discussion of minor themes?	
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