PRESERVING A HOSPITALISED PATIENT'S SAFETY

First steps in the development process for a future eHealth technology to prevent surgical site infections

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6-12-2017
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Acknowledgements

This report is the result of my graduation assignment for the master Health Sciences, at the University of Twente. The performed study comprises the first steps in the development of an eHealth technology. The subject intrigues me very much, particularly due to the combination of my knowledge in biomedical sciences and health sciences, specialised in eHealth. After the first meeting with L. van Gemert-Pijnen and F. Sieverink, I was immediately enthusiastic. My enthusiasm was especially encouraged by the fact that I could contribute to the first steps of this project applying my recently gained knowledge, and that presumably the end-product of the entire project contributes to the prevention of surgical site infections. I definitely wanted to learn new methods during my graduation project and I have never performed qualitative research before, so this was a great opportunity to learn new things. However, the main reason for me to contribute to this project was that the final developed eHealth technology (hopefully) will be able to indirectly contribute to the emerging global problem of antibiotic resistance, which I am always concerned with.

I really enjoyed performing this graduation project. Nevertheless, this would not have been made possible without the support and effort of certain people. Therefore, I would like to thank my supervisors, L. van Gemert-Pijnen and F. Sieverink, for the great opportunity they have provided for me to develop myself and for their belief in me. I am also thankful for the possibility they gave me to gain experience both within the research center (Centre eHealth Research & Wellbeing) as well as within the lab (persuasive eHealth technology). The guidance throughout the entire project could not have been better, and as an extra I really enjoyed the trips with F. Sieverink to the hospitals. Furthermore, I would like to thank all the participants, all who were willing to participate in this study, the success of this study could not have been made possible without their effort and input. Finally, I would like to thank Lars, my family, my friends and my fellow students for their support and advice during my graduation period.

I hope you will read this thesis with great pleasure.

With regards,
Mariska ter Horst
Enschede, December 2017

Abstract

Background

In today's changing world of medicine, it is of great importance to pay attention to surgical site infections (SSIs). Nowadays, much research is focused on the prevention of such infections, because they can cause unnecessary pain, fear and inconvenience for the patient. This can manifest as longer hospitalization, permanent disability or even death. By preventing SSIs, the morbidity, mortality and additional costs will be decreased. Additionally, the antibiotic resistance will be addressed. To prevent SSIs, special guidelines have been compiled and applied within hospitals in order to maintain patients' safety. However, it is known that compliance with these guidelines could be improved. This study focuses on the prevention of SSIs. Here will be investigated if there is a possibility to develop an eHealth technology that supports the compliance with SSI guidelines by the operating theatre staff. The aim of this study is to determine the added values assigned to a supporting technology in the compliance with SSI guidelines, in order to develop requirements and persuasive features. These are required for further research in the development of an eHealth technology.

Methods

The study is executed according to the CeHRes roadmap, the phases contextual inquiry and the value specification are elaborated upon. The first step was to perform a literature research in order to establish the Dutch SSI guidelines and to gain insight in order to generate the script required for the focus groups. Three focus groups (N=6, N=4 and N=5) with identified stakeholders were conducted across two hospital groups, with the aim to establish the context, needs and added values concerning the topic. Eventually the added values were translated into requirements by using the approach of Van Velsen (2013); subsequently the requirements were being translated into persuasive features by using the approach of Oinas-Kukkonen & Harjumaa (2009).

Results

The results showed that the healthcare workers did know the Dutch SSI guidelines but that the compliance with certain guidelines could be better and must be improved. The most criticised guideline is hand hygiene. It was described as not feasible to carry out, resulting in poor or non-compliance, particularly during non-sterile proceedings. The lack of awareness is the main reason for poor or non-compliance with SSI guidelines according to the stakeholders. Furthermore, the technology should be focused on the organisational culture, including hierarchical influences, role modelling, no sanctions culture and the need for evidence. The functionality and modality requirements were based on duration/location and ease of use. The usability and user experience requirements were mostly based on the way of operating, which should be stimulating. With the help of the formulated requirements are different persuasive features generated some are simulation, rehearsal and self-monitoring but also cooperation, recognition, trustworthiness, praise and rewards were interlinked with some requirements.

Conclusion

It can be concluded from the results that an eHealth technology which will support the compliance with SSI guidelines by the operating theatre staff is definitely of added value. It can be said that the conducted focus groups were successful in order to gain important information to establish the values that are assigned to the eHealth technology by the stakeholders, which are necessary for the formulation of the requirements for the eHealth technology and these are subsequently necessary to generate persuasive features in order to incorporate in the eHealth technology. It can be concluded that the most important added values are: the lack of awareness, the influence of organisational culture (esp. non-addressing each other) and the importance of showing consequences of poor or non-compliance with SSI guidelines. These are valuable to take into account for the next steps in the development process for a future eHealth technology to prevent surgical site infections.

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1. Introduction

Healthcare associated infections

In today's changing world of medicine, it is of great importance to focus on nosocomial or also called 'healthcare associated infections' (HAI). An HAI is an infection obtained in a hospital by a patient, who is admitted for another reason, occurring more than 48 hours after admission.[1] The infection occurs during hospital or healthcare facility stay and was not present or was not incubating at the time of admission.[1] This includes infections appearing after discharge of the patient and occupational infections among healthcare workers (HCW) of the healthcare facility.[1] According to the World Health Organization (WHO) HAIs are the most common complication affecting hospitalised patients worldwide, resulting in significantly increased morbidity and mortality.[2,3] Because of increased morbidity, mortality and additional costs, a significant burden is placed upon the patient, HCW, national healthcare services and public health.[1,4,5] For this reason infection control is a critical component in patient's safety.[3] The HAIs are categorised by sites of infection: surgical site infection (SSI), septicaemia/bacteraemia, urinary infection, respiratory infection, other infection and gastrointestinal infection.[1,6] In the Netherlands, most HAIs (66,7%) are categorised as SSI.[6]

Surgical site infections

An SSI is a post-operative wound infection, which is the result of contamination by a micro-organism during the surgical procedure.[7] If an SSI appears within 30 days postoperative, excluding non-human implants for which supplies one year, it will be defined and be registered as an SSI.[8] It can cause unnecessary pain, fear and inconvenience for the patient. This can manifest as longer hospitalization, permanent disability or even death.[9,10,11,12] According to the report of 2014 by the ECDC (2013 and 2014 data), the percentage of SSIs per 100 surgical procedures varied from 0.6% to 9.5% depending on the type of procedure.[13] The different types of surgical procedures are as follows: hip prosthesis (33%), knee prosthesis (23%), caesarean section (21%), cholecystectomy (10%), colon surgery (6%), coronary artery bypass graft (5%) and laminectomy (2%).[14] In the Netherlands, an SSI occurred in approximately 3% of all surgeries in 2014.[14] Unfortunately, the distribution of pathogenic particles is not always preventable during a surgical procedure. These pathogenic particles are mainly aroused from the skin of patients and HCWs.[15] The most common form of contamination is caused by pathogen transmission from the native flora of the patient's skin, mucous membranes or hollow viscera towards the wound.[16] Many benefits would arise if the incidence of SSI will be decreased; not only for the patient but also for the HCWs, global health and for the continuously increasing multi-drug resistant micro-organisms (MDROs), resulting in an increased worldwide antibiotic resistance.[17,18]

Antibiotic resistance in healthcare

The spread of infectious diseases is widely promoted by human activities such as air travel. On the other hand, however, big advances in public sanitation and in medicine are preventing the spread. Antibiotics, also known as antibacterials, belong to the most used successful class of preventing infection drugs. They kill or slow down the growth of bacteria. Unfortunately, there is a downside of using antibiotics, because of the ever-evolving qualities of both the pathogen and host. The process of developing resistance to antibiotics is accelerated due to the rapid evolution of pathogens. The WHO published a list of antibiotic-resistant pathogens, classified by three classes of priority: critical, high and medium priority.[19] This list was published in order to guide and promote research and development (R&D) of new antibiotics to address

the growing global resistance to antibiotics. The increasingly multi-drug resistance bacteria are widely acknowledged. Healthcare institutions, such as hospitals and nursing homes, are places where resistant bacteria originate and spread. Therefore, strict guidelines are created by the government and healthcare sectors regarding the prescription and use of antibiotics and care for patients. It is important to comply with these guidelines because otherwise the chance of antibiotic resistance increases, even though it could be easily prevented by correct compliance with the antibiotic prescription guidelines.
In healthcare institutions many patients receive antibiotics, and this eventually leads to an increase in resistant bacteria. Bacteria can easily be spread during the care of patients. Hence it is extremely important to aspire for good hygiene in care at all times. An infection with an MDRO is highly threatening for vulnerable patients. For that reason, it is important to improve the way of antibiotic prescription by the doctor and to provide better guidance in the administration of it by HCWs. Guidelines composed to prevent antibiotic resistance in healthcare are as follows: antibiotic prescription may only be by doctor, doctors must follow the guidelines regarding antibiotic prescription, HCWs must follow hygiene guidelines in order to prevent diffusion of resistant bacteria and infected patients with an MDRO must be isolated.[20] By collecting data with the help of PREZIES (Dutch surveillance network) an overview of antibiotic usage and number of resistant bacterial infections is created to gain insights in the antibiotic behaviour and infection rates. In recent years many interventions have been introduced concerning SSI prevention, and thus antibiotic resistance.

Guidelines for SSI prevention

To prevent the incidence of SSIs, the WHO introduced the 'global guidelines for the prevention of surgical site infection'. The aim of these global guidelines is to provide a range of evidence-based recommendations that could be used for interventions to prevent SSIs. The global guidelines are applicable during all operative phases (pre-, peri- and postoperative).[21] It is estimated that up to 60% of the SSIs are preventable by using evidence-based guidelines.[22] In the Netherlands, the global guidelines of the WHO are translated into a bundle of care in order to prevent SSIs (table 1). This is introduced by the safety management system (in Dutch: veiligheidsmanagementsysteem – VMS).[9] The intervention bundle includes four different measures: antibiotic prophylaxis, no hair removal before surgery (unless specifically required), normothermia and hygiene discipline in the O.R. (Operating Room). The fourth one, discipline in the O.R., is difficult to measure.[5,23] For that reason, it was decided to include one surrogate marker to measure the discipline in the O.R., namely the number of door openings during surgical procedure.[7,24] According to Koek et al. (2017), the bundle of care that was introduced by the VMS, was proven to be effective in significantly reducing the chance of SSI.[25] Their conclusion was that adherence to a surgical care bundle does significantly reduce the chance of SSI. Nevertheless, the compliance could be improved.[25] All four of the elements should be implemented with a compliance rate of at least 90% in order to reach the goal of decreasing the incidence of SSIs.[24,9] Within hygiene measures an essential measure is included, namely the hand hygiene (HH). HH is an important guideline in preventing HAIs.[26]

Table 1 Dutch SSI guidelines obtained from the bundle of care (introduced by VMS).

Dutch SSI guidelines	
Hygiene measures	<u>Hand hygiene:</u> · Hand cleaning · Hand disinfection Removal of all jewellery No artificial nails <u>Inside the O.R.:</u> · Correct wearing of sterile operating clothes (smock and pants) · Correct wearing of clean shoes · Correct wearing of a surgical mask (enclosing nose and mouth area) · Correct wearing of a surgical cap Correct cleaning and sterilization of surgical instruments and gloves <u>Door counters:</u> So far no official guidelines · Setting a norm of 'x' total door movements · Implementation of automatic door counters · Counting during surgical time · Using intercom system for communication with the outside of the O.R. · Take into account (coffee or lunch) breaks with regards to the planning · No clean up before wound closing
Antibiotic prophylaxis	Optimal time 30 minutes before incision with the correct type of antibiotics. The initial dose will be administered intravenously over a time interval of 15 and 60 minutes prior to the incision. Required during: · Surgeries of wound class 1 and 2 · Surgeries including implementation of prostheses
Normothermia	Maintain the state of normothermia unless otherwise required. The body temperature should be rectal between the 36 and 38 degrees Celsius and non-rectal between the 35,5 and 37,5 degrees Celsius · Body temperature between the 36 and 38 degrees Celsius - two hours prior to anaesthesia - during surgery - during stay at recovery room · Prevention of cooling down during transport from nursing ward to the O.R. - warming blankets/heat mattresses during all operative phases - warmed up IV fluids - socks and caps during surgery
(No) Hair removal	· Right before the surgery in the O.R. complex · Only if it is mandatory due to surgical technical reasons · Usage of clippers instead of razors
Other	· Infections of the patient outside the O.R. should be treated beforehand · Changing clothes of patient at nursing ward, removal shoes · Disposal of waste and contaminated equipment should be executed properly · Wound care: special guidelines apply for the type of wound · Bed hygiene: no change during open wound care

Compliance with SSI guidelines

Despite the fact that the association between unwashed hands and HAIs was already discovered in the mid-1800s by Ignaz Semmelweis, the compliance with the HH guideline is still disappointing in the 21st century.[27,28] HH is recognised as the most effective approach in preventing cross-transmission of MOs and thus reducing rates of HAIs.[29,30,31] The compliance with HH protocols worldwide is 'unacceptably poor' according to the public health authority in London, United Kingdom.[32] It is poor in most clinical settings and may very seldom reaches levels of 60% compliance.[29,33,34] According to a systematic review by Smiddy et al. (2015) the poor or non-compliance with HH seems to be influenced by two different core concepts.[35] These are motivational factors and perceptions of the work environment. Motivational factors are related to behaviourism of the HCW, while perceptions of the work environment are related to structural empowerment. Social influence is seen as a high impact influencing HH compliance, it is also evident in many studies.[36,37] Social influence can be defined in several ways, such as influence of clinical leaders, medical hierarchy, role modelling, fitting in, patients' perceptions and more external factors.[35,38–41] In the Netherlands, a qualitative study was conducted by Erasmus et al. (2009) about studying determinants of HH compliance among HCWs.[42] The study showed that the main reason for good compliance was self-protection. The lack of convincing evidence about the effectiveness of SSI guidelines in preventing SSIs and the lack of positive role models were given as reasons for poor or non-compliance.[42] The influence of role models in the organisational culture is also mentioned by Chaberny et al. (2001). They conducted a survey among medical students asking about their knowledge and beliefs regarding HH.[33] The main reasons were the lack of knowledge about performing correct HH and the influence of role modelling by the senior staff.[33] Also Lankford et al. (2003) showed that the compliance of HH is indeed lower if a supervisor was present giving a bad example.[41]

Much research is conducted in order to investigate the poor or non-compliance with the HH guideline. However, some are also investigating the compliance with other SSI guidelines or other guidelines in a hospitalised setting because the compliance with it could be improved.[43] The literature predominantly mentions lack of awareness, information overload, complexity of the guidelines, evidence-based, organisational aspects (e.g. high staff turn-over, complex surgeries, time pressure, etc.) and behavioural aspects as reasons for poor or non-compliance with SSI guidelines by HCWs.[35,44–47] To improve compliance with SSI guidelines by HCWs, in order to reduce the chance on SSIs and the antibiotic resistance, it is important to take into account all (adherence) barriers, an associated behavioural modification programme and all involved end-users, the ones who have to follow the policy, all in order to design an intervention that will succeed and is usable in practice.[38,43,48]

Interventions

Technology can support in the prevention of SSIs and can focus on environmental and practical issues. One environmental intervention is the implementation of designated developments as laminar air flow (LAF) systems in the O.R. in order to reduce the microbial air count to prevent SSIs.[4,15] However, this laminar air flow innovation by itself is insufficient in preventing contamination by pathogens.[15] Interventions could also focus on environmental hygiene in order to prevent SSIs. For example, by using special cleaning robots that make use of ultraviolet germicidal light in order to eliminate viruses, bacteria, mould, yeast and protozoa. Studies of the CDC showed that such technology is effective in reducing HAI. Furthermore, it could be that (technological) interventions are more educational oriented for the HCWs.

Educational (technological) interventions

Most (technological) interventions are focused on improving the compliance with HH guidelines in order to prevent SSIs. In 2005 the WHO launched its first Global Patient Safety Challenge campaign 'Clean Care is Safer Care', in order to address the HAI worldwide. In 2009 as part of the 'Clean Care is Safer Care' programme the campaign 'SAVE LIVES: Clean Your Hands' was introduced, wherein a 'multi-faceted, multi-model hand hygiene strategy' is introduced. The *SAVE LIVES: Clean Your Hands* programme strengthens the 'my five moments for hand hygiene' approach to protect patient, HCW and environment against the transmission of pathogens.[21,49] The model stimulates HCWs to wash their hands at five particular moments: before touching a patient, before clean/aseptic procedures, after body fluid exposure/risk, after touching a patient and after touching patient's surroundings.[49] However, a study by Pereira et al. (2016) showed that the effectiveness of the multimodal hand hygiene strategy in a Brazilian learning hospital (high staff turnover, high complexity and low attendance of educational sessions) was not high.[50] It did not improve the performance of HH compliance among HCWs seen in this context, i.e. learning hospitals.[50] On the contrary, a study by Higgins et al. (2013), showed that the compliance of HH is significantly improved in an acute healthcare setting by using the gaming technology and audit tool setting of the multimodal strategy of the *SAVE LIVES; Clean your hands* programme. One part of the multimodal strategy is an implemented educational training programme for HCWs about HH techniques that includes an automated gaming technology training and an audit tool.[51] The study proved that learning and training by HCWs are stimulated through the incorporation of the teaching technology into the programme, which ultimately results in improved HH compliance and technique.[51]
Nowadays, technologies such as video and 3D virtual worlds (3DVW) are upcoming and have proven to be effective as well.[52] Weber et al. (2016) investigated if video-based instructions are more effective compared to the former instructions. Results show that video-based instructions about HH are more effective, efficient and acceptable as a teaching method.[52] Since 2000, 3DVW is being used in the medical world, mainly functioning as training tools, but since 2006 also as evaluation and actual treatment.[53] An example of virtual worlds is a supporting technology developed by Bertrand et al. (2011). This technology makes use of virtual reality (VR) in order to improve HH compliance.[54] The simulation is designed to train and teach HCWs hand hygiene procedures according to the five moments of HH by the WHO. Further research has to be executed about its effectiveness.

Non-educational (technological) interventions

Many (technological) interventions provide audits and feedback and are based on monitoring certain proceedings, mainly HH performance. Most of the time the monitoring is performed by direct observation. Direct observation of HH performance by a trained observer is considered as the golden standard for monitoring compliance, but it is prone to the Hawthorn effect.[31,55,56] New technologies, such as video or radiofrequency identification (RFID) sensors, are able to continuously and objectively monitor specific proceedings and thereby provide regular feedback and/or real-time reminders, but costs begin a disadvantage.[31,57,56,58] Observational approaches can be very successful in improving the compliance with guidelines, for example Armellino et al. (2012) installed cameras in intensive care unit rooms that were focused on the sink and dispensers. Afterwards, real-time HH performance rates were displayed on electronic boards, that were made visible for both the visitors and the staff. The HH compliance rate increased significantly from 6.5% to 89%, though long term findings still need to be examined.[59]
Another technology that works through monitoring HH performance is the *The Semmelweis hand hygiene system*. It is designed to improve the HH performance and compliance with it and above all to raise awareness for the users. The scanner is able to detect HH performance and the results are immediately visible by providing real-time feedback. The system is effective in improving HH compliance which is shown as a decrease in the incidence of HAIs.[60]

As mentioned before, the limitation of door openings in the O.R. is included in the SSI prevention bundle in order to measure the hygiene discipline in the O.R. This can be seen as O.R. traffic. A study led by Esser et al. (2016) investigates the O.R. traffic by using a multifaceted approach including education, wireless communication technology and policy development.[61] O.R. traffic was counted by the frequency of door openings. Results show that the approach did significantly decrease the amount of door openings per hour. More research is needed to evaluate the effectiveness on the SSI incidence.[61]
Another approach to prevent SSIs is focused on the minimisation of invasive procedures by surgical robots. Unfortunately, nowadays it is not perfectly designed nor used properly by the user, which can result in opposite outcomes.[17] Another technology focusing on perioperative proceedings is the so-called: *operating room monitoring system: O.R. Cockpit,* developed by a company called NewCompliance in the Netherlands. This intervention is able to measure several parameters in and around the O.R. which will be presented to the operating theatre staff in order to provoke reactions and to change long term behaviour. The cockpit registers and analyses air quality and uses the SSI guidelines as parameters. It is installed outside the O.R. and it shows an overview of all activities and measured parameters in all operating rooms of the hospital. The system makes use of real-time feedback towards the operating theatre staff. The direct feedback gives the possibility for adequate anticipating by the operating theatre staff. It has been shown that the patient's safety is significant improved.[62] Another technology designed for the O.R. is the *digital surgical assistant Dora*, still in development by the Dutch technical university Delft. Dora is designed for the operating theatre staff and is even located inside the O.R.[63] The technology makes use of an RFID system and monitors all the equipment needed to perform that particular surgery. It does not monitor compliance with guidelines by the operating theatre staff. [63]

Furthermore, it is essential to want to keep in mind to design and implement technologies, e.g. simulation-based medical education, with great care.[64,65] To ensure that the technology will succeed, certain knowledge is required. Knowledge about aspects such as priorities, values, and the context, but also about the way of implementation.[64] All of these are fundamentals of eHealth.

e-Health

The previous paragraph showed the importance of supporting technology and interventions in healthcare, some can also be defined as eHealth. But what is eHealth? The legendary definition of eHealth by G. Eysenbach is as follows: *'e-health is an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve healthcare locally, regionally, and worldwide by using information and communication technology.'*[66] During the development of eHealth it is important to involve stakeholders from the beginning of the development process in order to obtain a best fit between the technology and the end-user.[67,68] This study is part of the Health-i-care project, an interregional partnership between the Netherlands and Germany. The main focus of the Health-i-care project is on the prevention and control of HAIs and on how to cope with antibiotic resistance. It focuses on the development of new interventions in the form of products and technologies. The project is set up from the wishes and needs from users and involved parties. By operating cross-border, the amount of networks is more widespread and expanded which would result in an improved innovative capacity. Finally, this results in a reinforcement of the innovation capacity and therefore an elaboration of one strong health-economic region. Within this project a total of thirty different consortia, small and medium sized enterprises, work together in projects to

maintain the best approaches. Altogether, this contributes to the maintenance of important hygienic standards and the development of it.

In this study will be investigated if there is a feasibility to develop an eHealth technology that supports the compliance of the operating theatre staff to the SSI guidelines. The aim of this study is to determine the added value assigned to a possible supporting eHealth technology in the compliance with SSI guidelines. The added values that are assigned to the eHealth technology by the stakeholders will be used to develop requirements and persuasive features necessary for the design of an eHealth technology. The main research question is as follows:

How can the needs and values among healthcare workers be identified and translated into requirements and persuasive features for the design of an eHealth technology, to support the compliance with SSI guidelines?

The main research question will be answered with the help of the following sub questions:

- *Which guidelines are known within the hygiene protocols according to the stakeholders?*
- *What are the reasons for poor or non-compliance with the SSI guidelines according to the stakeholders?*
- *What are the needs, values and wishes of the stakeholders regarding new technologies which could support the compliance with the SSI guidelines?*
- *What are the requirements and persuasive features necessary for the first prototype design to support healthcare workers in SSI compliance?*

The relevance of this study concerns patients, HCWs, global health and the growing antibiotic resistance. If the incidence of SSIs will decrease, then patients will recover quicker, costs will be saved and the prescription of antibiotics will decline. Finally, at the end of the study a supporting eHealth technology will be designed, developed and ready to be implemented. The difference between this and other studies is that other studies are mainly focused on improving the compliance with one specific guideline, such as HH (mostly on the five moments of HH), and is mainly intended for HCWs in general or only within a hospital care unit or such as the *digital surgical assistant Dora* addressing the required equipment in the O.R. This study will instead only focus on the operating theatre staff and on their compliance with the SSI guidelines. The developed eHealth technology will be used by the operating theatre staff inside the O.R. or at least near the O.R. Thus, the compliance by the operating theatre staff will be addressed in order to eventually decrease the incidence of SSIs.

2. Theoretical framework

In this chapter various frameworks and methods used in this project will be described in detail. The CeHRes roadmap and persuasive systems design model will be discussed.

CeHRes Roadmap: a holistic approach for eHealth development

The CeHRes Roadmap serves as a guideline for eHealth development, implementation and evaluation. The approach can be used to help plan, coordinate, execute and support the participatory development process of eHealth technology.[68] The roadmap aims to establish a perfect match between humans, technology and the context in which it is used.[68] This framework combines different approaches for the development of eHealth technologies. The CeHRes roadmap, developed by Van Gemert-Pijnen et al. (2011), has emerged as an effective eHealth framework through combining approaches for participatory development, human centred design, persuasive design and business modelling.[67,68] The combinations of theoretical foundations with infrastructural factors can be defined as a holistic approach. All parts of the whole are interconnected with no possibility to analyse or consider it separately. Throughout the entire development process iterative evaluation cycles takes place. The development of the most accessible, applicable, manageable, enjoyable and feasible eHealth technology will be stimulated because of the holistic approach.[67,68] Ultimately the roadmap is based on five principles that form the foundation of the holistic approach. These five principles are, eHealth development: is a participatory development process, is intertwined with implementation, is connected with persuasive design, requires evaluation cycles (formative and summative evaluation).[68] An eHealth framework addresses the needs of prospective end-users in order to realize a successful technology that innovates healthcare.[67]
This holistic approach is translated into five intertwined phases connected by iterative cycles of activities (fig. 1). These five phases are: contextual inquiry, value specification, design, operationalization and summative evaluation. All phases are intertwined by formative evaluations executed by stakeholders. The evaluation cycles are required to guarantee that the outcome fit the stakeholders' perspectives and its context. The development process will be guided by a multidisciplinary project team, consisting of the prospective end-users and of people with expertise in system design, content development and research. The team is also responsible for the organization of the formative activities. Below is given short explanations about the different phases.

Contextual inquiry
During this phase the identification of the stakeholder's needs and problems takes place in order to achieve the goal of the eHealth technology. The first step is to conduct a state-of-art inquiry, which follows in the identification of the stakeholders. Stakeholders are people who are most involved concerning the future eHealth technology. The stakeholders select the key-stakeholders and specify their roles for the eHealth intervention. Subsequently, the multidisciplinary team should understand the context following an examination of the strong and weak points about the current situation. Finally, after the knowledge and information is obtained and processed, a concept is devised about how to fulfil the expectations of the intended users.

Value specification
During this phase the aim is to formulate the added values of the eHealth technology. These can be formulated as economic-medical, socio-psychological and organisational values. The key-stakeholders are responsible for the establishment of the added values they assign to the eHealth intervention. Furthermore, the identified added values will serve as input for the development of requirements of the

eHealth technology. The requirements represent design details and serve as a blueprint for the eHealth technology. Both added values as well as requirements increase the chances of the technology being used properly and assist in creating a good combination between technology, stakeholders and context. Lastly, the development of a business model should start during this phase because such a model, required for deliberating, planning and operationalising the implementation of eHealth, should consider the added values.

Design

The design phase elaborates further on the outcomes of the contextual inquiry and the value specification. During this phase, multiple prototypes will be developed by the development team. The prototypes expand upon the initial idea and are simplified and visualised representations of the eHealth technology. The technology requires to be tested through usability tests by selected stakeholders in order to create the best fit between eHealth technology and the needs of the end-users. Furthermore, persuasive features will be added to the technology in order to change users' behaviour and to achieve adherence to the technology by the users. If the formerly output obtained from the earlier phases is processed well, the possibility of a good fit between context, technology and people increases.

Operationalisation

During the operationalisation the planning and finalising of the eHealth technology implementation will be executed. First the business model for the implementation of the eHealth technology should be finalised. The business model describes the expected cost-benefits and the resources, capacities and abilities which are all required for the implementation. An implementation plan is created by using the business model, input of the stakeholders and by using implementation theories, all to assure that the eHealth technology is introduced and used properly long term. Besides that, it is also required to set up a certain strategy for the implementation of the eHealth technology in practice.

Summative evaluation

The summative evaluation represents the evaluation of the uptake and of the impact of the eHealth technology. The evaluation of the impact of the eHealth technology focuses on the formerly determined values. The effectivity will be measured by taken clinical, behavioural or organisational outcomes into account. The uptake of the eHealth technology in practice refers to the evaluation of the usage of the technology by both people and organisations, whether technology is used properly and as designed for, and if the technology is implemented properly as planned during the operationalisation. Based upon the outcome of this evaluation it can be decided if redesign is necessary.

Formative evaluations

During every step of the CeHRes roadmap an evaluation takes place among the stakeholders. This is required to obtain the best possible fit between the people, technology and context. These so-called formative evaluations are essential to continuously attune the technology.

As mentioned in the *introduction,* it is very important to include several aspects, such as all barriers, an associated behavioural modification programme and the prospective end-users (in this case the ones who have to follow the policy) in order to create a successful eHealth intervention. These aspects are all embedded in the CeHRes roadmap. It was therefore decided to work according to the roadmap. The first two steps of the CeHRes roadmap will be elaborated. An in-depth contextual inquiry is essential to achieve a perfect fit between the technology, prospective users and their environment.[68] In this study during the contextual inquiry, the identification of stakeholders and a needs assessment with the help of focus groups will be executed. The focus groups will be conducted to obtain background information of the context

and stakeholders, and to identify the 'strong and weak' points of the current situation, the current situation wherein an eHealth technology could be of added value. Secondly the needs and expectations of the stakeholders will be identified. Then the outcomes and context are being considered, and what could possibly follow from an establishment of a concept of the future eHealth technology. During the second step, value specification, the added values that the stakeholders assigned to the eHealth technology will be identified and listed. These added values will be used for the development of the requirements and possibly persuasive features. The requirements are necessary for the prototyping phase of the eHealth technology during the design phase.

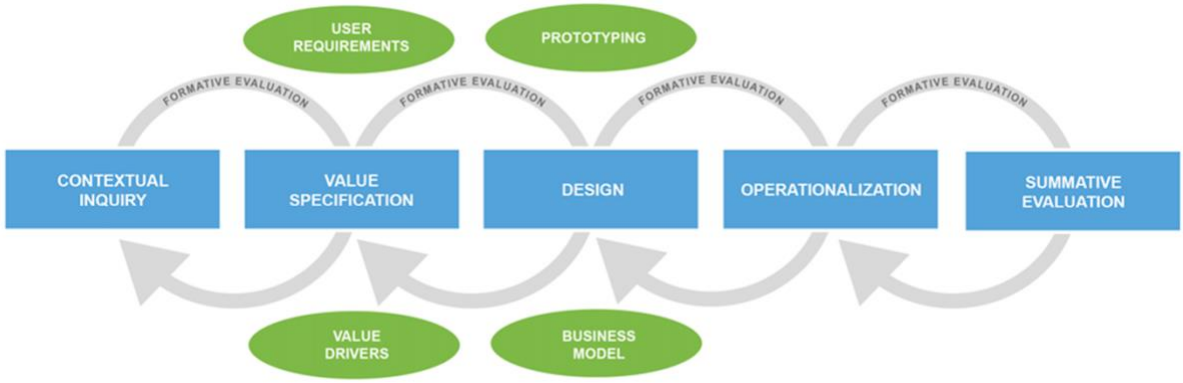

Figure 1 The CeHRes Roadmap (obtained from: www.ehealthresearchcenter.org)

Persuasive System Design Model

A persuasive system could be defined as *"computerized software or information systems designed to reinforce, change and shape attitudes or behaviours or both without using coercion or deception".*[69] The persuasive system design (PSD) model of Oinas-Kukkonen focuses on the process of designing and evaluating persuasive systems and on which functionalities the final software should contain. [70] Four different persuasive system principles are defined: primary task, dialogue support, system credibility and social support.[71] Each category is divided into several subcategories. Table 2 shows all categories with their corresponding design principles. The primary task support includes the main task that needs to be performed by the user. It embraces different categories all focused on the main task of it. The dialogue support defines the way of interaction between the system and the user. Also here several design categories are determined, all with the aim to help the user to keep moving towards their goal or target behaviour.[71] The system credibility support describes how to design a more credible and more persuasive system. Lastly, social support describes how to design a motivating system by using social influences.

Table 2 Overview of the principles with corresponding categories of the PSD model.

Primary task support	Dialogue support	System credibility support	Social support
Reduction	Praise	Trustworthiness	Social learning
Tunnelling	Rewards	Expertise	Social comparison
Tailoring	Reminders	Surface credibility	Normative influence
Personalization	Suggestion	Real-world feel	Social facilitation
Self-monitoring	Similarity	Authority	Cooperation
Simulation	Liking	Third-party endorsements	Competition
Rehearsal	Social role	Verifiability	Recognition

3. Methodology

To answer the research questions, three focus groups are conducted to verify if the HCWs do work according to the Dutch SSI guidelines, to gain insight into the context of compliance with SSI guidelines, to identify the needs and wishes of the stakeholders with regards to an eHealth technology and to establish the added values that the stakeholders assign to an eHealth technology supporting in compliance with SSI guidelines. Subsequently, the requirements and persuasive features are developed by using the formerly established added values, useful for the development of an eHealth technology.

Furthermore, in this study the CeHRes roadmap is applied for the development of an eHealth technology. This is achieved by conducting focus groups including stakeholders that are involved in SSI prevention. The first two steps of the framework are elaborated; these are the contextual inquiry and the value specification. The same focus groups are used to elaborate the phases in consequence of the overlap of both phases. An overview of the steps with corresponding methods and research questions is given in table 3.

Table 3 Overview of the research plan by applying the CeHReS roadmap.

CeHRes Roadmap			
Phase	**Research questions**	**Methods**	**Output**
Contextual inquiry	Which guidelines/topics are known within the hygiene protocols according to the stakeholders? What are the critical points in the compliance with the SSI guidelines according to the stakeholders?	Literature study Focus groups • UMC, Groningen • ZGT, Almelo Using focus group data to establish the contextual inquiry of the current situation.	Dutch SSI Guidelines identification Stakeholder identification: • UMC,Groningen • ZGT, Hengelo
Value specification	What are the needs, values and wishes of stakeholders regarding new technologies which could support the compliance with the SSI guidelines? How can the needs and values of the stakeholders be translated into requirements and persuasive features necessary for the design phase, first prototype design to support healthcare workers in SSI compliance?	Using focus group data to establish the added values, that are assigned to the eHealth technology by the stakeholders. Using the added values as input for creating the requirements by using the Van Velsen approach (2013). Using requirements for the development of persuasive features with the help of the PSD model.	Problems, needs and wishes among stakeholders Added values Requirements Persuasive features

Contextual inquiry

The goal of the contextual inquiry in eHealth development is to get an all-encompassing interpretation of the prospective users and their situation. Three focus groups are conducted in order to identify trends and patterns in the perceptions of the stakeholders. The focus groups are held in the Dutch hospital groups: UMC Groningen and ZGT Almelo/Hengelo.
The following questions are answered during the contextual inquiry:

- Who are the stakeholders relevant to the project and its development?
- Which guidelines/topics are known within the hygiene protocols according to the stakeholders?
- What are the critical points in the compliance of the SSI guidelines according to the stakeholders? What does the current situation look like and what is going well? What are points of improvement?
- What behaviour could possibly be changed? What are the causes for that particular behaviour according to stakeholders and literature?
- What are the needs and wishes of stakeholders regarding new technologies which could support the compliance of the SSI guidelines? What kind of existing eHealth interventions are used in this context? What are the experiences of the stakeholders?

Target group

The target group in this study includes HCWs who are working in the O.R. or are involved in another way with regards to the prevention of SSIs. The target group includes the list composed by the WHO: the surgical team (e.g. surgeons, nurses, technical support staff, anaesthetists and anyone else providing surgical-related-care), the senior managers, hospital administrators, quality improvement and patient safety officers and those involved in staff education and training.[21] The total number of SSIs is seen highest among the surgeries executed by the plastic surgery, orthopaedic sector and general surgery (performing a lot of abdominal, breast, skin and veins surgery).[13] Therefore, it is important to include a plastic surgeon, orthopaedic surgeon and general surgeon within this study.

Stakeholder identification

At first the relevant stakeholders are identified based on the WHO list.[21] Because of the workload and the variety in working hours of most stakeholders, it is difficult to compose a group including all critical stakeholders as defined by the WHO. Two hospitals can be approached for participating in the project due to collaboration. The stakeholders of the focus groups were all participants in different initiatives regarding SSI prevention, in infection prevention projects and/or familiar with the topic. The selection of stakeholders was based on their participation in the infection prevention workgroups and was based on snowball sampling.[72]

Focus groups

A focus group is a qualitative research method and highly recommended for gaining insight and understanding in background information and opinions of stakeholders.[73,74] Focus groups are useful for the establishment of the context, roles and tasks that could be supported by a technology, besides that they could also serve to explore the context and need of a new activity involving eHealth.[67] Moreover focus groups provide insight into how to design an intervention and integrate it into the current work patterns and helpful for the development and inventory of new ideas, for the development of requirements, scenarios and personas and for determining if the obtained information from literature is correct.[67,74] Therefore, focus groups fit well within the human centred design approach.[67] The design of a focus group is planned carefully in order to obtain perceptions on a specific topic in a nonthreatening and permissive

environment. The focus groups are led by the moderator, who actively leads the discussion. The moderator will ensure that the discussions follow a certain structure.[75]
The choice for focus groups in this study is based on the research questions because focus groups are useful to gain insight and information in the context and stakeholders' perceptions. The conducted focus groups include stakeholders wherein differences prevail seen on hierarchical level, work operations and personal thoughts. However, all stakeholders are obligated to operate according to the same SSI guidelines and all are involved in preventing SSIs. The aim of the focus groups was to gain insight of the context and stakeholders' perceptions regarding the current situation in the compliance with SSI guidelines and with regards to an eHealth technology. In contrast to conducting interviews and taking questionnaires among stakeholders, focus groups are proven to be more effective in gathering additional information about the context and the insight because of the discussion among stakeholders, and in this case it could also be beneficial because that it could stimulate the adaptability and the understanding of the stakeholders in relation towards each other, also in order to obtain additional information.
The script used for all focus groups mainly was based on the Critical Incidence Technique (CIT), originally developed by Flanagan (1954).[76] It proved to be an efficient method to generate much qualitative data.[77] The CIT is a useful approach for structuring focus groups or in-depth interviews with the aim to identify different critical incidences about a certain problem or issue. It embraces different questions for the researcher to ask the participant: What actually happened? Who was involved? What caused the event? What were the consequences of the event?[78] All of these questions are necessary for gaining insight in the critical incidents happening within an organisation.[76] The choice to use the CIT approach here is also based on the research question, because in order to answer the question it is necessary to identify the current situation which includes several critical incidents, these incidents can be referred as the different SSI guidelines. The same questions as above are used in the script for the focus groups (see Appendix I).
The scheduled time for each focus group was approximately 1.5 hours. All focus groups were recorded with record material in order to be able to transcribe verbatim. The stakeholders were asked to sign an informed consent for the participation in this study (see Appendix III).

Data collection and analysis

Data was collected by conducting focus groups and recording material was used to record the data. The records are transcribed verbally for the analysis. A specific approach is highly recommended to facilitate the analysis of a lot of qualitative data. This approach, the six steps of Plochg et al. (2007), is used in this study as a tool for data analysis.[79] The approach includes the following steps: organization and making it understandable for the analysis, obtaining a global overview of the data, start of detailed analysis, deepening the analysis, obtaining a meaningful view of the data and the interpretation of the analysis as a whole. In order to obtain reliable results and to reduce bias, one fellow student also analysed one focus group in order to gain inter reliability. The software program Atlas.ti was used for the analysis to make the process of analysing more systematic, ordered, transparent and accessible.[79] [80]

Value specification

The value specification phase elaborates further on the data that is obtained earlier during the contextual inquiry. The outcomes are translated into added values of which the eHealth technology should include. The first step is to specify what the exact goals of the technology are and what it should contain to reach these goals according to the stakeholders. It is important to prioritise the values obtained from the stakeholders in order to make proper decisions about conflicting values. The following sub research question is answered during this phase:

How can the needs and values of the stakeholders be translated into requirements and persuasive features necessary for the design phase, first prototype design to support healthcare workers in SSI compliance?

Requirements for eHealth technology

The values of the stakeholders are distilled from the data and are used for the development of requirements. The requirements of eHealth technology are developed using the approach for the development of eHealth technologies of Van Velsen (2013). This systematic approach facilitates the development of an eHealth technology which is embedded in the holistic approach for eHealth.[67] The needs, wishes and values are translated into requirements.[67] The requirements are categorised by type, there are five different types of requirements, these are: content, usability and user experience, functional and modality, service and organizational requirements.[67] The data is used to obtain user expressions which are necessary to create the requirements. Worthy expressions are translated into requirements, given in a table including value, rationale and requirement.[67] The choice to present the rationale behind the requirement is because it clarifies the requirement more precisely.
To formulate the requirements and to set priorities the MoSCoW method has been used. This is a way of prioritising requirements in software engineering. The classification of prioritisation is as follows: Must have - these requirements must be used in the design of the technology, Should have - these requirements are highly recommended, Could have – these requirements should only be applied if there is enough time, Won't have – requirements won't be applied in the technology.[81] Besides that, the prioritising of stakeholder also is taken into account in order to formulate the requirements. All HCWs which are or were belonging to the O.R. team are considered to be the most important stakeholders, which means that the nursing specialists, quality and safety staff and the head of units were considered as second important stakeholders.

Persuasive features

The persuasive features that can be derived from the requirements are developed according to the approach of Oinas-Kukkonen & Harjumaa (2009). Requirements will be translated into persuasive features if possible.

4. Results

In this chapter the results contrived from the conducted focus groups with stakeholders will be discussed. In the first section of this chapter the identification of critical incidents with regards to SSI guidelines is presented. Subsequently the identified critical incidents, which are classified on the order of Dutch SSI guidelines, are presented. These include the context, needs and wishes regarding that particular critical incidence and the added values assigned to an eHealth technology according to the stakeholders. Finally, the requirements and persuasive features for the development of an eHealth technology are presented. The coding tables are enclosed in appendix IV.

Stakeholder identification

The focus groups are conducted across two different hospital groups: the learning hospital group UMC (in Dutch: Universitair Medisch Centrum), Groningen (focus group I + II), and the non-learning hospital group ZGT (in Dutch: Ziekenhuis Group Twente), Almelo (focus group III). Focus group I includes mainly surgery nurses and infection prevention specialists. Focus group II includes one plastic surgeon, one orthopaedic, one anaesthesiologist and one nursing specialist on orthopaedics. Focus group III includes one quality and safety employee, head of units, anaesthesiologist and an operating room assistant. The stakeholders who participated in the focus groups are presented in table 4.

Table 4 Stakeholders with their functions. Stakeholders of focus group I and II, are working in the UMC Groningen, the Netherlands. Stakeholders of focus group III, are working in the hospital group Twente, Almelo/Hengelo. *Stakeholder leaves after 0.5 hour.

Focus group I		Focus group II		Focus group III	
Stakeholder 1	Head surgery assistants sector 3 & O.R. assistant	Stakeholder 1	Orthopaedic surgeon	Stakeholder 1	O.R. assistant
Stakeholder 2	Head operative care organisation & O.R. assistant	Stakeholder 2	Anaesthesiologist	Stakeholder 2	Anaesthesia worker
Stakeholder 3	Head nursing day-care & O.R. assistant	Stakeholder 3	Nursing specialist on orthopaedics	Stakeholder 3	Quality and safety employee
Stakeholder 4	Head operational surgical organisation & O.R. assistant	Stakeholder 4*	Plastic surgeon	Stakeholder 4	Head of unit central sterilisation assistants
Stakeholder 5	Staff adviser quality and safety operative care organisation			Stakeholder 5	Head of unit intensive care
Stakeholder 6	Head surgery assistants sector 1				

Focus groups

The results obtained from the data from the conducted focus groups are presented in the following sections. The first question is given below.

Which critical situations are most common concerning the compliance of the SSI guidelines?

Most of the stakeholders did mention hand hygiene as most important critical situation, *"hand hygiene is difficult, the protocol is impractical and infeasible, it is an important problem, that comes back over and over again"* (N = 10), wherein the compliance of its guidelines must be improved. Furthermore, the SSI guidelines in general, headwear, and clothing are mentioned. During focus group II, which includes mostly medical specialists, the stakeholders were repeatedly discussing and mentioning the compliance with the headwear guidelines *"you often see lures underneath, neck hair not covered, it just gets underneath!"* in a rather negative way. The participants of focus group III were mainly focused on the compliance with the SSI guidelines in general. On the next page an overview is presented in table 5 that includes the most mentioned critical situations giving with an example citation.

Table 5 overview of identified critical situations regarding the compliance of SSI guidelines with corresponding example citation and number of stakeholders (N = x).

Identified critical moments		
Critical situation	Example citation	No. of stakeholders
Hand hygiene	*"I think that almost during every positioning of the patient, people do not change their sterile gloves often enough, also in case of different actions and disinfection of the hands."*	N = 10
Headwear	*"I think the current compliance with headwear is just terrible. There are a lot of employees inside the O.R., who just not have covered all their hair."*	N = 9
SSI guidelines in general	*"It's the whole set of discipline, you have to work together. That will stimulate the discipline, when you make sure you have clean clogs and correctly covered your hair and make sure to be aware of door openings, then you will be aware of the rest and that all raises awareness."*	N = 8
Clothing	*"I think if people are leaving the O.R. for some reason, then when they come back, they have to change their suit for a clean one, and that does not happen."*	N = 5
Hospital clogs	*"There are people out there who never wash their hospital clogs, never!"*	N = 2
Normothermia	*"In the end, it's all fine, because in the end the patient is at temperature again, but what's happening in between is not always good."*	N = 6
Wound care	*"Every department has its own guideline, 'do you make up the bed while there is wound care?' or 'can you bring food around while there is wound care?'; all different each department."*	N = 6
Door openings	*"...as much as possible reduce the unnecessary door openings"*	N = 4
General hygiene measures	*"In times of emergency you regularly see people decorated with jewellery."*	N = 4
Antibiotic prophylaxis	*"Antibiotic prophylaxis performance and compliance is generally good."*	N = 4
Bed hygiene	*"Sometimes you wonder, 'hey is that bed really clean'; it's not controllable"*	N = 3
Number of people in O.R.	*"You do not want more than a total of 10 people present in the O.R., but there are exceptions of course."*	N = 2
Removal contaminated instruments waste	*"The O.R. assistants must clean and remove all, the anaesthetist must guide the patient out, it all happens at the same moment. If you'll wait for each other, then that will affect the next patient and the changeover times, and we don't want that either."*	N = 2

SSI guidelines in general

All focus groups were criticising the SSI guidelines in general (N=8) mainly as negative.

Main causes

The overall main cause mentioned by the stakeholders was the organisational culture, specifically the hierarchical influences. In the medical world it is a recognised phenomenon that people tend to be afraid to address their supervisor or others higher in the hierarchy *"Do you dare to address your boss? And does your boss address you? Or does he think it's all unimportant?"* Furthermore, is seen in this organisational culture the relevance of sanctions *"Do you dismiss the world famous thoracic surgeon? Of course not, and he is aware of that fact"*, because most of the time no sanctions exist for not maintaining the SSI guidelines. In addition to the general organisational culture and sanction issue, which are more or less intertwined with each other according to the stakeholders, is the need for evidence. Evidence is highly appreciated in the medical world; if there is no evidence for a particular guideline, then people tend to not follow that particular guideline correctly: *"It will never change. That's the medical world, they all want to prove it. There must be evidence!"*

What is often mentioned as an important cause as well is the awareness of the consequences of poor or non-compliance with SSI guidelines. One stakeholder described this as: *"You do not have to do it for me; you have to do it for the patient! And definitely operated patients, those are vulnerable patients, they are already sick! That is the only reason you are willing to contribute and comply with the rules, for that purpose!"*

Besides that, it is important to have uniform guidelines that also facilitate also the accessibility of protocols, "*One protocol is needed for the operating patient, no matter which surgery he undergoes. I wonder if we have that...."* Moreover, is the high staff turnover also an important issue regarding the compliance with SSI guidelines in general *"... jungle of protocols ... and one who changes between departments or comes new in doesn't learn all the different protocols"*.

Technology

According to the stakeholders, the main focus should therefore lie on 'uniformity': *"Uniformity is needed in the entire hospital."* All SSI guidelines should be uniform and applicable at every department and in the entire hospital. In the stakeholders' opinion it is difficult to maintain and comply with guidelines if they differ between departments, especially with the high staff turnover in mind. Furthermore, it is important to limit the amount of information as much as possible. Besides all that, the lack of awareness is also of great importance. HCWs should be more aware of the risk of SSI as result of poor or non-compliance with the SSI guidelines. According to the stakeholders the awareness by HCWs about the danger of SSIs should be addressed by influencing and changing behaviour: *"All these points, just awareness that you are not doing it for yourself, but for your patient."* Ideas for a supporting technology in the compliance with SSI guidelines are mainly based on an automated system that indicates a system wherein all guidelines are easy to find, easy to understand, uniform for the entire hospital and applicable in a learning hospital working with high turnover staff and complex surgeries. *"The intention is that ultimately there will be a universal work programme for everyone, for each medical specialist, assistant or whoever is involved. That could be applied from your first working day, because if people are unknown about the protocol, you cannot expect them to comply with it."* Other ideas were more focused on raising awareness and changing behaviour by demonstrations, short movies/films, in order to show the consequences of poor or non-compliance with SSI guidelines.

Hygiene measures

Hand hygiene

All focus groups' main importance critical situation was the compliance with HH guidelines (N = 10). The compliance with HH guidelines must be improved according to the stakeholders. The overall conclusion was highly negative.

Main causes

The main reason for the disappointed compliance with HH performance is the impractical protocol *"...even if you know the rules, the rules are impractical."* Mentioned by the participants of focus group I is that it is impossible to correctly maintain the guidelines during all operating phases but especially during non-sterile proceedings *"for people who are working non-sterile, this is the most important point for improvement, the protocol is too difficult."* Lack of awareness is mentioned as an important reason by the stakeholders as well: "*I think there is a lot to win regarding awareness."* Furthermore, stakeholders mention the organisational culture wherein a hierarchy dominates (i.e. people are afraid of addressing each other on particular topics). This particular cause for poor HH performance is mentioned quite often by the stakeholders: *"There is no student who would appeal to me, as head of the department, as in; 'professor would you not wear gloves now?'".*

Technology

If a technology would be designed for improving the HH guidelines compliance, the focus should lie on facilitating its protocol. The present protocol is too difficult to maintain according to the stakeholders: *"It's completely impractical, the rules are impractical; you simply cannot comply with these rules, therefore you get all kinds of adjusted behaviour."* Moreover, it is important to make people aware again of what the consequences are of poor or non-compliance: *"... I think there is a lot to win by creating awareness."* Besides that, it is important to minimise the information quantity as much as possible because nowadays there is just too much information: *"... a jungle of protocols".* The supporting eHealth technology should be based on raising awareness and should be implemented easily according to the stakeholders. It should also be easy to use and not be able to obstruct any kind of proceedings executed by the operating theatre staff. Real-time feedback to address the lack of awareness issue, for creating a self-learning system and a smart system, for facilitating the HH guidelines, would work best according to the stakeholders: *"See if it's possible to create something smarter and better."*

Headwear

The poor or non-compliance with headwear guidelines in the O.R. was mentioned by nine different stakeholders. Poor or non-compliance can result in threatening and risky situations, while these are easily avoidable, according to the stakeholders.

Main causes

Stakeholders mentioned the hierarchical structure as the main cause. People are experiencing it as bothersome to address each other: *"Is that environment safe enough to speak? I know that many O.R. assistants are becoming tired of saying the same thing over and over again."* Furthermore, it is mainly the medical specialists who are not correctly wearing their surgical headwear, automatically giving a negative example to other HCWs. Role modelling can be a powerful influence and it is a well-known important issue according to the surgeons from focus group II: *"The head of surgeon gives the ultimate example and yet he is the one who says: 'I will not wear that Glenn head, because then I can't hear a thing' while he stands in the O.R. with all his hair loose, then the rest will automatically follow and no one will wear that particular hat every again."* The negative impact of role modelling reaches far and creates an environment wherein people tend to forget the purpose of the guidelines. Moreover, all focus groups' stakeholders

mentioned the introduction of the Glenn Head, a surgical head covering the whole head/neck area. Every hair is covered and therefore it provides a very safe option to prevent SSI infections by hair transmission. Unfortunately, the introduction of mandatory wearing this particular head in the O.R. was fought out against to the highest council of the UMCg. According to the stakeholders some of the medical specialists were claiming that the Glenn head was impractical and affecting their work performance: *"'I do not hear a thing', 'It feels stuffy', regarding the Glenn surgeon head according to the surgeons."* The stakeholders were of the opinion that the medical specialists should adjust themselves for the sake of patient's safety, that it is part of their job to make compromises and that it could not always be that comfortable as you would wish for. The Glenn head problem fits well in the upcoming issue, which is the lack of awareness. The stakeholders mentioned the lack of awareness as one of the main causes for poor or non-compliance with correct headwear. Some are not aware that the chance of SSI infection highly increases by incorrect headwear and that it is necessary to comply with proper headwear for the patient's safety. Furthermore, the ignorance of the protocol is mentioned as cause for poor or non-compliance; this ignorance is mainly caused by the high staff turnover: *"What we've noticed is that people who come in new, medical assistants, medical specialists, do not know the correct guidelines; if you address them they'll answer: 'Oh I didn't know that'",* and the shortcoming in the uniformity of protocols regarding headwear.

Technology

Here the main focus of a new technology should lie on the clothing aspect in the O.R.: *"The two most difficult things here are: hand hygiene and hygiene measures, such as the surgeon hat."* The lack of awareness and uniformity is also mentioned as a focal point for a future technology. No uniformity in wearing the correct headwear follows in, no guarantee that HCWs will address each other on wearing proper headwear and maintain the headwear guidelines correctly *"The intention is that there will be a universal working programme for everyone, for each surgeon, O.R. assistant or whoever involved."* The lack of awareness results in no guarantee that HCWs will maintain the headwear guidelines and insure a patient's safety first: *"... all for creating awareness."* Some high-technology ideas were mentioned as an idea to address the headwear compliance, such as systems using chips, RFIDs and/or facial recognition: *"Ideal would be that if you don't cover your hair correctly, that the door will stay closed. I can imagine that you could measure something by using face recognition or you insert a chip in the surgeon hat or a RFID. If you don't have the right hat, then you cannot enter the O.R."* All intended to raise awareness about the importance of correct headwear and to verify if the guideline is complied with. Demonstrations are mentioned as idea to show to the HCWs the consequences of not wearing the headwear correctly: *"Things that you could do are, organising meetings, demonstrations, all for showing everyone that hair is a major source of infection, all for creating awareness."*

Clothing

Another critical factor that is often mentioned and criticised is clothing and hospital clogs (N = 7). Hospital clogs is mentioned mainly by the stakeholders of focus group II, who are medical specialists and are working in the O.R. at all times. However, the topic of clothing was discussed during all focus groups. The stakeholders aimed for the hygiene of clothing and clogs during the perioperative phase. The general rating was clearly negative. The stakeholders were referring to moments wherein surgeons were walking in and out the O.R. every time wearing the same green suits. They agreed that it is unacceptable and more importantly, the patient's safety will be jeopardized. As a possible solution one stakeholder brought up disposable coats which could be worn leaving the O.R. for a short notice, or making new clean suits available by the entrance and upon leaving the O.R. They agreed that the clothing hygiene, in this case white coats and operating suits, was a serious case which should be addressed in some way. Another major problem according to the stakeholders of ocus group II appeard to be the hygiene of hospital clogs: *"There are people out there who never wash their hospital clogs. Never!"* Nowadays HCWs are responsible for

the hygiene of their own clogs; no such thing as a clog washing centre exists and no guidelines are composed. They agreed that the clog hygiene was a serious case which should be tackled in some way. During focus group I and III the clothing was not mentioned quite as often as during focus group II.

Main causes

Several causes were defined contributing to the poor or non-compliance of clothing and hospital clogs guidelines. The main cause here is the lack of awareness: *"I have the idea that clothes and hygiene measures, it is the whole set of discipline ... all of that raises awareness."* The hierarchical structure was often mentioned as well: *"Often you see them walking in their green suits through the corridors, and then I want to address them about it, but then I think: 'Oh no, he has an exceptional position' and that's so silly!"* Another cause is the problem of logistics; because of the high staff turnover and many surgeries it is difficult to introduce new coats or disposable coats because they will all disappear over time: *"Do you know how many people work inside the O.R. every day? Do you know how many of these people left the O.R., taken the white coat ... Sure, we tried! But they disappear! The coats are not registered; they are gathered in all corners of the hospitals."* And the impact of role modelling is important here: *"We've all agreed with each other that no one can walk through the hallways wearing their green suit, showing their green suit to others, but still you see them walking in their green suits ..."*

Technology

As focal point is mentioned to keep in mind that the purpose of a guideline must be clear and understandable (e.g. why the guideline is necessary): *"We need to be careful not to push it too far; what's the purpose of that? What will we achieve with it?"* Because if a guideline or intervention is not considered useful, then people will not take it seriously and will not comply with it in the right manner: *"You have to feel that it makes a contribution, a contribution which would be achieved by all working together. In particular for us as clinical doctors; it must be practical and if we find something useful or experienced as meaningful, then of course we will follow that."* Ideas for a technology are based on clog hygiene more so than clothing hygiene. For the clog hygiene is mentioned some sort of clog washing machine: *"... a clog washing machine, it's not that hard."* and a general clog rack. Both options would facilitate a way for cleaning a person's clogs. For the clothing part is mentioned an idea to work with disposable coats: *"It's better to choose for disposable coats",* in some way. Addressing this topic for a future technology is definitely mentioned, only not in a way of high-technology terms or changing behaviour techniques.

Door openings & total number of people in the O.R.

In general, the situation regarding door openings was not evaluated as negative nor as positive. It was mainly discussed by stakeholders from focus group II and focus group III. As main reason for the excessive number of door openings is given the level of preparation: *"The door movements are nevertheless a surrogate parameter for your preparation and readiness."* Most comments were regarding the fact that the hospital still did not install a door counter, which could be very useful to refer to certain situations in which the number of door openings was notably higher: *"For example, here we have a lot more door openings than average, 'what happened here?', this could be used for management and to change behaviour..."* It could also be used as one of the key parameters, which could be presented in an automated overview or summary of every surgery according to the stakeholders. The number of door openings processed in an automated overview in the O.R. area along with other key parameters, and processed in a system which is helpful as reference and for evaluating the performance of the operating theatre staff, could both be very useful and helpful in order to improve the prevention of SSIs. It also raises awareness just by being confronted with the number of door openings, which can be related to the chance of an SSI or other complications or some proceedings during surgery or other key parameters.

The need for evidence was also discussed as reason. It has to be evidence-based, especially in the medical world, before one will follow and obey the protocol: *"We proved that the infection rate was decreasing by*

the number of door openings. But that followed into a discussion, because more parameters could be responsible for that. That is the medical world, they want to prove it. The evidence must be there." The stakeholders were of the opinion that it is important to reduce door openings as much as possible and that the amount of people inside the O.R. should be limited: *"... door openings and total number of people inside the O.R. are important parameters; you do not want to have more than ten people present in the O.R. Of course there may be exceptions. And then you can register both parameters automatically."* One idea that came up was to combine the number of people in the O.R. and number of door openings as one parameter which should be made visible for the HCWs in order to evaluate the surgery and to make it possible to refer to it. No specific technology was mentioned for the number of door openings and number of people in the O.R. The wish for a door counter was high, combined with a system in which the count would be registered. Furthermore, the number of door openings and the number of people in the O.R. should be used as one of the key parameters, which could function as parameters in an electronic overview giving perioperative and postoperative in the O.R.

"If there is a registration of too many people in the O.R. Okay, so what was going on? Was there a special situation that asked for that amount of people or not? Then you can recall a team by the sang-out procedure, 'we have 20% more door movements than usual with this type of surgery, has there been a special situation that caused it?' 'Why were there two too many people present in the O.R? Why has that been?"

Other

As main point of general hygiene measures came up the wearing of jewellery by the operating theatre staff. This could be improved, especially during emergency situations: *"In times of emergency you regularly see people decorated with jewellery."* As main cause was mentioned the hierarchical culture in which people tend to find it difficult to address each other on particular points. As second cause was mentioned the lack of awareness; people need to realise the risks it entails.

Normothermia

In general, the evaluation of normothermia was quite neutral. However, some points of improvement were mentioned later on. Some situations came up as negative, but that was mainly during the postoperative phase: *"I have the idea that attention is paid to it, but what I see is that patients cool down too much at the beginning, during the postoperative phase."* The stakeholders of focus group I and II all agreed on the fact that normothermia could be improved by making sure that the patient is arriving the O.R. with the right temperature. During focus group II was mentioned by the anaesthesiologist that the temperature at the beginning and at the end of the surgery is good, but what happens in between, perioperative, is insufficient. Mentioned as main cause for cooling down the patient perioperative is a management problem: *"There is no surgery that we cannot perform normotherm and if the patient really cools down, it is a management problem."* Furthermore, the stakeholders discussed the required actions which needs to be performed in order to enter data in the SSI registration system. The input of data is not adapted to the duration of a surgery and its complexity, resulting in a biased overall SSI score: *"At this moment the problem with the SSI registration is that during a short operation, the import of information in the SSI registration system would be completed insufficiently compared to long duration operations. The overall SSI score is therefore worse than it should be. so that could be something to improve."* The proceeding was also not user-friendly, because entering data has to be done manually at two different moments *"The only problem we currently have is that we now have to do two actions manually, one at the beginning and one at the end, you have to fill it in the good SSI registration."*

Besides the SSI registration the protocol for normothermia was discussed as well. Namely, no uniform protocol exists, which results in different guidelines generated by each department: *"Patients arriving with the right temperature at the O.R. is very important, and we do not have that registered in one protocol. At some departments they transport the patient completely packed to the O.R. and at other departments they do nothing to keep someone warm, and there is more in between."* No explicit focus on a future technology was given here, but rather that the normothermia could be improved by adjusting the SSI registration system. This would change the different protocols into an automated uniform protocol for the benefit of the patient, where it is clear which guideline everyone needs to follow and at which moment.

Antibiotic prophylaxis

Antibiotic prophylaxis was mainly evaluated as positive by all stakeholders. They agreed that everyone knows the correct guidelines about how to administer the antibiotic, at what moment and the duration of it: "*The performance of antibiotic prophylaxis and compliance is generally good."* The anaesthesiologist mentioned that the administration is during the patient introduction most of the time, because this is most convenient for the logistics part and it does not encounter any problem: *"...for our logistics, it is logical to do it during the introduction of the patient."*

Other guidelines

Wound care

The situation regarding wound care is exclusively discussed during focus group I (including most O.R. assistants). The stakeholders did not evaluate wound care as negative nor as positive. A few things came up and that was mainly about the ignorance about the protocol, all stakeholders did not know where to find the exact guidelines. They all performed wound care in the way they once had learned, without knowing if it was still the correct way of performing it or if anything else regarding wound care was changed. The performance of wound care is slowly integrated and changed over time and each department has its own guidelines regarding the performance of wound care: *"The guidelines varying between each department, questions arise as: 'Can you change the bed while wound care takes place in the room?' and as in: 'May you dispense food while wound care takes place in the room?' this differs per departmental level."* No further comments were given. For improvement could be focused on educating everyone about the correct way of performing wound care.

Bed hygiene

The bed hygiene and removal of contaminated instruments inside the O.R. is discussed by focus group I. One issue regarding the bed hygiene was the unawareness on whether a bed was clean or not: *"Sometimes you wonder, 'hey is that bed really clean'; it's not controllable."* The hygiene of beds is based on trust; it is uncontrollable if a bed is clean or not. Some stakeholders were of the opinion that sometimes the bed was not cleaned before the patient was placed in bed. The main focal point for this problem was to raise awareness for people. The individuals that are responsible for clean beds should be aware that this is critical and as such they should take this task serious for the safety of the patient.

Removal of contaminated instruments

It also happens that the removal of contaminated instruments takes place at the wrong moment and in many cases too early; sometimes it happens during the patient's outbreak, while this is not according to the guidelines. This situation occurs due to time pressure, because otherwise the entire planning will be

affected: *"The O.R. assistants must clean and remove all, the anaesthetist must guide the patient, it all happens at the same moment, if you will be waiting for each other, then that will affect the next patient and the changeover times, and we do not want that either."*

Summary

The results of the focus groups show that a new technology, which would stimulate the compliance in the SSI guidelines is highly in demand and that the main focus has to lie on the hand hygiene performance. It is impossible to comply with the guideline, because it is impractical and infeasible, especially during non-sterile proceedings. Besides that, the headwear was also mentioned as one of most important focal points and something on which a new intervention coo8uld definitely focus. This was also mentioned by the stakeholders of all three focus groups. The stakeholders of focus group III were mostly of the opinion that besides headwear and hand hygiene, the compliance with SSI guidelines in general should mainly be addressed.

Below are given the key points and manners of approach for a future eHealth technology. These are based on both direct and indirect spoken content of the stakeholders obtained from all three focus groups.

Key points for development of a future eHealth technology

Different key points obtained from the focus groups are described below.
The technology is:

- Easy to use in order to maintain the compliance and to create willingness for the user
- Presenting minimal information in order to create willingness and to preserve the user's attention
- Considered useful by all users in order to improve and maintain the compliance with SSI guidelines
- Awareness-raising in order to improve and maintain the compliance with SSI guidelines
- Addressing the hierarchical culture in order to create an environment where one can speak freely
- Focused on key parameters in order to preserve the user's attention
  As key parameters for an eHealth technology were mentioned: door openings, total number of people present in the O.R., time of antibiotic gift, temperature of the environment (O.R.), surgical time and general environmental information. It is important to not show more information than that what is essential.

Manners of approach for a future eHealth technology

Different manners of approach are described below. The particular manners can be used for the future eHealth technology. All manners are obtained from the focus groups.

- Self-reflecting, to improve procedures performed by the user and to raise awareness for the user
- Evaluating, to improve procedures performed by the user and to raise awareness for the user
- Improving knowledge, to improve the user's knowledge regarding compliance with SSI guidelines in SSI prevention
- Providing demonstration, to show the consequences of poor or non-compliance in order to raise awareness
- Repetition, to become an essential and indispensable part of every operating theatre staff's regular actions
- Empathy, to address the organisational culture and other peer-related issues (e.g. non-addressing each other, role modelling and peer pressure)

Technology

Ideas most frequently mentioned by the stakeholders are smart systems, self-learning systems, e-learning models and automating protocols. All HCWs be feeling overwhelmed with an information overload no matter what; it should be a stimulating process for all involved. Technologies such as stimulating games and self-learning systems came up quite often. The stakeholders of focus group II and III were of the opinion that an e-learning model is already a bit outdated; its stimulating effect is reduced and its motivating effect is slightly moved towards a demotivating effect instead. Their wishes were more based on a modern new technology which is new for everyone and therefore an enjoyable challenge to be a part of.
A technology providing real-time feedback was positively received and discussed on terms that it could be in no possible way negatively interfere with the proceedings of the operating theatre staff or obstruct proceedings in emergency situations or in any other way. Real-time feedback could work if it would be attractive for the entire operating theatre staff, easy to process, and if it takes into account the frequency of high staff turnover and the complexity of some surgeries.

To conclude this chapter a citation summarising the main wishes and needs for an eHealth intervention is giving below:

"If there is a registration of too many people in the O.R. Okay, so what was going on there? Was there a special situation that asked for that amount of people or not? Then you can recall a team by the sang-out procedure, 'we have 20% more door movements than usual with this type of surgery, has there been a special situation that caused this?' 'Why were there two too many people present in the O.R.? Why has that been?' You can learn of it, about its necessity for example. Then people will gain awareness. You can only influence behaviour by creating awareness! You can raise awareness by using technology. The best way is to do that in a fun way, game-like, stimulating instead of punishing. Just like a puppy dog, ignore the bad behaviour and reward good behaviour. Saying afterwards the surgery: 'Well done everybody, only one door movement, everyone was wearing their surgical clothes and hat correctly, the antibiotic gift was right on time, all together just fantastic! We have done everything we could do for this patient!'."

- Orthopaedic surgeon -

Requirements

Various requirements concerning the eHealth technology have been identified based on the results obtained earlier from the focus groups held with the stakeholders. Tables 6, 7 and 8 present 15 requirements, all of which have their value, rationale, requirement and requirement type described. The formulation of the requirement is based on the MoSCoW method.

Most mentioned is the lack of awareness (N = 10). The stakeholders were of the opinion that in order to improve the compliance with SSI guidelines people need to be aware again of why this is important. It is essential to address the awareness issue in order to let the eHealth technology be successful. The ease of use (N = 8) is also mentioned quite often and is translated into a requirement. The system should be easy to use because of the workload, time pressure and high staff turnover, otherwise it will not be used properly nor be highly effective. Stakeholders also mentioned that the eHealth technology should provide and contain clear and uniform information, because now the guidelines are unclear and not uniform for the entire hospital. This also applies to the operating theatre staff. If the guidelines are not clear, how can one expect that the HCW will comply with it?[43] Furthermore, the influences of the hierarchical culture dominating the work floor is mentioned quite frequently. The eHealth technology must address the issue concerning the organisational culture in order to achieve success, according to the stakeholders (N = 9).

Table 6 The requirements for the eHealth technology (requirement 1 to 5). Value = ideal or interest a stakeholder aspires to or has, rationale = short statement justifying the need for this requirement, requirement = technical aspect that the technology should fulfil.

No	Value	Rationale	Requirement + type	Quote
1	Consistency	Provided information regarding SSI guidelines has to be uniform, consistent for all (new) healthcare workers, because of the high staff turnover.	System should provide the same information to all end-users. Type: Content	*"Each department, in every other hospital, creates its own protocols, so a jungle of protocols arises."* N = 8 - Executive quality and safety operative care –
2	Consistency	Provided information regarding SSI guidelines has to be presented to all who are involved in surgeries and working in the O.R. It is important that everybody has the same knowledge about the SSI guidelines.	System won't be applicable for the entire hospital, but only for the operating theatre staff Type: Functional and modality	*"The intention is that there will be a universal working programme for everyone, for each surgeon, O.R. assistant or whoever involved."* N= 8 - Head of operating assistants sector 1/O.R. assistant –
3	Clear	SSI guidelines should be clarified and clear to all involved ones, then there is no case of ambiguity and unwillingness about the guidelines.	System must provide clear information to the end-user. Type: Content	*"Many of the guidelines are interpretable, for example: 'is it a lot of hair or is it little hair that gets underneath?'."* N= 7 - Anaesthesia assistant –
4	No information overload	The information provided by the system should be succinct, as that makes it more clear and attractive for the users. It also makes it easier to remember the information and to adhere to it.	System must succinctly provide information to all end-users. Type: Content	*"Not too much information because the biggest problem is not the lack of information, but the abundance of it."* N= 5 - Anaesthesiologist –
5	Ease to use	The provided information/guidelines should be presented in an easy manner, due to time-pressure of the users' working environment and lasting attention of the users.	System must be easy to use. Type: Functional and modality	*If a technology exists that facilitates your actions, then humans won't perform their regular actions anymore. And that's how it works."* N = 8 - Head of central sterilisation assistants –

Table 7 The requirements for the eHealth technology (requirement 6 to 10). Value = ideal or interest a stakeholder aspires to or has, rationale = short statement justifying the need for this requirement, requirement = technical aspect that the technology should fulfil.

No	Value	Rationale	Requirement + type	Quote
6	Ease to use	Facilitating the performance of hand hygiene guidelines and hygiene measures guidelines. Guidelines should be experiences as easy to comply with in order to maintain compliance by the healthcare providers.	System must provide practical guidelines thus easy to use. Type: Functional and modality	*"It has to be practical."* N = 8 – O.R. assistant –
7	Easy to request	System should be easy to request, so that every prospective user can make use of the system. It is difficult because of time-pressure, working schedules of healthcare workers and high staff turnover to let them make use of the system at established moments.	System should be easy to request at any time. Type: Service	*"What we've noticed is that people who come in new; medical assistants, medical specialists, do not know the correct guidelines. If you address them they'll answer: 'Oh I didn't know that'."* N = 6 - Head of operating assistants sector 3/O.R. assistant –
8	Evidence	Evidence-based guidelines are more likely to comply with by healthcare providers.	System must show evidence or at least the essence of the guideline(s). Type: Content	*"Guidelines are conceived by a bunch of bureaucrats, behind a desk, not working in the O.R. But they do create rules for us, so people tend to think, 'Yes, of course they are creating the rules and ultimately we have to obey it? I don't think so'. 'What is the evidence?'"* N= 7 - Quality and safety employee -
9	Showing consequences	Consequences of non-compliance with the SSI guidelines are mostly forgotten or unknown by the healthcare providers. But demonstrating the consequences, would possibly raise awareness and lead to behaviour change and improved compliance.	System should show the consequences of poor or non- compliance. Type: Content	*"You not get to see the consequences of your actions, you do not see the surgical site infections. You're just a part of the chain. It someone makes a mistake preoperative, they complain, but if something went wrong perioperative or preoperative, you won't see the consequences of it. Except if a surgery of the wound infection is necessary. Fortunately, that does not occur often."* N= 8 - Head of unit intensive care -
10	Awareness-raising	Raising awareness by HCWs about the importance of SSI guidelines compliance gives improved compliance in return. If people are more aware of why they should comply with the guidelines, the compliance with it will automatically follow.	System must address the awareness about the importance of complying with the SSI guidelines. Type: Content	*"It is necessary to raise awareness first in order to improve the compliance of SSI guidelines."* N = 10 - Orthopaedic surgeon-

Table 8 The requirements for the eHealth technology (requirement 11 to 15). Value = ideal or interest a stakeholder aspires to or has, rationale = short statement justifying the need for this requirement, requirement = technical aspect that the technology should fulfil.

No	Value	Rationale	Requirement + type	Quote
11	Role modelling	Role modelling, mainly by the head of surgery, negatively influences the compliance with guidelines by other HCWs. It is important to show a positive example towards other HCWs, especially towards medical students and assistants.	System should show that role modelling is one of the reasons of poor or non-compliance with guidelines by healthcare providers. Type: Content	*"The head surgeon gives the ultimate example and he is the one who says: 'I will not wear the Glenn head, because then I can't hear a thing' while he stands in the operating room with all his hair loose, then the rest will follow and no one will wear that particular hat."* N = 7 - Anaesthesiologist -
12	Influencing organisational culture (hierarchical influences)	One important reason for poor or non-compliance with SSI guidelines is the prevailing hierarchy, which dominates the hospital work floor. People are tend to be afraid to address others.	System must address the hierarchical culture dominating the work floor. Type: Content	*"Sometimes I want to address someone but then I think; 'Oh no, he has an exceptionality position', well that is so foolish. And there is no student who would appeal to me, as head of the department, as in; 'professor would you not wear gloves now?'"* N = 9 – Plastic surgeon -
13	Sanctions	Important to tackle the sanctions issue if healthcare providers do not comply with the guidelines in order to change behaviour of medical specialists who sometimes tend to think they are untouchable.	System must show the influences of sanctions. Type: Content	*"Do you dismiss the world famous thoracic surgeon? Of course not, and he is aware of that fact."* N = 8 - O.R. assistant -
14	Fun/stimulating	People tend to be more open for a technology and will be motivated more if the technology is fun and stimulating, instead of focusing on negativity.	System could operate in a fun and pleasant way Type: Usability and user experience	*"You can raise awareness using technology. The best way is to do that in a fun way, game-like, stimulating instead of punishing."* N = 2 - Orthopaedic surgeon -
15	Evaluating/self-reflecting	People will become more motivated and aware if there is a possibility of evaluating their habits and proceedings afterwards.	System could use an evaluating and self-reflecting approach Type: Usability and user experience	*"If a system registers certain key-parameters, then evaluation and self-reflectance is made possible afterwards, such as: 'Well done everybody, only one door movement, everyone was wearing their surgical clothes and hat correctly, the antibiotic gift was right on time, all together just fantastic! We have done everything we could do for this patient'."* N = 2 - Orthopaedic surgeon -

Persuasive features

Different persuasive features could be used in the eHealth technology in addition to the requirements and are shown in table 9. The features are generated with the help of the PSD model. In the table the corresponding requirements are given, followed by the corresponding PSD category and its design feature. An example citation to clarify the requirement and persuasive feature is given as well.
Some requirements can be translated into different PSD features, such as the requirement about addressing the organisational culture, for example, by applying cooperation and recognition as social support. Cooperation can be helpful in order to make the user aware of the feelings and behaviour of the other user in order to become aware of their own behaviour. Recognition, on the other hand, can be helpful to gain recognition for the positive behaviour of the user. Not all requirements can be translated into persuasive features, requirement 4, 5 and 7 are not translated into a persuasive feature because these requirements contain more practical design conditions.

Table 9 overview of the persuasive features developed with the PSD model. .

Requirements	PSD category and function	Example citation
1. System should provide the same information to all end-users.	Primary task support Tailoring	*"One protocol is needed for the operating patient, no matter which operation he undergoes."* (N = 8)
2. System won't be applicable for the entire hospital, but only for the operating theatre staff	Primary task support Tailoring	*"The intention is that there will be a universal working programme for everyone, for each surgeon or whoever involved."* (N = 8)
3. System must provide clear information to the end-user.	Primary task support Tunnelling Tailoring	*"Jungle of protocols ... and one who changes between departments or comes new in doesn't learn all different protocols."* (N = 7)
6. System must provide practical guidelines thus easy to use.	Primary task support Reduction	*"The guideline has to be practical."* (N = 8)
8. System must show evidence or at least the essence of the guideline(s).	System credibility support Expertise Trustworthiness Primary task support Simulation	*"It will never change. That is in the medical world, they all want to prove it. The must be evidence!"* (N = 7)
9. System should show the consequences as result of non- compliance.	Primary task support Simulation Rehearsal	*"The consequences cannot be mapped, that's difficult."* (N = 8)
10. System must address the awareness about the importance of complying to the SSI guidelines.	Primary task support Simulation Rehearsal Social support Normative influence	*"You do not have to do it for me! You have to do it for the patient!"* (N = 10)
11. System should show that role modelling is one of the important reasons for poor (non-)compliance by HCWs.	Dialogue support Similarity	*"Example behaviour, what should I say, they simply do give the good example..."* (N = 7)
12. System must address the hierarchical culture dominating the work floor.	Social support Cooperation Recognition	*"There is no student who would appeal to me, as head of the department, as in; 'professor would you not wear gloves now?'"* (N = 9)
13. System must show the influences of sanctions.	System credibility support Authority	*"You can warn a medical specialist, but the board cannot fire them.... The medical specialists still have a decent power. That is why you should involve them."* (N = 8)
14. System could operate in a fun and stimulating way	Dialogue support Praise Rewards Liking	*"You can raise awareness using technology. The best way is to do that in a fun way, game-like, stimulating instead of punishing."* (N = 2)
15. System could use an evaluating and self-reflecting approach	Primary task support Self-monitoring Rehearsal	*"If a system registers certain key-parameters, then evaluation and self-reflectance is made possible afterwards..."* (N = 2)

5. Discussion

The aim of this study was to identify the needs and values among stakeholders about a possible eHealth technology supporting the compliance with SSI guidelines in order to develop requirements and persuasive features which are necessary for the development of the eHealth technology. The technology's goal will be to increase and maintain the compliance with SSI guidelines by HCWs in order to prevent SSI infections. To achieve this goal, various sub questions have to be established. Here, the sub questions will be answered and discussed in the following subheadings with the help of a literature comparison. Furthermore, the limitations of this research will be discussed, followed by discussing recommendations for further research.

Research questions

Which guidelines/topics are known within the hygiene protocols according to the stakeholders?

In the Netherlands, the SSI guidelines in the O.R. are retrieved from the National Institute for Health and Environment (in Dutch: RIVM). It includes four main guidelines which are further explained within its own protocol, these guidelines are as follows: antibiotic prophylaxis, no hair removal before surgery, normothermia and hygiene discipline in the O.R. During the focus groups the stakeholders confirmed that they all work according to these SSI guidelines. It is necessary to mention the fact that it is difficult to find the correct SSI guidelines. Previously the VMS (in Dutch: veiligheidsmanagementsysteem) published a bundle of care including the guidelines for the prevention of SSIs. However, this is not retrievable anymore and also applies to the workgroup infection prevention (in Dutch: WIP - Werkgroep Infectie Preventie) that also published SSI guidelines, which has even been lifted.[7] Nowadays it is hard to easily retrieve the correct SSI guidelines from one particular system; this issue should be addressed. It should be easy to request any SSI guideline at any given moment for the HCW, according to the stakeholders.
The guideline for HH was the most criticised one. The guideline was described as impractical and difficult to comply with, particularly during non-sterile proceedings. By impractical is meant the time needed for adequate HH and the number of times necessary to perform HH. This corresponds to literature, however in many studies is also mentioned the way of hand rubbing with detergents that is uncomfortable and causes dryness and soreness of the hands.[3,39,82,42]

What are the reasons for poor or non-compliance with the SSI guidelines according to the stakeholders?

As main reason for poor or non-compliance with the SSI guidelines is the lack of awareness. It seems that the awareness of why one must perform according to the SSI guidelines is diminished and forgotten. According to the stakeholders every proceeding of a HCW is in order to establish and preserve the patient's safety; this should be every HCW's goal at all times and may never be forgotten. Unfortunately, according to some stakeholders of the focus groups this is not always the case. Also as important reason for poor or non-compliance with SSI guidelines is the organisational culture dominating the work floor in hospitals. By organisational culture is meant the prevailing hierarchy, role modelling, need for evidence and the issue around sanctions. The prevailing hierarchy ensures that some HCWs tend to be afraid to address each other. The problem of not addressing co-workers is particularly seen between medical assistants/students and the senior staff. Due to the difficulties in addressing each other, role models (mainly medical specialists) are able to show bad examples towards other HCWs (mainly medical students and assistants). Therefore, role modelling can negatively affect behaviour of other HCWs. The compliance with headwear is mentioned as most negatively influenced through role modelling by medical specialists. Moreover, the need for evidence is important. If one guideline is not proven to be effective in preventing

SSIs, then most HCWs tend to not comply with that particular guideline according to the stakeholders. The relevance of sanctions was explicitly mentioned as important reason for poor or non-compliance especially seen by the senior staff, including the medical specialists. In the medical world sanctions are not very common. The feeling of power and being untouchable (especially by medical specialists) is possibly provoked by the organisational culture where in no sanctions occur if an individual does not obey to certain rules. This can result in changing behaviour, thus also changed behaviour in the compliance with SSI guidelines according to the stakeholders. If a HCW's compliance with guidelines can be affected by the no-sanctions culture, it should mean that the HCW was not taking the guidelines seriously in the first place. The reasoning for this is that if the HCW does see the relevance of correct compliance with the SSI guidelines, then the no sanctions culture could not be of influence. Not much was found in the literature and therefore it was not expected to be found in this study.
Another reason for poor or non-compliance with the SSI guidelines was the overload of information of guidelines, which can even differ between departments within one hospital. Some guidelines can be interpreted differently, resulting in inconsistent behaviour. The wish for more uniformity regarding the guidelines within the entire hospital was highly present. Consequently, the overload of information, differences between protocols, are causing confusion and chaos regarding the guidelines among HCWs and are not beneficial for the compliance with it. Presumably this can be solved by creating uniform guidelines, that are easy to retrieve at any given moment from one particular system and not from different (sometimes even raised) organisations, as mentioned before.

One of the most common reasons found in literature, especially for nurses and medical students, for poor or non-compliance with SSI guidelines (mainly HH guidelines) is the influence of role models and the organisational culture, wherein they feel a need to fit in.[38,40–42,83] This is in line with the results of this study. Other studies did also find that self-protection is in relation with the compliance with HH, but this was not found in the results of this study.[42,84] Also mentioned in literature as one of the main reasons for poor or non-compliance with SSI guidelines, in particular to the HH protocol, is education.[34,40,50,82,85] This was not mentioned as one of the main reason in this study. The compliance with the antibiotic prophylaxis guideline is frequently defined as a problem in literature. Several studies showed that the compliance with it is poor, which is mainly caused by issues as knowledge and organisational culture.[44,86–89] The outcomes of this study were contrary to the expectations; the compliance with antibiotic prophylaxis is not rated as negative. Ditto for the normothermia guideline; in this study the overall conclusion was that the performance of normothermia is well enough and it should not be a focal point for the eHealth technology, contrary to what can be found in most of literature.[24,46,90,91]

What are the needs, values and wishes of stakeholders regarding new technologies which could support the compliance with the SSI guidelines?

The most important needs and values found here according to the stakeholders are the lack of awareness, the influence of the medical (hierarchical) culture and to show the consequences of someone's proceedings. However, the most mentioned value was the lack of awareness. If an eHealth technology could raise awareness among the HCWs with regards to the compliance with SSI guidelines, then the compliance would be improved according to the stakeholders. Presumably awareness could be raised by showing the user the (harsh) consequences of poor or non-compliance. According to the stakeholders this is important to show, because some HCWs do not know what the (harsh) consequences of their proceedings could be. The organisational culture, specifically the case of non-addressing each other (caused by the hierarchical structure), was rated as second important value. However, the organisational culture comprises also role modelling, need for evidence and the sanctions issues besides the hierarchical culture. According to the stakeholders this issue should be addressed by changing the behaviour of HCWs. It is meaningful to take into account the added value of using evidence-based facts. The eHealth technology should be considered as important and should be considered of added value by all its users.

This can be achieved if the eHealth technology incorporates evidence-based information, the relevance of using the eHealth technology will be clarified. Furthermore, the new eHealth technology must show the HCWs the consequences of their proceedings in order to raise awareness, because these (harsh) consequences are not acquainted among some HCWs according to the stakeholders.
Another value mentioned by the stakeholders is based on consistency; the information provided by the eHealth technology should be consistent and should be applicable in all proceedings in the O.R. environment. As for the parameters, it is essential to minimise the number of different presented parameters as much as possible. Merely significant parameters should be presented in order to maintain the user's attention and to stimulate adherence, according to the stakeholders. Thus, the eHealth technology must focus only on important parameters inside or around the O.R according to the stakeholders.
Other values were based on more practical issues, as duration/location and ease of use. Important to take into account because of the time pressure, high staff turnover and the complexity of surgeries where the operating theatre staff have to deal with at all times. The eHealth technology should fit within the existing procedures, otherwise the eHealth technology will not be used as designed for according to the stakeholders.

What are the requirements and persuasive features necessary for the first prototype design to support healthcare workers in SSI compliance?

In the *Results* section (table 6, 7, 8 and 9) the requirements and persuasive features for the design of an eHealth technology to support the compliance with SSI guidelines are given. The most valuable requirements are defined as content requirements and among these is the most important requirement that the eHealth technology should raise awareness about the importance of SSI guidelines compliance in order to improve the compliance with these guidelines. Awareness-raising achievement can be done by demonstrating the consequences of poor or non-compliance with the SSI guidelines and also by demonstrating the influences of the organisational culture on the compliance with SSI guidelines. This is necessary to make the users aware of their current behaviour with corresponding consequences. To address the lack of awareness different persuasive features can be incorporated such as normative influence; this can be achieved by peer pressure of other HCWs to achieve adopted behaviour by the user. However, simulation and rehearsal, as primary task support, can also be helpful in order to address the lack of awareness by showing the consequences of poor or non-compliance, but also can be helpful in order to address the need for evidence or the issue about non-addressing each other. Actual demonstrations of the consequences could be made visible in a specific environment by using persuasive features such as rehearsal and simulation. Simulations can persuade the user to comply with the guidelines, which is the goal of the used technology, by showing the connection between cause and effect (in this case between poor or non-compliance and the occurrence of an SSI). By incorporating the persuasive feature rehearsal, the consequences of the HCW's proceedings can be presented, which is in this case the performance of SSI guidelines. Furthermore, it is essential to address the hierarchical culture by incorporating it as content requirement. Possibly this will result in a safe environment wherein one is not afraid to address the other. As for the persuasive features is chosen for social support features such as cooperation and recognition and for a dialogue support feature such as similarity. If HCWs will be recognised for their positive behaviour or if hospitals, nationally, or hospital teams within one hospital, cooperate in order to decrease the incidence of SSIs, this can affect the preconceived opinions about each other and the prevailing hierarchy. Poor compliance as result of the influence of sanctions can be stimulated by involving external endorsements and having an effective leadership.[47,92] Methods based on organisational and behavioural change can be applied in order to strengthen the practice and policy and to improve adherence and compliance with protocols.[47,39] This corresponds to the persuasive feature, authority, to design a system that is more credible and could be referring to people in the role of authority in order to be more persuasive. It is important to take this into account for further research; in every focus

group this came up as meaningful reason for poor or non-compliance. Other content requirements focus more on the transfer of knowledge by requirements such as clarity, consistency and the amount of information transfer. For this case can be incorporated persuasive features as tunnelling and tailoring.
Other requirements are defined as functionality and modality requirements, to assure that the eHealth technology must be easy to use and should be easy to request at any time because of the high turn-over staff and time-pressure. Presumably this can be stimulated by incorporating the persuasive feature reduction.
The requirements about the eHealth technology's operating way are defined as usability and user experience requirements, the presentation of the eHealth technology's content should be in a fun and stimulating way rather than serious or punishing way. Possibly this can be achieved by incorporating the persuasive feature praise, rewards and liking. One of the stakeholders' wishes was to design an eHealth technology which can be used to evaluate and self-reflect their own proceedings as team or as individual, which is also translated into a usability and user experience requirement. As for the persuasive features is chosen as primary task support, self-monitoring and rehearsal, in order to evaluate other's or their own proceedings and behaviour.

According to Edwards et al. (2012), communication and demonstration integrated into an intervention can play an essential role in order to achieve behaviour change and to provoke a certain individual's actions, what applies for the requirements regarding the consequences, hierarchical culture and the self-reflecting and evaluating requirements.[93] The relevance of letting HCWs observe the consequences of poor or non-compliance with SSI guidelines by for example simulation or rehearsal in order to improve the compliance and to change behaviour is in line with the study of Kho et al. (2008) and Nicol et al. (2009).[47,94,95] The results of Kho et al. (2008) show a high increase in the compliance rate by confronting the users with actual data by timely delivered human endorsed computerised recommendations. This can also be seen as a way of confronting HCWs with the consequences.[95] The study performed by Nicol et al. (2009) showed that the effectiveness of interventions did improve by using vivid experience via exposure to graphic, emotion-arousing narratives and/or videos, showing the results of inadequate infection control.[94] Furthermore, Turnel and White (2005) showed that it is important to address also the issues of psychological preparedness of medical staff in order to change behaviour.[96] This could be taken into account also as requirement and/or persuasive feature for the design of the eHealth technology.

More literature comparisons

Awareness, social influence and knowledge are all reasons which were established in this study and found in literature.[36,38,42,48,85,97] However, some reasons which were found in literature by conducting focus groups and/or interviews with HCWs did not come up once during the focus groups in this study; these were self-efficacy and self-protection.[36,42,48,84,98,99] It could be that these issues occur more frequent in countries outside of the Netherlands or do not occur in these particular hospitals or did not outweigh the other reasons. Self-efficacy and self-protection were expected to be found in this study because of the findings in literature and of the theory of planned behaviour (TPB). In recent years, many studies are performed in which behavioural theories in order to determine the determinants of poor or non-compliance with HH are being used, for example the social cognitive model TPB.[38,94,100,101] By applying the TPB in order to evaluate predictors of health behaviour many important findings came up, such as reasons for poor or non-compliance with SSI guidelines, but also the effectivity of using a multifaceted approach in order to reach to all HCWs was proven to be more succesful.[36,94] The TPB suggests that intention is the most important factor for planned behaviour which is in this case to perform according the SSI guidelines, it is divided into three different aspects: perceived behavioural control (self-efficacy), subjective norm and attitude. This is also applicable here: the subjective norm stands for social influences (an individual's perception of pressure from peers), such as for the role modelling, the need to fit in and the hierarchical influences that affects one behaviour in the compliance to SSI guidelines.[38] Attitude can be described: someone's

behaviour is associated with certain attributes, this can be applicable for the value need for evidence but also for the hierarchical structure. The compliance to guidelines is influenced by evidence-based facts and the prevailing hierarchy influences the behaviour of medical specialists in their attitude towards compliance with SSI guidelines. However, perceived behavioural control (self-efficacy) is not found in the key outcomes of this study, though this does not apply for the compliance to HH guidelines that are evaluated as too difficult to perform.

The influence of the organisational culture dominating the work floor on the compliance with guidelines is showed in many studies. The hierarchical culture and negative role modelling are very important barriers in the compliance with guidelines.[38,40–42,83,84,102–104] To address these determinants different approaches can be used, for example by providing information about peer behaviour and opportunities for social comparison. This can be achieved by organising group sessions with peers or by mobilising the social norm in order to achieve empathy and understanding for the other.[36,105] In the current study these values also came up as expected, and are taken into account for further research.

Many infection prevention interventions are based on improving knowledge by continuous staff education in order to provoke automatic behaviour in compliance with SSI guidelines, an example is the organisation of audits combined with feedback.[40,51] Behaviour change theories suggest that by using feedback it is possible to address social norms, self-efficacy and awareness.[28,106,107] Some examples are risk communication, real-time reminders, delayed/direct/real-time feedback on behaviour and feedback on clinical outcomes.[36,59,85,108-110]

It would be better if all the different reasons for poor or non-compliance are addressed by using different approaches, also taken with the diversity of users into mind. Therefore, in order to address all the different issues, it is recommended to create a multidisciplinary approach with a multidisciplinary team by combining the different disciplines in order to not only address target behaviour, but also to improve the proceedings.[37,111]

Limitations

In this study the CeHRes roadmap was used as toolkit to combine different approaches in order to achieve its goal. Here the first two phases were elaborated upon; to achieve this goal it was chosen to conduct focus groups with identified stakeholders. Subsequently, the formative evaluation will be executed in order to establish the current results, which are the values, requirements and persuasive features. The characteristic continuous evaluation cycles improve the representativeness of the research. With an eye on the future, if all steps of the roadmap will be followed, it can be time and energy consuming to combine several methods in order to answer the research questions and to evaluate its outcomes, both for the stakeholders as for the multidisciplinary team. Furthermore, it can also negatively affect the cost/benefit analysis. This has to be taken into account for the further course of the study. On the contrary, if the iterative evaluations and multiple methods do not take place, there is a chance that the design of the eHealth technology does not fit properly within its context and with the end-users; this can negatively affect the technology's aspired effectiveness, cost-effectiveness and its implementation.

In this research there can be a case of selection bias, because all of the stakeholders were already motivated and willing to participate to improve the compliance with SSI guidelines and to prevent SSIs. This can be explained by the fact that every stakeholder already participated into an infection prevention workgroup that could be at organisation level or national level or even both. However, in this context of focus groups the stakeholders should be motivated because the focus groups were conducted in order to make an inventory about the critical incidents with regards to poor or non-compliance with SSI guidelines. Therefore, it could be beneficial to present and discuss the topic with motivated stakeholders. Every stakeholder was aware of the importance of the focus group and actively participated into the discussion about the current problems and context regarding the compliance with SSI guidelines.

During focus group II, one stakeholder left early and did miss one hour of the discussion, which could have biased the results by attrition bias. However, the data obtained from this particular stakeholder was included in the analysis, because it was very informative and shared by the other stakeholders.
In this study the stakeholder analysis was based on literature, network, practical issues and snowball sampling. According to the WHO the optimal stakeholder composition consists of the following stakeholders: nurses, O.R. assistants, the complete anaesthesia team, surgeons (plastic surgery, general surgery and orthopaedic surgery), quality improvement and patient safety staff, involved ones in staff education and training, senior managers, hospital administrators and the technical support staff.[8] Fortunately, most of the identified stakeholders were included in this study. The missing stakeholders according to the WHO's list are ones that are not important in the context of this study; in this study the most important stakeholder is defined as the operating theatre staff, because of the identification and elaboration of the context and problems in the compliance with the SSI guidelines. However, the missing general surgeon could be possibly of added value in identifying moments about the compliance with SSI guidelines occurring during those particular surgeries. Nonetheless, the included stakeholders: head of central sterilisation assistants, head of unit intensive care, heads of operative care organisations/surgery assistants were of great added value within this context, because of their possibility to overview the proceedings of other HCW's with regards to surgeries, compliance with SSI guidelines and sterilisation equipment. Nevertheless, it is important to keep in mind all the identified stakeholders and to include the technical support staff, education and training staff and the hospital administrators during the next phases of the CeHRes roadmap, with an eye on the design and implementation phase of the eHealth technology.
The coding of the transcripts is carried out by one researcher, except for the first focus group, which is also coded by a second executer. However, after comparison both of the outcomes, the results were almost the same. But in order to promote high reliability, it could be better if a second researcher will be involved to code also the other two transcripts. Afterwards the interrater reliability could be determined to define the degree of reliability.
In the future it would be recommended to conduct focus groups that includes a reliable number of stakeholders; a minimum of four stakeholders and a maximum of eight stakeholders, which are all identified stakeholders and who are familiar with the O.R. proceedings and SSI prevention. It would also be recommended to conduct focus groups across more than two different hospital organisations.[73]
For the prioritisation of requirements is chosen to work according the MoSCoW method, which is mainly used in the engineering sector.[81] In this study it would be more suitable to work according the Volere Requirements Specification Template in order to prioritise and formulate the requirements, because the Volere template is more focused on the stakeholder point of view instead of the engineering point of view.[67]
It is difficult to say if the results of this study represent for all Dutch hospitals. On the other hand, the results are obtained from all three independently conducted focus groups, across both learning and non-learning hospitals that differs between the level of high staff turnover and between the complexity of surgeries. Nonetheless, it is the case that the lack of awareness is the most important reason in poor or non-compliance with guidelines, also compared to literature. It is difficult to address this issue, because of the hierarchical structure and that it is highly incorporated in the behaviour of the HCW, according to the results.

Recommendations

The next step according to the CeHRes roadmap is to evaluate the outcomes of the value specification in order to adjust the outcomes and to proceed to the next phase, which is the design phase. It could be of added value to develop scenarios based on the formulated values and to present these scenarios to the stakeholders, asking for any feedback during a scenario-based focus group or during scenario-based interviews. A scenario could depict different situations, for example one in which a nurse is obligated to

comply with a certain guideline, but that this was negatively influenced because a medical specialist was exerting time-pressure and peer-pressure. Another scenario can be focusing on awareness-raising by depicting a situation in which the medical specialist did not properly wear their headwear, resulting in an SSI and consequently resulting in death of the patient. The following step is to create a low-fidelity prototype of an eHealth technology (including the formulated requirements and persuasive features). Afterwards usability testing can be conducted and the stakeholders will be asked to give feedback on this particular first prototype in order to adjust it where necessary. The scenario-based focus groups and usability testing should be performed with stakeholders who are all working on the floor and therefore have to comply to the SSI guidelines.

The main value that the eHealth technology must contain according to the results was to raise awareness by the user in order to improve the compliance with SSI guidelines. Several educational interventions about SSI compliance and infection prevention are introduced in the past years. However, many of these programmes were not able to achieve their goal, which is to maintain the compliance also long term. HCWs are experiencing these programmes as quite informative but somehow also uninteresting and it is not effective long term. According to the results, the HCWs were not feeling challenged or motivated by these programmes anymore. Therefore, the new technology should not be presented as an e-learning module or as part of an e-learning module, because this is outdated and will not draw attention from the users. It should be presented in a new, fun and stimulating way according to the results. Taken all the outcomes of this study summarised it can point to an advanced technology, virtual reality (VR) based technology. A VR technology makes use of visualisation, for example to show the consequences of poor or non-compliance with SSI guidelines in order to raise awareness among the user and to preserve the user's attention. It can also simulate the current situation, in which hierarchical influences will be simulated in order to address the user's thoughts and perceptions about it. In a VR based technology the different persuasive features, similarity, simulation and rehearsal can be integrated. For example, the following questions can be integrated into the virtual reality world: how did the incident happen? Why did it happen? How could it have been prevented? How could fatalities be avoided?[112] Therefore, it could be possible to integrate the most important values (awareness raising, hierarchical structure and showing consequences), requirements and persuasive features found in this study in a VR based technology. Many studies showed that VR or video-based interventions can be very successful in education in the healthcare sector by using it as successful tool for training, education and solving complex problems.[53,54,112–114]

An example which can be conceived from the results is a self-learning system wherein the user's knowledge and proceedings will be improved over time with regards to the patient's safety. A smart environment with the help of sensor technology can be helpful in order to create such a system. An environment in which the HCWs will be stimulated to perform correctly according to the SSI guidelines and will be able to evaluate and self-reflect both during perioperative and postoperative times on their proceedings concerning SSI prevention. This could also raise awareness among the HCWs by showing them the consequences of their proceedings and by stimulating the team bonding of the operating theatre with the help of the evaluation possibilities afterwards. It could possibly positively affect the hierarchical threshold, by incorporating persuasive features such as cooperation and recognition, though more persuasive features can be depicted here such as self-monitoring, rehearsal, praise and rewards. Hopefully in the end, the HCWs will be motivated and stimulated to correctly perform according to the SSI guidelines.

6. Conclusion

In this study the needs and values of stakeholders regarding an eHealth technology that will support the compliance with SSI guidelines was collected across two different hospital groups. It can be concluded from the results that an eHealth technology which will support the compliance with SSI guidelines by the operating theatre staff is definitely of added value and that the most important identified issues here are, the lack of awareness, influences of the organisational culture (esp. non-addressing each other) and to show the consequences of poor or non-compliance to SSI guidelines. However, it is important to take into account the context in which it will be used and the values assigned to the eHealth technology. It can be said that the conducted focus groups were successful in order to gain important information to create the values, which are necessary for the development of requirements, and these are subsequently necessary for developing persuasive features. The results, the requirements and persuasive features, can be used in the following steps for the design of an eHealth technology.

It is difficult to conclude if these findings are applicable for all hospitals in the Netherlands because of the fact that the focus groups were conducted across two different hospital groups. On the other hand, however, most of the results correspond to what is found in literature and the results are obtained from focus groups across both learning and non-learning hospitals, which differs between the level of high staff turnover and between the complexity of surgeries.

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Appendix I: focus group script

DRAAIBOEK FOCUSGROEPEN POWI-PREVENTIE

Datum:

Tijdstip:

Locatie:

Doel

- Inzicht krijgen in de zwakke punten in de naleving van de richtlijnen zoals beschreven in de POWI-bundel.
- Identificeren van de behoeftes, verwachtingen en barrières m.b.t. technologie ter ondersteuning van de uitvoering van de POWI-richtlijnen.

Fases van de focusgroep

- Stap 1: Algemene introductie
- Stap 2: Omschrijven incidenten
- Stap 3: Het voorkomen van kritieke situaties → Kansen voor ondersteuning

Materialen

- Lege tabellen geprint op A1-formaat
- Flip-overs
- Naambordjes
- Post-its in 4 kleuren
- 2x Voicerecorder
- Pennen/stiften
- Fotocamera

Aanwezigen

Moderator

- Leidt de discussie, maar reageert neutraal
- Zorgt ervoor dat iedereen aan het woord komt, iedere deelnemer is even belangrijk
- Kent het draaiboek
- Let op dat er inderdaad een antwoord op de vragen komt.

Assistent-moderator

- Helpt bij de voorbereiding van de ruimte, materialen, klaarzetten catering enz.
- Is er zeker van dat de opnameapparatuur werkt en controleert dit tussentijds
- Verwelkomt de deelnemers
- Zit tijdens de focusgroep tegenover de moderator en dichtbij de deur
- Als deelnemers verlaat zijn vangt de assistent-moderator deze buiten op, praat ze bij en geeft aan waar de deelnemer plaats kan nemen.
- Deelt de materialen uit.
- Maakt aantekeningen tijdens de focusgroep-discussie, noteert belangrijke quotes, trends, veranderingen van mening, emoties en maakt een schets van de focusgroep-opstelling.
- Reageert tijdens de focusgroep-discussie alleen als de moderator hier om vraagt
- Geeft aan het eind eventueel een samenvatting

Voorbereiding:

- Posters POWI-tabel ophangen
- Opnameapparatuur klaarleggen & controleren
- Post-its, pennen klaarleggen

Deel 1: Algemene Introductie (10 minuten; 16:30u-16:40u)

Tijd	Wie	Wat	Uitleg
10 minuten	FS	Welkom	Goedemiddag allemaal en welkom. Ik wil jullie allereerst hartelijk bedanken dat jullie tijd hebben vrijgemaakt om hier vanmiddag te zijn. Mijn naam is Floor Sieverink, en ik ben onderzoeker bij het Centre for eHealth and Wellbeing Research van de Universiteit Twente. Ik heb daarnaast Mariska ter Horst meegenomen, zij is bezig met haar masterthese voor Health Sciences en zij assisteert mij vandaag.
	FS	Introductie onderwerp	• Zoals u wellicht heeft vernomen, is eind 2016 het startsein gegeven voor het Health-i-Care project onder leiding van professor Alex Friedrich, hoogleraar medische microbiologie in het UMCG. Binnen dit project gaan dertig Duits-Nederlandse consortia, bestaande uit midden- en kleinbedrijven en kennis- en zorginstellingen, innovatieve hulpmiddelen ontwikkelen voor de preventie van infecties en antibioticaresistentie. • In het kader van dit project zijn de Universiteit Twente, de Universität Bielefeld uit Duitsland, eLabbs en Coolminds gestart met de ontwikkeling van systemen (virtual reality; smart environments) die ondersteuning bieden bij de uitvoering van de maatregelen zoals omschreven in de POWI (post-operatieve wondinfectie) bundel. • Vandaag zijn we hier omdat we samen met u willen verkennen wat mogelijke knelpunten zijn bij het uitvoeren van de richtlijnen in de POWI-bundel. Wat zijn kritieke momenten in de naleving van deze richtlijnen? Wat gebeurt er in zo'n situatie, waar wordt het door veroorzaakt, wie zijn de betrokkenen en wat zijn de consequenties van de gebeurtenis? Wat maakt bijvoorbeeld dat het lastig is om de maatregelen voor handhygiëne op te volgen? En wat zijn knelpunten bij antibioticaprofylaxe? Waarom gaan de deuren van de OK vaker open en dicht dan zou moeten? • Tevens willen we graag van u weten hoe dergelijke situaties voorkomen zouden kunnen worden en welke ondersteuning hierbij nodig is. • Uw deelname van vandaag is dus van belang omdat we een technologie willen ontwikkelen dat aansluit bij de context waarin u werkt en ook voldoet aan uw wensen en eisen. We zullen de informatie die wij verzamelen daarom verwerken in

			een eerste ontwerp, een prototype, van een mogelijke technologie. Deze zullen wij gaan testen en opnieuw aanpassen totdat u en wij tevreden zijn. • Met uw deelname draagt u bij aan de ontwikkeling van producten om de naleving van de richtlijnen in de POWI-bundel te verbeteren zowel in Nederland en Duitsland.
		Opzet van de bijeenkomst	Ik ga straks een aantal vragen stellen en opdrachten geven. De opdrachten leg ik in de loop van de bijeenkomst uit. Ik wil hierbij graag een aantal zaken benadrukken • Er zijn **geen goede of verkeerde antwoorden**, we gaan ervan uit dat we veel verschillende meningen te horen krijgen. • **We nemen de discussie op met een voicerecorder,** omdat we geen enkele opmerking willen missen. Echter, er zullen geen namen worden genoteerd in de gespreksverslagen, en er zal ook geen deelnemerslijst worden weergegeven in het eindrapport, dus **jullie opmerkingen zijn vertrouwelijk**. • Als u iemand anders wilt aanvullen, als u het ergens mee eens bent of juist niet, of als u een voorbeeld wilt geven**, u bent vrij om dat te doen.** • Vanwege de tijd hebben we vandaag een strakke planning. Dit betekent dat ik soms wellicht een interessante discussie moet afkappen, omwille van de tijd. Ik ga natuurlijk wel mijn best doen om u allemaal de kans te geven om iets te zeggen. • Verder wil ik u vragen om **mobiele telefoons op stil te** zetten. Mocht u een telefoontje echt moeten beantwoorden, dan zou ik willen vragen om even naar buiten te lopen. • Er zal **geen "echte" pauze** worden ingelast.
		Tekenen informed consent	Daarnaast wil ik u vragen om het toestemmingsformulier te ondertekenen. Hiermee verklaart u op de hoogte te zijn van het doel en de andere details van de bijeenkomst. Tevens staan in dit formulier uw rechten gedurende het onderzoek vermeld. Zijn er nog vragen tot zo ver?
	Notulist	Uitdelen IC-formulieren	De notulist deelt de toestemmingsformulieren uit. Deze formulieren worden aan het eind weer ingenomen.
	Notulist	Aanzetten opnameapparatuur	Nadat iedereen het ic-formulier heeft getekend, zet de notulist de opname-apparatuur aan.
5 minuten		Opening	Laten we beginnen met een voorstelrondje. U heeft allemaal een naambordje gekregen. Vertel even kort uw functie en uw rol in de naleving van de richtlijnen in de POWI-bundel.

Deel 2: Omschrijven incidenten (50 minuten, 16:40u – 17:30u))

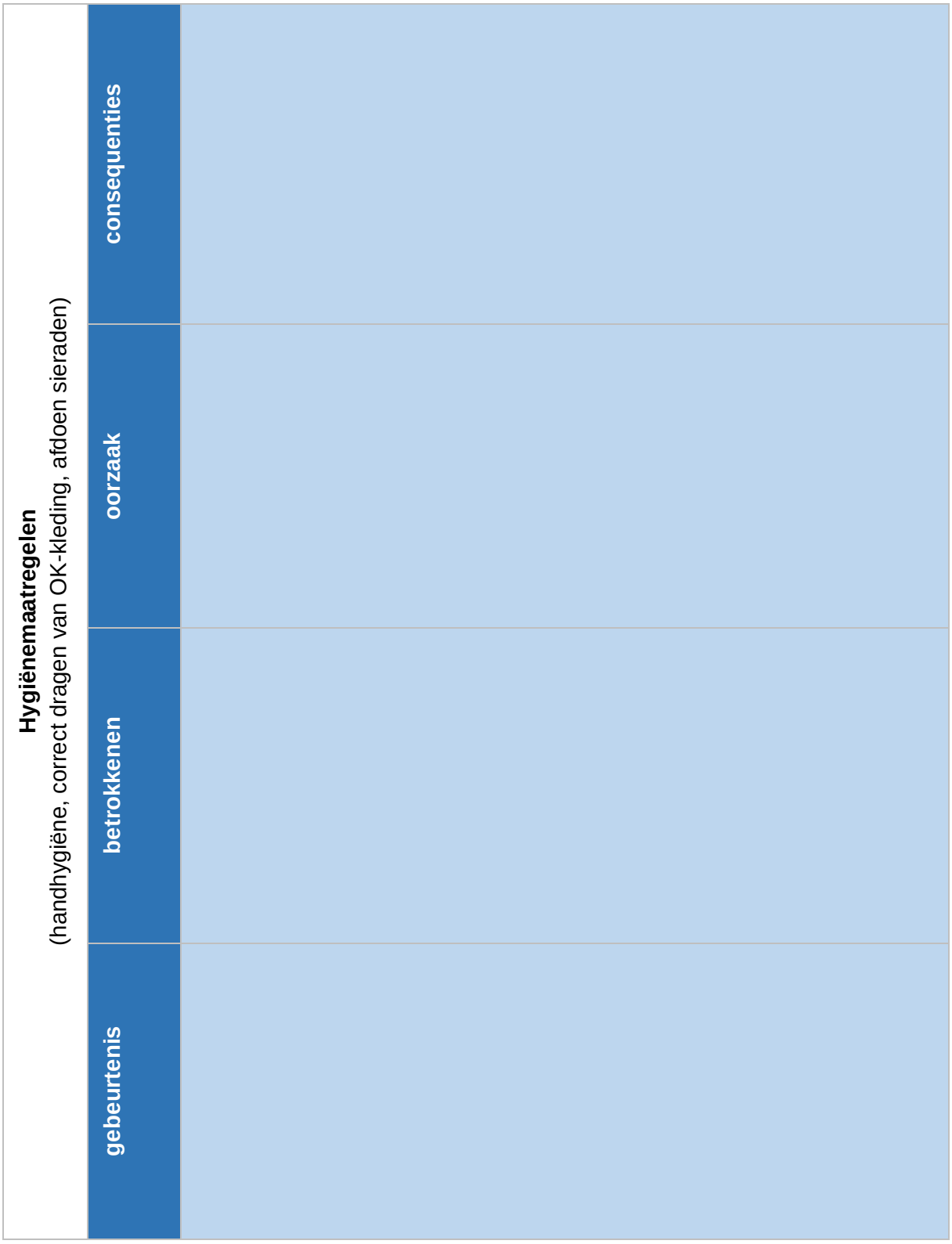
Tijdsduur	Wie	Wat	Uitleg
5 minuten	FS	Richtlijn	· Zoals u ziet ligt er een stapeltje tabellen voor u klaar. Voor elke maatregel uit de POWI-bundel is er een tabel. · We willen u nu vragen om vanuit uw eigen ervaringen, een situatie te beschrijven waarin de desbetreffende POWI-richtlijn niet werd nageleefd. Probeer deze situatie zo concreet mogelijk te omschrijven in de eerste kolom. · Vervolgens vult u in wie de betrokkenen waren bij deze situatie. · In de derde kolom vult u in wat volgens u de oorzaken zijn voor het ontstaan van deze situatie. · Tot slot vult u in wat de consequenties zijn van de desbetreffende situatie. · Op deze manier vult u alle tabellen in die op tafel liggen. Ook hebben we een lege tabel neergelegd die u kunt gebruiken voor een eventuele extra situatie. · U mag de tabel direct invullen, maar u mag ook post-its e.d. gebruiken. We willen u vragen om uw initialen te noteren op de tabel. Dit geeft ons de mogelijkheid om zoveel mogelijk visies te analyseren.
10 minuten		Inventarisatie incidenten	· Invullen tabellen
45 minuten		Plenaire discussie	· Welke situaties zijn gedefinieerd? · Komen deze situaties vaker voor? · Zijn deze herkenbaar voor de rest? Waarom wel, waarom niet? · Eventuele aanvullingen · Welke situaties zijn het meest ‘kritiek’?

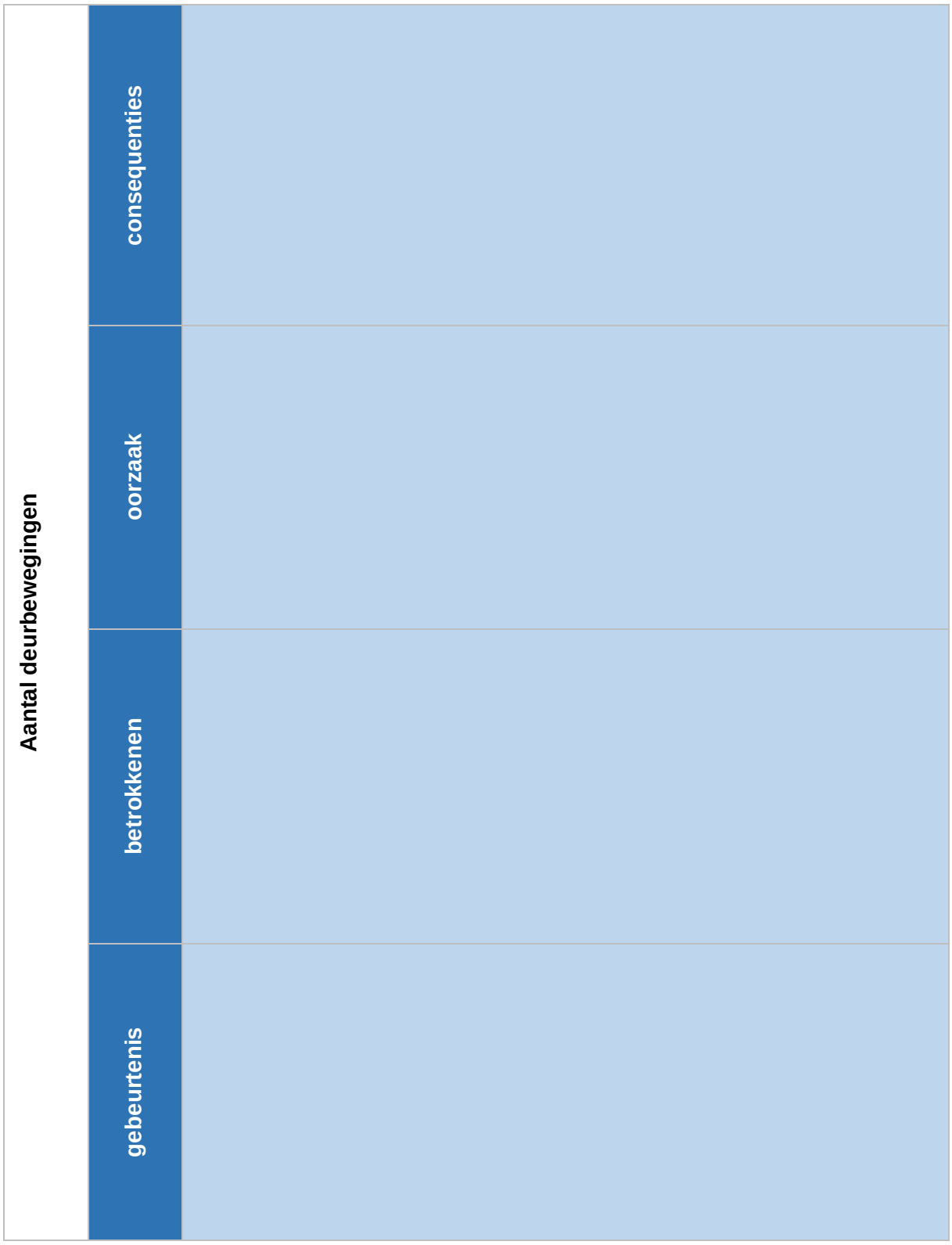
Deel 3: Het voorkomen van kritieke situaties → Kansen voor ondersteuning (30 minuten; 17:30u-18:00u)

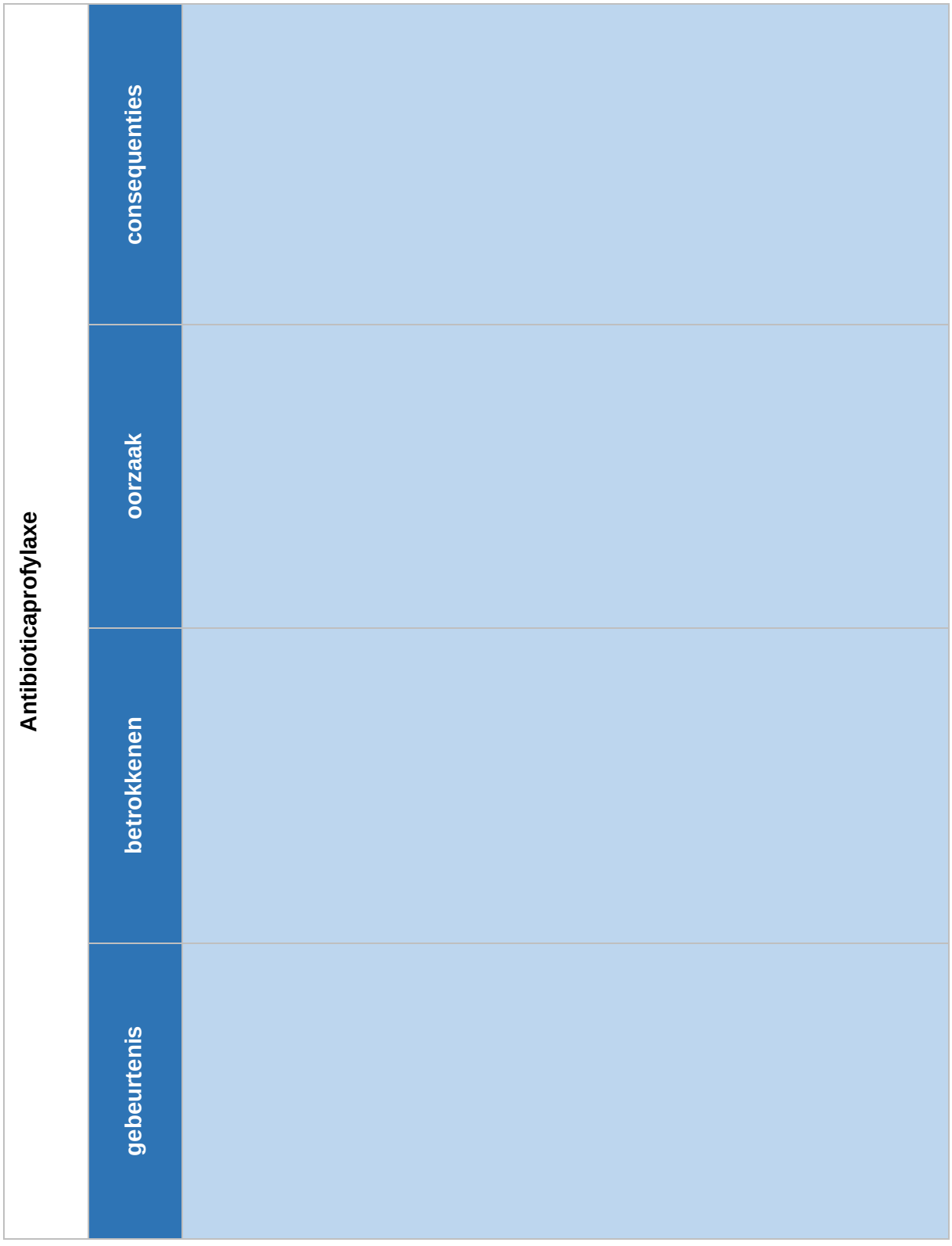
Tijdsduur	Wie	Wat	Uitleg
25 minuten	FS	Introductie	We hebben nu situaties in kaart gebracht. We willen nu graag met u van gedachten wisselen over hoe dergelijke situaties voorkomen zouden kunnen worden. Welke (technologische) ondersteuning kan hierbij van toegevoegde waarde zijn? Wat is daarvoor nodig? · Schaduwvragen: · Hoe kunnen dergelijke situaties voorkomen worden? · Welke (technologische) ondersteuning kan hierbij van toegevoegde waarde zijn? · Wat is er nodig om dit een succes te laten zijn? · Real-time ondersteuning of ondersteuning d.m.v. een training? · Een trainingsvorm denk aan: e-learning modules of VR. · Een Real-time ondersteuning denk aan: smart environments (voorbeeld bestaande cockpit MST laten zien), sensoren.
3 minuten	FS	Vragen/ opmerkingen	Daarmee wil ik de bijeenkomst afronden. Zijn er nog vragen of opmerkingen?
1 minuut	FS	Afsluiting	Ik wil u allemaal heel hartelijk bedanken voor uw komst! De resultaten gaan we verwerken in een eerste ontwerp van een mogelijke technologie die ondersteuning biedt bij het naleven van de richtlijnen in de POWI-bundel. Zouden we u mogen benaderen voor deelname in de volgende stap van dit project, het bespreken van dit eerste ontwerp? Wij wensen u nog een hele fijne dag.

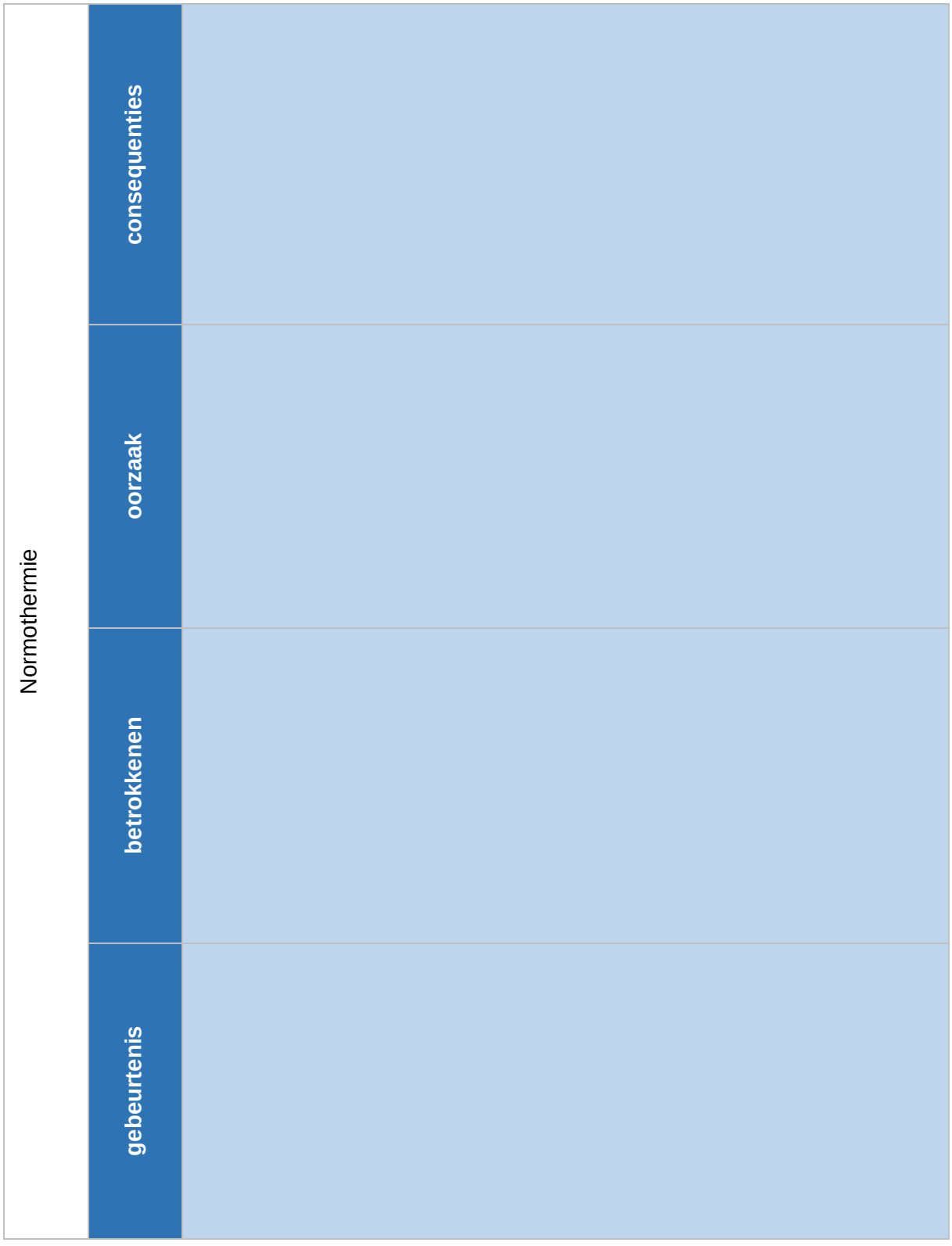
Appendix II: tables used for focus groups

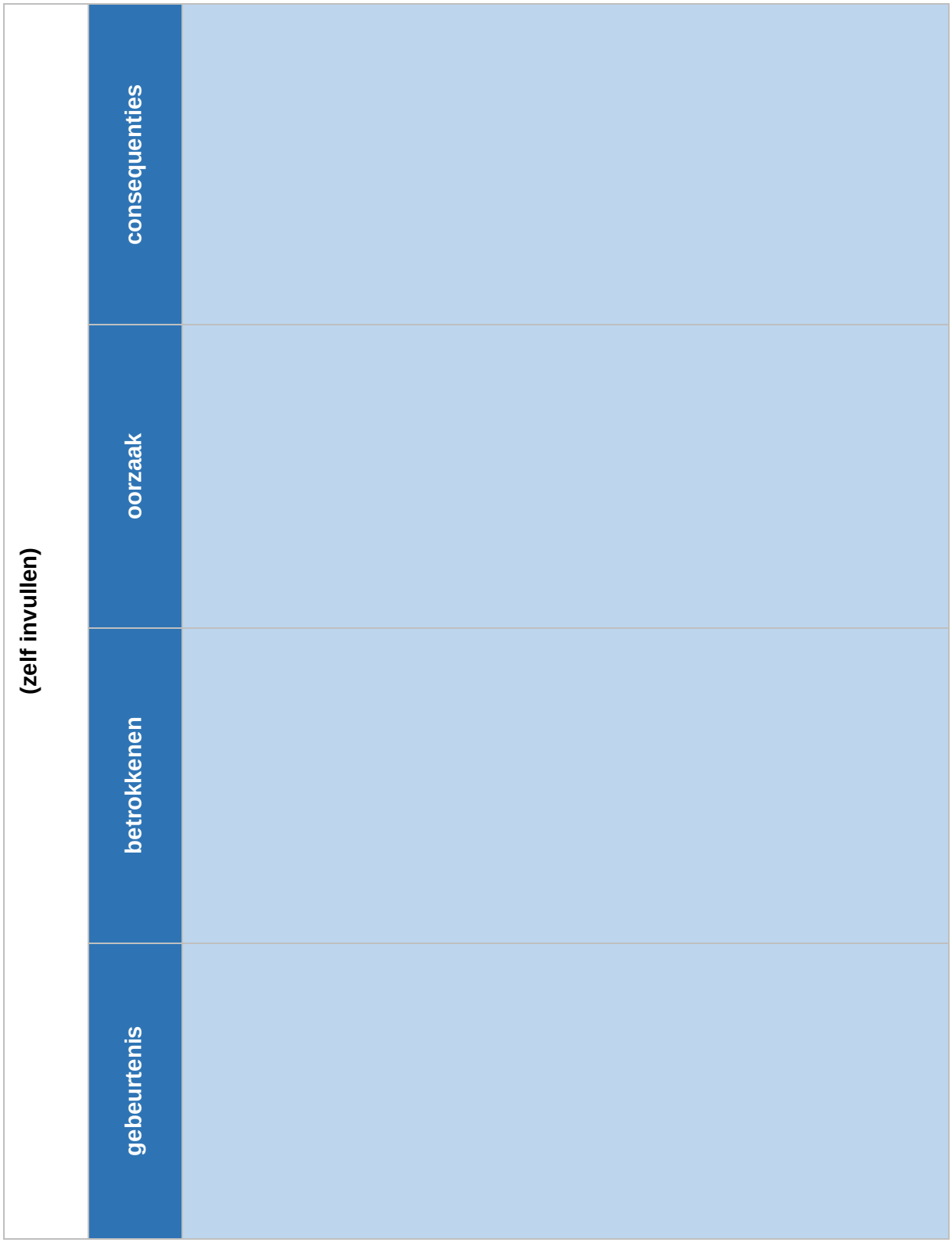
Below are shown the tables used during the focus groups. The participants were asked to fill these in, it was printed in A3 size. The tables were based on the Dutch SSI guidelines and on the CIT approach.




Aantal deurbewegingen
gebeurtenis
betrokkenen
oorzaak
consequenties


Antibioticaprofylaxe
gebeurtenis
betrokkenen
oorzaak
consequenties


Normothermie
gebeurtenis
betrokkenen
oorzaak
consequenties


(zelf invullen)
gebeurtenis
betrokkenen
oorzaak
consequenties

Appendix III: informed consent

Toestemmingsverklaringformulier (informed consent)

Titel onderzoek:	Health-i-Care / POWI-preventie
Verantwoordelijke onderzoeker:	Floor Sieverink, MSc. / Prof. dr. Lisette van Gemert-Pijnen Centre for eHealth and Wellbeing Research Universiteit Twente, Enschede

In te vullen door de deelnemer

Ik verklaar op een voor mij duidelijke wijze te zijn ingelicht over de aard, methode en het doel van het onderzoek. Ik weet dat de gegevens en resultaten van het onderzoek alleen anoniem en vertrouwelijk aan derden bekend gemaakt zullen worden. Mijn vragen zijn naar tevredenheid beantwoord.

Ik begrijp dat film-, foto, en videomateriaal of bewerking daarvan uitsluitend voor analyse en/of wetenschappelijke presentaties zal worden gebruikt.

Ik stem geheel vrijwillig in met deelname aan dit onderzoek. Ik behoud me daarbij het recht voor om op elk moment zonder opgaaf van redenen mijn deelname aan dit onderzoek te beëindigen.

Naam deelnemer: ……..

Datum: …… Handtekening deelnemer: ……

In te vullen door de uitvoerende onderzoeker

Ik heb een mondelinge en schriftelijke toelichting gegeven op het onderzoek. Ik zal resterende vragen over het onderzoek naar vermogen beantwoorden. De deelnemer zal van een eventuele voortijdige beëindiging van deelname aan dit onderzoek geen nadelige gevolgen ondervinden.

Naam onderzoeker: ……..

Datum: …… Handtekening onderzoeker: ……

Appendix IV: codebook

The code book is based on the critical incidence technique, which is used as framework for the focus group script. Therefore, is chosen for the critical situation framework and is the coding divided into six different categories. The first one categories the critical situations, the second one categories the main causes for the occurrence of the critical situations. Coding scheme number three includes main focus points and information, that is important to consider for a new eHealth technology. Coding scheme number 4 is focussed on the ideas for a technology. Furthermore, includes number 5 additional information and number 6 shows the ratings giving by the participants.

1: Which (critical) situations do occur?

1.	Hand hygiene
2.	Headwear
3.	Clothing
4.	Hospital clogs
5.	Door openings
6.	General hygiene measures (e.g. wearing jewellery)
7.	Antibiotic prophylaxis
8.	Normothermia
9.	Number of people in O.R.
10.	Wound care
11.	SSI guidelines in general
12.	Removal contaminated instruments and waste
13.	Bed hygiene

2: What are the main causes?

1.	Organisational culture (incl. hierarchical culture)
2.	Role modelling
3.	Need for evidence
4.	Lack of awareness
5.	Management problem
6.	Level of preparation
7.	Impractical protocol
8.	No uniform protocol
9.	Too many protocols
10.	SSI registration (PREZIES)
11.	Usefulness
12.	Uncontrollable
13.	Knowledge problem
14.	Logistics problem
15.	High staff turnover
16.	Complexity of surgeries
17.	Sanctions issue
18.	Time pressure

3: Main focus points and information to take into account for possible new intervention

1.	Awareness
2.	Key parameters (antibiotic gift, temperature operating room, air, operating time, total number of people inside operating room, general environmental information)
3.	Clog hygiene
4.	Hand protocol adjustment
5.	Clothing (coats, suits and headwear)
6.	Preparation operating theatre staff
7.	Changing behaviour
8.	Total number of people in O.R.
9.	Door openings
10.	Limiting amount of information
11.	High staff turnover
12.	Usefulness
13.	Adjusting SSI registration (PREZIES)
14.	Uniformity
15.	Complexity of surgeries
16.	Costs
17.	Connection to O.R.
18.	Septic rooms

4: Ideas for possible new intervention

1.	Clog washing machine
2.	General clog rack
3.	Disposable coats
4.	Clean suits
5.	Video & sound (focussed on operation)
6.	Stimulating game
7.	Chips
8.	RFID
9.	Face recognition
10.	e-learning
11.	Real-time feedback system
12.	Self-learning system
13.	Repeatedly playing movie/alternative
14.	Automatic registration key parameters
15.	Learning/demonstrations
16.	Door counter
17.	An automated uniform protocol

5: Additional information about the circumstances

1.	Sterile
2.	Non-sterile
3.	Both sterile & non-sterile
4.	Preoperative phase
5.	Perioperative phase
6.	Postoperative phase
7.	All operating phases

6: General rating

1.	Positive
2.	Negative
3.	Both/Neutral

Appendix V: Results

Results of the identified critical incidents with total number of stakeholders.

1.	Hand hygiene	N = 10
2.	Headwear	N = 9
3.	Clothing	N = 5
4.	Hospital clogs	N = 2
5.	Door openings	N = 4
6.	General hygiene measures (e.g. wearing jewellery)	N = 4
7.	Antibiotic prophylaxis	N = 4
8.	Normothermia	N = 6
9.	Number of people in O.R.	N = 2
10.	Wound care	N = 6
11.	SSI guidelines in general	N = 8
12.	Removal contaminated instruments and waste	N = 2
13.	Bed hygiene	N = 3

1.	**<u>Hand hygiene</u>** **Causes** Impractical protocol (N=7) Lack of awareness (N=4) Organisational culture (N=3) Knowledge problem (N=3) Role modelling (N=2) Too many protocols (N=2) No uniform protocol (N=2) Uncontrollable (N=2) Logistics problem (N=1) High staff turnover (N=1) Need for evidence (N=1) **Focus points** Hand protocol adjustment (N=3) Awareness (N=2) Changing behaviour (N=2) Uniformity (N=1) High staff turnover (N=1) Limiting amount of information (N=1) **Ideas for intervention** Learning/demonstrations (N=1) An automated uniform protocol (N=1) **Additional information** Non-sterile (N=4) Both sterile and non-sterile (N=2) Preoperative (N=2) Perioperative (N=1) All operative phases (N=2) **General rating** Negative	N = 10

2.	**Headwear** **Causes** Organisational culture (N=7) Role modelling (N=5) Impractical protocol (N=3) Sanctions (N=3) High staff turnover (N=2) Lack of awareness (N=1) Uncontrollable (N=1) No uniform protocol (N=1) Knowledge problem (N=1) Too many protocols (N=1) Management problem (N=1) **Focus points** Awareness (N=4) Clothing (N=3) High staff turnover (N=2) Limiting amount of information (N=1) Uniformity (N=1) Changing behaviour (N=1) **Ideas for intervention** Automated uniform protocol (N=1) RFID (N=1) Chips (N=1) Face recognition (N=1) Learning/demonstrations (N=1) **Additional information** Sterile (N=1) Perioperative (N=2) **General rating** Negative	N = 9

3.	**<u>Clothing</u>** **Causes** Lack of awareness (N=2) High staff turnover (N=2) Role modelling (N=2) Organisational culture (N=1) Usefulness (N=1) Uncontrollable (N=1) Knowledge problem (N=1) Too many protocols (N=1) **Focus points** Clothing (N=5) Uniformity (N=2) Usefulness (N=1) Clog hygiene (N=1) Limiting amount of information (N=1) High staff turnover (N=1) **Ideas for intervention** Clean suits (N=4) Disposable coats (N=3) Chips (N=1) Face recognition (N=1) Learning/demonstrations (N=1) General clog rack (N=1) Clog washing machine (N=1) An automated uniform protocol (N=1) **General rating** Negative	N = 5

4.	**Hospital clogs** **Causes** Lack of awareness (N=2) **Focus points** Clothing (N=2) Clog hygiene (N=2) **Ideas for intervention** General clog rack (N=2) Clog washing machine (N=1) Clean suits (N=1) **General rating** Negative	N = 2

5.	**Door openings** **Causes** Management problem (N=4) Level of preparation (N=2) Need for evidence (N=2) High staff turnover (N=2) Complexity of surgeries (N=2) Time pressure (N=2) Lack of awareness (N=1) Organisational culture (N=1) Logistics problem (N=1) **Focus points** Door openings (N=4) Total number of people in O.R. (N=2) Awareness (N=1) Changing behaviour (N=1) Preparation O.R. staff (N=1) Complexity of surgeries (N=1) **Ideas for intervention** Door counter (N=2) Automated registration key-parameters (N=2) Self-learning system (N=1) Stimulating (N=1) **Additional information** Perioperative phase (N=1) **General rating** Negative	N = 4

6.	**General hygiene measures (e.g. wearing jewellery)** **Causes** Organisational culture (N=2) High staff turnover (N=2) No uniform protocol (N=2) Lack of awareness (N=1) Uncontrollable (N=1) Knowledge problem (N=1) Too many protocols (N=1) **Focus points** Awareness (N=1) Uniformity (N=1) Limiting amount of information (N=1) High staff turnover (N=1) **Ideas for intervention** An automated uniform protocol (N=1) **General rating** Both/neutral	N = 4

7.	**Antibiotic prophylaxis** **Causes** Logistics problem (N=1) Complexity surgeries (N=1) High staff turnover (N=1) Management problem (N=1) **General rating** Positive	N = 4

8.	**<u>Normothermia</u>** **Causes** SSI registration (PREZIES) (N=4) No uniform protocol (N=3) Management problem (N=2) Too many protocols (N=2) Usefulness (N=1) Time pressure (N=1) **Focus points** Uniformity (N=2) Adjusting SSI registration (PREZIES) (N=2) Usefulness (N=2) **Ideas for intervention** An automated uniform protocol (N=1) **Additional information** Preoperative (N=4) Perioperative (N=4) **General rating** Both/neutral	N = 6

9.	**<u>Number of people in O.R.</u>** **Causes** Management problem (N=2) Time pressure (N=1) **Focus points** Total number of people in O.R. (N=2) Door openings (N=2) Awareness (N=1) Preparation operating theatre staff (N=1) Changing behaviour (N=1) **Ideas for intervention** Automatic registration key-parameters (N=2) Door counter (N=2) Stimulating game (N=1) Video and sound (focussed on operation) (N=1) Self-learning system (N=1) **General rating** Both/neutral	N = 2

10.	**<u>Wound care</u>** **Causes** Knowledge problem (N=4) No uniform protocol (N=4) Too many protocols (N=1) Time pressure (N=1) **Focus points** Uniformity (N=1) Limiting amount of information (N=1) **Ideas for intervention** An automated uniform protocol (N=1) **Additional information** Postoperative phase (N=6) **General rating** Both/neutral	N = 6

11.	**<u>SSI guidelines in general</u>** **Causes** Organisational culture (N=6) Sanctions (N=6) Lack of awareness (N=5) No uniform protocol (N=4) High staff turnover (N=3) Role modelling (N=3) Need for evidence (N=2) Management problem (N=1) Too many protocols (N=1) SSI registration (PREZIES) (N=1) Usefulness (N=1) Knowledge (N=1) **Focus points** Awareness (N=5) Changing behaviour (N=5) Uniformity (N=4) High staff turnover (N=3) Limiting amount of information (N=2) Adjusting SSI registration (PREZIES) (N=1) Complexity surgeries (N=1) **Ideas for intervention** An automated uniform protocol (N=3) Learning/demonstrations (N=2) Repeatedly playing movie/alternative (N=2) **Additional information** All operating phases (N=3) **General rating** Negative	N = 8

12.	**<u>Bed hygiene</u>** **Causes** Uncontrollably (N=3) Need for evidence (N=1) **Additional information** Preoperative (N=2) Postoperative (N=2) **General rating** Neutral/both	N = 3