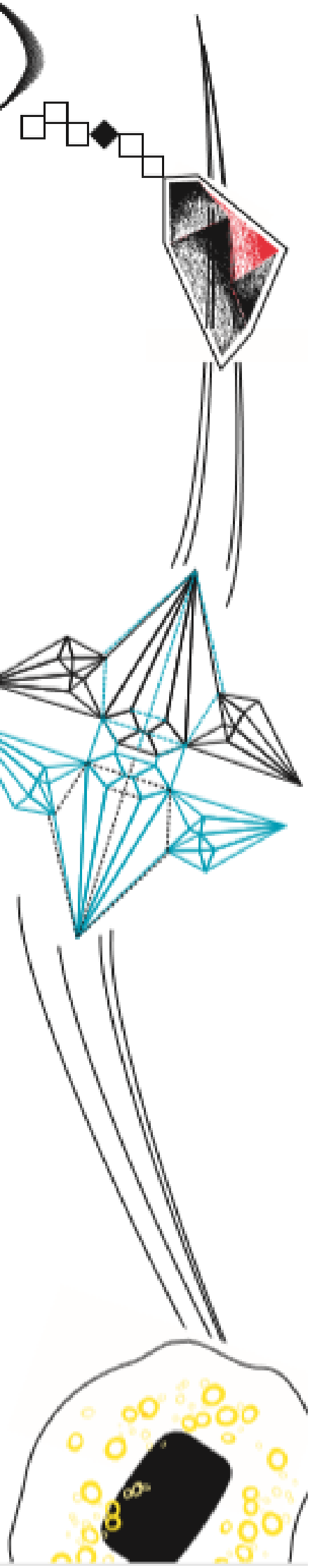

NEW COMPLIANCE

Master Thesis

Improving the development and implementation of audit-and-feedback-systems for healthcare workers' performance practices

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Abstract

Background: The incidence of healthcare associated infections (HAI) has increased over the years. To enable healthcare workers to follow the infection prevention and control recommendations for HAI, audit-and-feedback systems (AFS) have been developed for monitoring of healthcare workers' performance practices. Studies demonstrate that AFS have positive effects in changing the behaviour of healthcare workers and improving patient outcomes. However, current development of AFS often lacks identifying stakeholders' and contextual needs and characteristics during development, which results in the occurrence of hindrances after implementation. To create an optimal fit between the user, AFS and context, it is necessary to involve stakeholders throughout development and implementation of AFS.

Objectives: To identify which elements can improve the development and implementation of AFS intended to improve healthcare workers' performance practices

Methods: A mixed method study was performed, which combined a scoping review and conducting interviews, aiming to investigate current practices of existing AFS and healthcare workers' needs for and experiences with AFS. A total of 24 studies were selected, which contain information about technological AFS strategies or interventions. Data related to the design, implementation and usage in practice of AFS were extracted. To gain insight into needs and experiences of healthcare workers, semi-structured interviews were conducted with nine respondents from six hospitals.

Results: Respondents indicated several requirements related to the design, implementation and usage in practice of AFS. Design requirements include system functionalities (e.g. utilizing reminders, addressing knowledge gaps, measuring outcomes continuously and a user-friendly design) but also explored the wish for tailored feedback (e.g. feedback should be positive, nonthreatening, supportive and needs further explanation). Furthermore, AFS should provide a visualisation of data and direct access to feedback. Implementation requirements include the integration of AFS with other existing systems or protocols. Other indicated enablers for implementation are the assignment of those responsible for AFS, employing a bottom-up strategy and providing training and test moments. Barriers for implementation include a negative feeling of being judged by AFS. For the usage of AFS in daily practice, a positive attitude is required (determined by e.g. healthcare workers' engagement with AFS and their belief in the value and trustworthiness of AFS). Barriers include negative attitudes (determined by e.g. disbelief in AFS usefulness) and healthcare workers' resistance to utilise AFS.

Discussion and conclusion: In order to improve the development and implementation of AFS, AFS should be user-friendly, continuously collecting data and connect with other systems; additionally, feedback should be tailored, and it is valued to utilise reminders. Recommendations to encourage an optimal fit between the user, AFS and context include the following: implement a bottom-up approach (active healthcare workers involvement) with top-down stimulation (supervisor support); and provide training and test possibilities to gain a better knowledge about AFS and the expectations of healthcare workers. Because every user, technology and context is different, it is crucial to consider the influence of characteristics of users and their context in the design and implementation of AFS. Future research should study the effects of a bottom-up approach in the hospital setting.

Keywords: Audit-and-feedback system, Healthcare Associated Infections, Performance improvement Patient Safety, Quality Improvement

Table of content

1. Introduction

1.1 Healthcare associated infections

Every year, many patients are affected by healthcare associated infections (HAI) in hospitals [1]. Although many HAI are partially preventable [2], the European Centre for Disease Prevention and Control reports that the incidence of HAI is increasing [3]. There are several reasons why this increase is alarming. First, patients have become more susceptible to infections [2]. Second, the spread of pathogens has increased; caused by for example, healthcare workers transporting pathogens from one patient to another and inadequate attention to preventive measures that should be performed [2]. Third, inadequate prescribing of antibiotics creates an opportunity for the emergence of resistance by certain microorganisms [4]; which results in ineffective medicine, because the 'bad' bacteria and viruses in the human body are no longer destroyed by the medicine. General recommendations for the prevention of HAI are often implemented, including training healthcare workers in infection control and hospital hygiene [5]. However, studies demonstrate that healthcare workers may not have knowledge regarding these recommendations or do not adhere to them [3]. Although these recommendations have improved infection prevention and control (IPC) in hospitals, these recommendations rapidly reached their limits and revealed unintended effects [6] caused by, for example, resource limitations, institutional behavioural culture (e.g., healthcare workers believe that because current practices are long-standing, they do not need to change) and on occasion, lack of support from hospital boards [2].

1.2 Audit-and-feedback systems

To enable healthcare workers to follow IPC recommendations, health technologies are developed for monitoring healthcare workers' practices [7]. These systems provide healthcare workers with information regarding the consequences of their behaviour or teach them to achieve improved results; such feedback is a powerful strategy for enhancing learning and improving clinical performance [8]. Technologies that utilise these feedback mechanisms are the so-called audit-and-feedback-systems (AFS). These systems employ observations and evaluations to improve performances and quality of care [9]; they measure pre-set guidelines or recommendations for clinical practices over a specific period and provide feedback to healthcare workers [10]. Studies indicate that healthcare workers are prompted to adjust their practices after receiving performance assessments that reveal that their clinical practices are inconsistent with guidelines [11].

A major advantage of AFS is that it can be broadly applied. Not only can the performance aspects being audited vary depending on interests or available information, but also the feedback method can differ in terms of recipients, formats, sources, frequency, duration and content [12]. In addition to registration of data, it may also reveal underlying causes of safety problems and therefore could provide clues regarding necessary improvements to prevent HAI [13]. Studies support this concept by demonstrating the positive effects of AFS on the behaviour of healthcare workers and patient outcomes [13]. However, there are also multiple disadvantages for currently implemented AFS that promote IPC, including technological problems (e.g., poor Wi-Fi connections or incorrect location tracking) and interpretation problems [14]. These problems usually occur after implementation and are not considered during the development process. To prevent such hindrances after implementation, it is important to consider them during development, which includes not only designing the AFS, but also creating a new infrastructure, in which user, technology and context are dependent on each other [15].

1.3 The CeHRes Roadmap for the development of audit-and-feedback systems

The CeHRes Roadmap offers guidelines which can aid developing AFS to suit users and their contexts [16]. The Roadmap focuses on the human standard by incorporating a human-centred design, persuasive features and stakeholder involvement throughout the development process [16]. The roadmap consists of five intertwined phases with connected evaluation cycles that ensure that all activities in each phase relate to stakeholder perspectives as well as the context and outcomes of the previous phases [17]. The definition of *context* in this study is as follows: '*the tangible and intangible environment in which a technology is intended to be used, consisting of multiple elements such as the physical surroundings, the people and their perspectives, the existing processes and routines and the rules and regulations' [17].*

In the first phase, contextual inquiry, developers must thoroughly investigate the context for which a system will be developed [17], to identify stakeholders' perspectives and understand the environment. If a contextual inquiry is not conducted, then mismatches between users, technology and context can occur [17]. The contextual inquiry is also crucial for the further development process, because the results of the contextual inquiry are also necessary in subsequent phases. These results are important for identifying stakeholders' requirements for technology (phase 2); additionally, the design (phase 3), the operationalization (phase 4); and the evaluation of the technology in practice (phase 5) [17].

1.4 Knowledge gap

Extant research lacks reporting information obtained during the contextual inquiry (phase 1) and value specification (phase 2), or even lacks to perform these phases. Therefore, characteristics and needs of the involved users and their contexts are unknown [18], which might result, in a mismatch between users, AFS and context. According to the CeHRes Roadmap, the implementation of AFS originates with the beginning of the development process [17]; problems that occur after implementation could have been solved during development with active stakeholder involvement. Moreover, aspects of the clinical environment, such as time constraints and patient volume, can influence the ability of healthcare workers to adopt technology in their working routines [9]. If these factors are not considered during development, an appropriate fit between user, technology and context [17] may not occur.

1.5 Research question

To determine factors that can lead to achieve this appropriate fit, the main research question of this study is formulated as follows: *Which elements can improve the development and implementation of AFS intended to improve healthcare workers' performance practices.*

Several sub-questions are formulated to answer the main question. The first two sub-questions are necessary to identify enablers or barriers regarding development and implementation of existing AFS; to discover the current situation of these AFS cases. The third sub-question is formulated to identify the needs of healthcare workers. Finally, to create an appropriate fit for an AFS in its context, the fourth sub-question is formulated to identify what is necessary to adjust in the context of AFS. Answering these questions will not only identify elements of best practices of AFS development and implementation but also permit converting barriers or missing elements into recommendations for AFS in practice or future research.

1. *Which elements of AFS in hospitals have added value?*
2. *How are existing AFS in hospitals implemented in working routines?*
3. *What are the needs of healthcare workers when receiving feedback from AFS?*
4. *What should be adjusted in the environment of the system to improve the imbedding of AFS in hospitals?*

2. Method

Because answering the research questions require both obtaining existing knowledge about AFS development and implementation, as well as the needs and experiences of healthcare workers, a mixed methods study was performed which combined a scoping review and interview study. This was a two-phase approach, in which first the scoping review was performed to collect existing data concerning AFS development and implementation; this data was also utilised to compile the interview scheme for the second phase, the subsequent interview study. This approach made it possible to reference findings in the literature during the interviews and to ask respondents their opinions of these topics.

Mixed methods utilises the strength of various elements of both methods, leading to an increase in depth and understanding of the findings [19]. In addition, results from one method can be explained with the results of the other method [20] and the different ways of gathering data can supplement the findings of the other method, thus increasing the validity of the data [21]. For example, the experiences of healthcare workers could be obtained and substantiated with the findings from literature and vice versa. The scoping review also informed insights into experiences of healthcare workers with AFS in other contexts, which could be compared with the experiences of healthcare workers in the interview study. Moreover, utilising a specific AFS as case within the interview study allowed findings from the scoping review to be illustrated and contextualised, which resulted in an improved interpretation of findings. These benefits could not be reached by using the scoping review or interview study alone.

The mixed method research involved two phases: segregated and integrated. Both methods are explained separately below; the same applies to the findings of both methods, which are presented in Chapter 3. In the discussion, Chapter 4, the findings of both methods will ultimately be merged which permits to answer the research question. In addition, the findings of the segregated data can be compared with findings of previous published studies and implications can be recommended for the development, implementation and usage in practice of AFS or future research.

2.1 Scoping review

A scoping review was performed, which provided insight into the status quo of scientific literature in this field of study [17] by mapping existing literature [22]. This would also be possible with a meta-analysis or systematic review, but, given the rapidly evolving field of eHealth, the advantage of a scoping review is that it focuses on a broader field [17]. Additionally, a scoping review was better suited to the broad nature of the research questions than a systematic review [22]. The review focused on answering the first two sub-questions: *Which elements of AFS in hospitals have added value?* and *How are existing AFS implemented in working routines?* The answers to these questions can also be supplemented by the findings of the interview study.

2.1.1 Search strategy

A scoping review was conducted to explore the extent of the literature about AFS developed to improve patient safety and quality of care. Therefore, a search was performed employing the PubMed and Scopus databases; these two databases cover the majority of substantively relevant journals and were easily accessible from the University of Twente. Additionally, because technology evolves quickly, publication dates were limited to studies published in the past five years (May 2014–May 2019).

Given that, in the majority of studies, the term *audit-and-feedback-system* was not mentioned, different search terms were used. The first search terms were a*udit* and *monitor,* with the latter being a common synonym for the former. These terms were utilised to reveal studies that involve technologies in which measurement and assessment is based on pre-set criteria. Next, *feedback* was utilised as a search term, as studies must employ feedback mechanisms in technologies. Only studies that aimed to improve patient safety or quality of care were selected, and therefore the search terms *safety* and *quality* were determined. Because this study also aims to discover current literature regarding the development and implementation of AFS, the search terms *development* and *implementation* were utilised. Additionally, *evaluation* was used to discover valuable insights concerning development and implementation of AFS in evaluation studies. Finally, *hospital* was used, because this study focuses on AFS utilised in hospitals. These search terms yielded the following search string:

('Audit' OR 'Monitor') AND 'Feedback' AND ('Safety' OR 'Quality') AND ('Development' OR 'Implementation' OR 'Evaluation') AND 'Hospital'.

2.1.2 Selection process

In the first step of the selection, two independent reviewers examined the titles and abstracts of the selected studies separately to determine whether they met the inclusion and exclusion criteria. The reviewers assessed the studies as *include, exclude* or *maybe*. The reviewers met to discuss the differences in assessment, after which they chose together to include or exclude the articles for the next selection round. The inclusion and exclusion criteria are displayed in Table 1. They chose to exclude all study protocols because these studies do not provide new knowledge but only repeat knowledge obtained from other studies. In evaluation studies, some abstracts did not provide relevant information, but these studies were included in the full text round because they could disseminate information relevant for answering the research questions.

In the second step of the selection, the included studies were retrieved in full text and again reviewed by the same two independent reviewers utilising the same criteria as mentioned previously. Evaluation studies that did not provide outcomes other than outcome-related statistical numbers were excluded. The reference list of each study was also examined to locate any additional studies that were overlooked during the first step of the selection (the so-called snowball sampling).

Table 1 Inclusion and exclusion criteria

Study characteristics	Inclusion criteria	Exclusion criteria
Setting		Non-clinical setting
Technology	Includes a monitoring or assessing aspect based on a pre-set audit	
	Provides direct or indirect feedback to healthcare workers	Non-technological feedback systems
Outcomes	Involves a detailed description of the development or implementation	Only outcome-related statistical numbers
Report criteria	Provides peer-reviewed articles	Written in languages other than English or Dutch
		Free full access unavailable via University of Twente

2.1.3 Data extraction

A data extraction form was created to systematically extract information relevant to the aim of this study [23] and determine which data to extract from the studies [24]. Because this study aims to identify elements for the development and implementation of AFS, it was deemed necessary to use the following three factors: 1) design of AFS, 2) implementation of AFS and 3) usage of AFS in practice. Design relates to *the actual, functioning technology* [17], including for example, the lay-out and technical features. Implementation describes *the activities that are undertaken to realize the adoption, dissemination and long-term use of an AFS in its contended context* [17]. Usage of AFS in practice is in this study defined as *the daily usage in practice of AFS after implementation*.

The data extraction form allowed each factor to be detailed in a separate table with as variable *requirements,* in which all fragments that mentioned what is necessary for AFS were tagged. As codes, *enablers* and *barriers* were created, which define to what extent a requirement contributes to successful implementation. This method is supported by studies by Colquhoun (2013) [10] and Ivers (2014) [25], which describe these codes as key findings that relate to effective development and implementation of AFS. Utilising the data extraction form, all valuable information regarding implementation and development of AFS could be extracted. If valuable insights were discovered that did not fit in the data extraction form, then new codes could be created during the scoping review.

Table 2a. Data extraction form: related to the design of AFS

Variables	Code
Requirements	Enabler
	Barrier

Table 2b. Data extraction form: related to the implementation of AFS

Variables	Code
Requirements	Enabler
	Barrier

Table 2c. Data extraction form: related to the usage in practice of AFS

Variables	Code
Requirements	Enabler
	Barrier

2.1.4 Data analysis

The framework from Tables 2a, 2b and 2c was engaged for data analysis. First, the total number of included studies and excluded studies and the phase in which they were excluded, were placed in a flowchart. Next, all information available in the selected studies regarding the development and implementation of AFS related to patient safety and quality was structured in the data extraction forms of Tables 2a, 2b and 2c [26]; a deductive method of coding. All factors from the studies that were appropriate to this data extraction form were extracted by one researcher. An independent researcher peer-reviewed the factors afterward to determine whether they were truly appropriate within the categories. This was an iterative process, in which the researchers continually revised the codes and updated the framework [24]. The data extraction forms below display the variables that were extracted (Tables 2a, 2b and 2c).

2.2 Interview study

In addition to the scoping review, interviews were conducted with healthcare workers using the OR-Cockpit system of NewCompliance; this AFS is utilised as a case in this study. Interviews allowed the identification of the experiences with and opinions of AFS from healthcare workers, as well as the roles and tasks they have, which supplied understanding concerning the context of AFS. Therefore, the interview study complemented the answers to the first two sub-questions but also answered the final two sub-questions: *What are the needs of healthcare workers when receiving feedback from AFS?* and *What should be adjusted in the environment of the system to improve the imbedding of AFS in hospitals?* Answers of these questions can in reverse also be supplemented by the findings of the scoping review. The outcomes of this study contribute not only to answering the research questions but also to providing recommendations to NewCompliance aiming to improve the embedding of their OR-Cockpit system in the working routines of healthcare workers.

2.2.1 Setting: The OR-Cockpit system

The OR-Cockpit is a technology developed by NewCompliance which has been implemented in operating rooms (OR) of several hospitals in the Netherlands and the United States. The system allows healthcare workers to improve patient safety by providing real-time feedback during surgeries. It consists of a dashboard with several informational modules that display all patient and OR information as well as all possible risks that may endanger patient safety. The modules are predominantly blue, but when the system sounds a signal or requires attention, the modules turn orange or even red in the case of an alarm, as can be seen in Figure 1 [27]. When healthcare workers select the orange or red modules, pop-ups are displayed with information about the signal or alarm. Any module can be selected at any time, and pop-ups display which protocols, procedures or specific required actions are described.

Figure 1 The OR Cockpit system

With the additional analysis tool, healthcare workers can examine the data and the OR performance. NewCompliance recommends that hospitals create committees to analyse the obtained data monthly and provide feedback to the healthcare workers. In addition to the real-time feedback that they receive during surgery, healthcare workers also obtain short-term feedback on their safety performances, and they can discuss solutions for problems encountered. Other additional dashboards, offered by NewCompliance, can be utilised in different locations—for example, outside the OR or in the holding and recovery area. This study focuses only on the dashboard inside the OR and the analysis tool.

2.2.2 Respondents

The respondents who were recruited for this study are OR managers and members of OR teams, such as OR nurses. The respondents must have had at least three months' experience with the OR-Cockpit to be included. They must also work with the OR-Cockpit directly, such as during surgery or while analysing the outcomes. Respondents who did not meet the criteria were excluded.

Before participant selection occurred, NewCompliance provided information concerning this study by emailing all healthcare workers who met the criteria. After this message was delivered, the researcher contacted these healthcare workers, again by email, and asked them if they would be willing to participate in this study. Selection of respondents was based on a convenience sample, which means that the sample was based on the availability of healthcare workers who met the inclusion criteria. The aim was to include a minimum of 10 healthcare workers from a minimum of five hospitals. Due to the homogeneous nature of this target group, no larger number of respondents was required to achieve data saturation [28].

2.2.3 Procedure

Prior to the interview, a brief introduction was presented regarding the purpose of the interview and the study, after which the informed consent was provided to each healthcare worker (see Appendix A). By signing this form, the healthcare worker agreed to permit recording of the conversation and the usage of data for analysis. After permission was granted, the recording began, and the interview was conducted. The recording was terminated after asking respondents if they agreed to end the interview. Each interview was conducted at the hospital in which the healthcare workers are employed at a time of the healthcare worker's choosing. The research (application number 190580) was approved by the Ethical Committee of the Faculty of Behavioural, Management and Social Sciences at the University of Twente on 30 April 2019.

2.2.4 Materials

Based on the findings of the scoping review, an interview scheme was created to identify the healthcare workers' needs with regard to AFS and experiences with the OR-Cockpit system. The interview scheme (see Appendix B) consisted of four components: 1) general component: background information on the respondent, 2) the OR-Cockpit system: usage, 3) the OR-Cockpit system: history and 4) the OR-Cockpit system: present and future. The interview scheme included semi-structured questions, which means that the researcher asks a question and then requests more information based on the respondents' answers.

2.2.5 Data analysis

The recorded interviews were transcribed verbatim in Microsoft Word, and analysis of the data was then performed in Atlas.ti, version 8 [29]. First, all transcripts were globally analysed to recognise relevant fragments concerning AFS development and implementation, or healthcare workers' needs and experiences. All fragments in which respondents discussed their knowledge of the system and the context of the system that had been obtained through their observation of and involvement with it were labelled *experience*. All fragments in which respondents mentioned what they considered to be desirable or necessary were tagged *requirements*. The requirements were detailed in tables; experiences have been reported to NewCompliance in an advisory report and this study only reveals healthcare workers' experiences in quotes. As mentioned previously, among the *requirements,* the codes *enablers* and *barriers* were created, with the former referring to what extent a requirement contributes to successful implementation.

Second, all relevant fragments were linked to individual codes, which can be found in the frameworks presented in Tables 2a, 2b and 2c. A deductive method of coding was employed, which means that fragments were labelled with codes that were created in advance. After coding all fragments, data was coded axially to link fragments with the same code to each other and make them new sub-

codes. The first transcript was coded by two independent researchers separately to determine inter-rater reliability. Thereafter, one researcher labelled all fragments from the transcripts while considering the coding agreements made with the other researcher. The coding scheme was revised several times by both researchers, and the fragments were re-read. To achieve high external validity, this iterative process was continued until the coding scheme had reached a level of abstraction in which details were omitted [28].

3. Results

This chapter presents the results from both the scoping review as the interview study. Because this study aims to identify elements for the development and implementation of AFS, the results of both methods are discussed separately, and segregated in terms of design, implementation and usage in practice of AFS, as explained earlier.

3.1 Scoping review

Figure 2 presents the database search results. In the initial search of the selected databases (PubMed and Scopus), 233 potential articles were identified. These articles were uploaded to *Covidence* [30], a software for article screening. *Covidence* identified 56 of these articles as duplicates, after which the duplicate articles were removed. Upon screening the abstracts, a total of 91 eligible articles were found, of which 67 were excluded for the following reasons: no mention of audit or feedback (n = 47), evaluative study with no relevant outcomes (n = 12), study protocol (n = 6) or inaccessible from the University of Twente (n = 2).

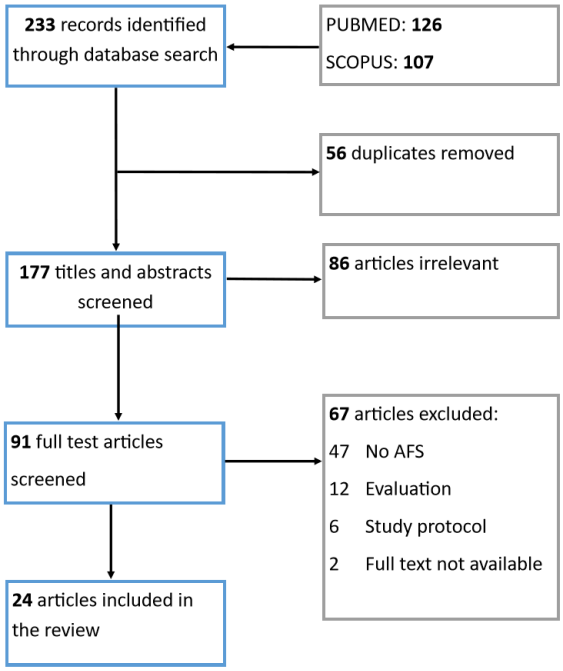

Figure 2. Flow diagram of the selection of eligible studies for inclusion in the scoping review

The characteristics of the included studies are presented in Table 3. Most of the studies were set in hospital practice (n = 13), which range from peripheral hospitals to academic hospitals and hospitals in low-income countries (n = 2). Other settings included primary care (n = 4), home care (n = 1), mental care (n = 1) or dental faculty school (n = 1), and, in three studies, the setting was broad or unknown. Several studies focus on practice performance of healthcare workers, while others focus on evaluation of or experiences with specific implemented interventions. In almost every study, the respondents were healthcare workers; their positions ranged from physicians to nurses or medical students. Of the 24 included studies, the majority adopted a qualitative approach (n = 10) in which interviews or focus groups were primarily utilised as a data collection tool. Six studies followed a quantitative study design, which mainly comprised questionnaires or systematic reviews. Five studies utilised a mixed method approach with both quantitative and qualitative design.

Table 3. Characteristics of studies included in this scoping review

First author	Country	Study aims	Setting	Study design	Study method
Ament, 2014 [31]	The Netherlands	To explore promising post-implementation hospital specific strategies as perceived by professionals to maintain or improve primary implementation successes (the innovation and its benefits)	Hospital practice	Qualitative	Interviews
Bravo, 2018 [32]	Canada	To develop user- and behaviour change technique - informed email content for a study testing variant of the email.	Primary care practitioner	Qualitative	Workshops and focus groups
Brown, 2018 [33]	United Kingdom	(1) To evaluate the usability of PINGR with target end-users; (2) refine existing design recommendations for e-A&F systems; (3) determine the implications of these recommendations for patient safety	Primary care practitioner	Quantitative and qualitative	Questionnaire and interviews
Brown, 2019 [34]	United Kingdom	To (1) describe the processes by which feedback interventions effect change in clinical practice; (2) identify variables that may predict the success of these processes; (3) formulate explanatory mechanisms of how these variables may operate; and (4) distil these findings into parsimonious propositions	Health care workers performance feedback	Qualitative	Systematic review and meta-synthesis
Buchanon, 2019 [35]	United Kingdom	To (1) audit their engagement with POT; (2) review the design(s) of POT in use; (3) assess participant's perceived value of POT and; (4) explore ways that the existing programme could be enhanced to maximise its utility	Dental school faculty	Quantitative and qualitative	Questionnaires and interviews
Ebben, 2018 [36]	The Netherlands	To identify effective strategies for improving guideline and protocol adherence in prehospital and ED settings	Hospital practice (emergency department)	Quantitative	Systematic review
Fraser, 2017 [37]	Canada	Hypotheses tested in this study: a consistent, long duration, client-focused feedback intervention would improve client outcomes among four important quality indicators: pain, falls, delirium, and hospital visits	Home care	Quantitative	Regression analysis and surveys
Gachau, 2017 [38]	Kenya	To examine the effect of A&F delivered as part of a wider set of activities to promote paediatric guideline adherence	Hospital practice in low-income countries	Quantitative	Longitudinal observation study
Gillespie, 2017 [39]	Australia	To undertake a process evaluation of four knowledge translation strategies used to implement the Pass the Baton intervention which was designed to improve utilization of the SSC	Hospital practice (OR)	Quantitative and qualitative	Observation study and interviews
Gotlib Conn, 2015 [40]	Canada	To understand, from the champions' perspectives and experiences, what influenced the success and sustainability of ERAS implementation in these centres	Hospital practice (OR)	Qualitative	Interviews
Grimshaw, 2019 [41]	Canada	This study describes implementation laboratories involving collaborations between healthcare organisations providing AFS on scale, and researchers, to embed head-to-head trials into routine QI programmes.	-	-	-

Hysong, 2014 [42]	USA	To identify changes in audit and feedback of clinical performance to primary care clinical personal resulting from implementing team-based care in their clinics	Primary care teams	Qualitative	Interviews
Kampstra, 2018 [43]	The Netherlands	To summarize the results of studies which use outcome measures from clinical registries to implement and monitor QI initiatives	-	Qualitative	Systematic review
Keyworth, 2017 [44]	United Kingdom	To evaluate the acceptability and feasibility of providing feedback on prescribing errors via My Prescribe, a mobile-compatible website informed by implementation intentions	Hospital practice	Qualitative	Interviews
Landis-Lewis, 2015 [45]	USA	To invite debate and direct research attention towards a novel AF component that could guide supervisors in adapting feedback messages for individual health-care providers' barriers to behaviour change: computer-supported feedback message tailoring	-	-	-
Lewis, 2015 [46]	USA	To determine whether an initial evaluation with surgeon feedback improved subsequent performance	Hospital practice (OR)	Quantitative	Observation study
Ling, 2016 [47]	Singapore	To highlight practical recommendations in a concise format designed to assist healthcare settings in the Asia Pacific region in implementing CLABSI prevention efforts	Hospital practice (infection prevention)	-	-
Maruti, 2014 [48]	Kenya	To describe how the SLMTA programme and enhanced quality interventions changed the culture and management style at BDHL and instilled a quality system designed to sustain progress for years to come	Hospital laboratory in low-income country	Quantitative and qualitative	Workshop and audit
Pedersen, 2018 [49]	Norway	To describe and explore mental healthcare full A&F cycle experiences	Mental healthcare	Qualitative	Focus groups
Polisena, 2014 [50]	Canada	To propose a surveillance system framework to improve the safety associated with the use of medical devices in a hospital	Hospital practice	Qualitative	Systematic review
Singh, 2019 [51]	India	To understand key findings from the ACS QUIK trial from the perspectives of physicians	Hospital practice (cardio)	Mixed method: quantitative and qualitative	Interviews, focus groups, surveys
Tuti, 2017 [52]	Kenya	To assess the effectiveness of e-A&F interventions in a primary care and hospital context and to identify theoretical mechanisms of behaviour change underlying these interventions	Primary care and hospital practice	Quantitative	Systematic review
Webster, 2016 [53]	Canada	To pilot-test the endoscopist A/F report to elicit opinions about the proposed report's usability, acceptability, and potential usefulness for knowledge translation	Hospital practice (endoscopists)	Qualitative	Interviews
Wooller, 2018 [54]	Canada	To describe the use of the safety LEAP program to drive improvement efforts, and specifically to reduce the prevalence of urinary catheters at a large academic health centre	Hospital practice	Quantitative	Observations, measurements

3.1.1 Requirements related to the design of audit-and-feedback systems

The indicated requirements related to the design of AFS are presented in Table 4. Amongst the enablers of successful AFS design, a separation is apparent between system requirements and feedback requirements. According to the literature, a system should, for example, employ reminders and provide suggestions for improvement to healthcare workers to help them in decision-making, to remind them to do certain tasks [31, 39, 49] and increase adherence [36]. One study mentions that the ability to raise awareness of certain factors and to address unknown weak points in routines helps healthcare workers to change their behaviour [44]. Also, it is identified as desirable if systems measure data continuously [31] and have the ability to compare performance data between workers to indicate how workers perform relative to others [32, 53]. In addition, the user-friendliness and ease of use of AFS is identified as desirable [34, 55].

Table 4. Requirements related to the design of AFS

Variable	Code	Sub-code
Enablers	System functionalities	Utilise reminders [31, 36, 39, 49]
		Provide suggestions for improvement (action plans) [33, 34, 39, 52, 53]
		Raise awareness [44]
		Address knowledge gaps [44]
		Measure outcomes continuously [31]
		Compare performance data with others [32, 53]
		Design for user-friendliness and ease of use [34, 51]
	Tailored feedback	Provide individualised feedback [38, 39, 45, 53]
		Provide both verbal and written feedback [39, 56]
		Provide nonthreatening, supportive feedback [35]
		Provide positive feedback [31, 48]
		Provide reliable feedback [35]
		Provide and receive frequent feedback [38, 39, 45, 53]
		Attend the healthcare workers directly [33]
		Adjust timing based on user wishes [44, 54]

Clear requirements are identified regarding tailored feedback, which means *adapting the feedback to the characteristics of the user* [17]. For example, feedback must be individualised [39, 45, 53, 57], positive [31, 48] and reliable [35]. The design should enable supportive and non-threatening feedback (as opposed to punitive or judgemental feedback) [35]. In addition, providing feedback frequently [39, 45, 53, 57] or adjusting the timing of feedback based on user wishes [44, 58] enables development and implementation of AFS. One study mentioned that the possibility of feedback to directly attend the healthcare workers enables successful AFS design [33] and it was also indicated that feedback should be both verbal and written to achieve better understanding [39, 56]. Furthermore, side benefits of AFS, which are other than those intended, were mentioned; these included improved efficiency in working processes [44, 58-60], such as saving time or utilising fewer resources.

3.1.2 Requirements related to the implementation of audit-and-feedback systems

An overview of all the requirements extracted from the literature related to the implementation of AFS is presented in Table 5. This table indicates that it necessary to focus on embedding AFS in practice. Enablers for implementation are, for example, an effective integration of AFS with existing clinical systems [33, 34, 61] and the normalisation of the usage of AFS in working routines [44, 61]. In some of the studies that explored healthcare workers' experiences, healthcare workers agreed that AFS are facilitators for

quality improvement [43]. Furthermore, periodic evaluation meetings regarding improvement progress remind healthcare workers to cooperate with the system [31, 39, 61].

Table 5. Requirements related to the implementation of AFS

Variable	Code	Sub-code
Enablers	Focus on embedding AFS in practice	Integrate effectively with existing clinical systems (technological facilitator) [33, 34, 40]
		Normalise AFS in daily practice and working routines [40, 44]
		Evaluate progress in periodic meetings [31, 39, 40]
	Divide responsibilities clearly	Support by supervisor or management [34, 38, 40, 41, 47, 48, 51, 54]
		Assign clearly those responsible for AFS and improvement process [46, 49, 54]
		Employ bottom-up strategy [31, 40, 42]
	Train and test	Allow pre-implementation pilot testing [50]
		Make training opportunities with AFS available [34, 51]
Barriers	Organisational and timing resources	

A clear division of responsibilities is helpful in the implementation of AFS. Examples are supervisory support [34, 41, 47, 48, 55, 57, 58, 61] and assigning one person or a group to be responsible for AFS or the improvement process so that all healthcare workers know whom to contact with problems or questions [49, 56, 58]. A bottom-up strategy, which includes self-organising teams, was mentioned several times as an enabler [31, 42, 61]. This strategy involves the adoption of activities in which healthcare workers are encouraged to participate in collective action towards the shared goal of improvement [62]. Pilot testing before implementation further facilitates the execution because errors can be solved before implementation in practice, which can prevent healthcare workers' resistance after implementation [50]. Training opportunities for healthcare workers also eases implementation, because healthcare workers can practice with the system without the measured values counting toward evaluations [34, 55].

Barriers related to AFS implementation include a lack of organisational or timing resources. For example, a shortage of staff or budget can influence the implementation of AFS or the follow-up of improvement plans [44]. Furthermore, timing resources, such as the frequently high workload of healthcare workers, can be barriers for implementation of AFS [34, 35].

3.1.3 Requirements related to usage of audit-and-feedback systems in practice

The surveyed literature indicated several enablers and barriers that should be considered for successful usage of AFS in practice; these are presented in Table 6. A positive attitude on the part of healthcare workers towards the AFS is required, what is determined by several factors. For example, the engagement of healthcare workers with the system [34, 39, 45, 47, 48, 58, 59, 61], which refers to *the situation when a full overlap between user's intentions and the characteristics of AFS exists* [17]; the belief of healthcare workers in the value of the AFS [39, 45, 49, 55, 61]; and healthcare workers' extent of self-efficacy in skills or performance [34, 45, 53], which indicates healthcare workers' belief in their capability to do the job. Another contributing factor to a positive attitude is the perception of AFS' trustworthiness and reliability [34]. In addition, a feeling of owning the AFS (rather than feeling that it has been imposed upon them) contributes to a positive attitude on the part of healthcare workers towards the system [34]. Besides a

positive attitude, an ongoing focus on improvement and skills development of healthcare workers enables an AFS to be successfully used in practice [47]. Furthermore, healthcare workers should be emotionally prepared before feedback is provided [45]; one study mentioned the 'feedback sandwich', in which points of improvement are framed by starting and ending with positive comments [45].

However, there are also some barriers for successful daily usage of an AFS. For example, a negative attitude on the part of healthcare workers is considered as a barrier. Distributing factors include a lack of belief in the usefulness of AFS [35, 39] and healthcare workers' unawareness or lack of knowledge regarding the implementation of AFS and associated goals for improvement [55]. Studies also revealed resistance of utilising AFS as a barrier [39, 49, 61]; some of the included studies recounted friction and doubt amongst healthcare workers, because, for example, the feedback was not or insufficiently explained [49]. Several studies also mentioned negative feelings of judgement as a barrier [39, 45, 53, 57], for example, if healthcare workers feel being judged or punished based on their performances [53]. Furthermore, omitting healthcare workers from improvement plans is identified as a barrier [34], which occurs when analyses or results from the observed data are not shared with them or when management teams do not involve healthcare workers in planning the improvement strategies.

Table 6. Requirements related to usage of AFS in practice

Variable	Code	Sub-code
Enabler	Positive attitude on the part of healthcare workers	Engagement with AFS [34, 37, 39, 40, 45, 47, 48, 54]
		Belief in value of AFS [39, 40, 45, 49, 51]
		Self-efficacy in skills or performance [34, 45, 53]
		Perception of AFS as trustworthy and reliable [34]
		Ownership of AFS assumed by healthcare workers [34]
	On-going focus on improvement and skill development [47]	
	Emotional preparation of healthcare workers before providing feedback ('feedback sandwich') [45]	
Barrier	Negative attitude on the part of healthcare workers	Disbelief in AFS usefulness [35, 39]
		Unawareness or lack of knowledge regarding implementation programme [55]
	Resistance to utilising AFS [39, 40, 49]	
	Negative feelings of judgement [38, 39, 45, 53]	
	Healthcare workers omission from improvement plans [34]	

3.2 Interview study

Six interviews were performed with nine respondents. Each interview was conducted at a different hospital, which means that six hospitals were visited in the Netherlands. Two of these hospitals are academic, and the other four are peripheral. To protect the anonymity of respondents, the names of the hospitals have not been published, but they are referenced by the letters A–F.

The characteristics of the respondents are displayed in Table 7. The mean age of the respondents was 49 years. Five respondents were male (55.6%); four were female (44.4%). Most respondents were heads of surgery at the OR complex, and, except for one respondent, all had backgrounds in nursing (OR

assistant). As the table reveals, there were three individual interviews and three interviews with two concurrent respondents. The mean duration of the interviews was 32 minutes (minimum 23 minutes and maximum 46 minutes).

Table 7. Characteristics of respondents

Respondent number	Age	Sex	Function	Background	Location
1	39	Female	Head of surgery	Business administration	A
2	60	Male	Head of surgery	OR assistant	B
3	42	Female	Head of surgery	OR assistant	C
4	37	Male	Day coordinator OR	OR assistant	D
5	51	Male	Head of surgery	OR assistant	D
6	64	Female	Planner OR; quality and safety OR	Anaesthesia nurse	E
7	62	Male	Staff consultant	Nurse	E
8	47	Male	Head of surgery	OR assistant	F
9	35	Female	OR assistant; day coordinator OR	OR assistant	F

3.2.1 Requirements related to the design of audit-and-feedback systems

Table 8 displays the requirements identified by respondents as being relevant to the design of an AFS. In terms of system functionalities, several enablers were indicated. The majority of respondents identified the raise of awareness as desirable. The respondents mentioned positivity regarding the awareness created amongst healthcare workers because, for example, they had become aware of their current behaviour. Respondent 8 said, '*What I particularly see is that, because of the feedback, people have become more aware of the influence of their behaviour on the process… when the NewCompliance score drops, people start thinking, oh dear, I have a negative influence on the score, how can I exert a positive influence on it?* '. Furthermore, one respondent wants the system to address knowledge gaps, which involves uncovering weak points which could be prevented or improved. Some respondents also indicated that AFS should measure outcomes continuously, thus allowing respondents to easily prepare longer-term reports.

Table 8. Requirements related to the design of AFS

Variable	Code	Sub-code
Enablers	System functionalities	Raise awareness [1, 3, 4, 5, 6]
		Address knowledge gaps [6]
		Measure outcomes continuously [1, 2, 4]
		Design for user-friendliness and ease of use [2, 3, 5, 6]
	Tailored feedback	Provide feedback to teams (instead of individuals) [6]
		Provide positive feedback [4, 5]
		Provide further explanation of feedback [2, 3, 5]
		Keep feedback concise [1, 2]
	Layout	Visualisation of data [3, 5]
		Access to overview of all feedback or data directly [2, 3, 6]
Barriers	Display of irrelevant information [1, 2]	

The OR Cockpit could also be used to collect data for other purposes, such as education, administration and accreditation. Some respondents utilised the data for medical research to discover associations

between certain healthcare workers' behaviour and the incidence of infections. Respondent 4 said, '… *a patient's blood pressure, smoking yes or no, you can decide for yourself what you want to put in, and afterwards you can compare the patients who did get an infection with those who did not get an infection, and so we find associations*'. Several respondents agreed that AFS simplify working routines, because they provide a clear overview and create structure. Moreover, respondents emphasised the importance of AFS being user-friendly, which makes a system accessible. Respondent 5 said, '*I think that, in general, if a system is [easy] to work with, it is also easier to access*'.

Respondents indicated specific enablers regarding the feedback AFS should submit. One respondent emphasized the importance of providing feedback to teams (such as per specialism) instead of individuals, to prevent people feeling judged. Respondent 9 said, *'… especially since they are in the OR with a team, then nobody ever feels personally addressed*'. Another enabler is providing positive feedback, including providing compliments to healthcare workers. Some respondents indicated that it desirable when feedback is further explained to healthcare workers, which also allows asking questions. Respondent 2 said, '*Look, at the moment they receive little feedback from the system, that might come later, but then, they would appreciate it if they can talk to me and ask questions about it, especially the OR nurses*'. Several respondents mentioned that the feedback AFS provide must be kept concise. Person 1 stated, '*The system should not give too many stimuli, I think that's the danger… because if there is too much displayed on the screen, you see nothing*'. For the same reason, displaying irrelevant information of the screen was identified as a barrier.

All the respondents were positive about the layout of the OR Cockpit. Some respondents indicated visualisation of data as desirable. Respondent 3 said, '*I think it is very nice that it is a visual system, you just see what goes well and what goes wrong, real-time, and I really like that about this system*'. Additionally, respondents desire a direct access to an overview of data. Person 2 said, '*It is very practical that you have insight into what you are doing during the entire surgery, with these systems you keep it more transparent, and therefore you can work safely*'. Also, the fact that it is custom-made (Respondent 4 said, '*It is built entirely on our own wishes*') makes it a pleasure to utilise the system.

3.2.2 Requirements related to the implementation of audit-and-feedback systems

The respondents identified several requirements as being related to the implementation of AFS, which are listed in Table 9. Respondents agreed that the ability to adapt AFS to the organisation is an enabler. For example, the system should integrate effectively with existing clinical systems and connect with protocols and quality and safety requirements. The OR Cockpit had the potential to connect with other systems and protocols, and respondents were enthusiastic about that factor. Respondent 9 said, '*We had the information before from different systems, but you just had to put a lot more energy in it to find the same information. Now we can find anything we want to know on the [OR] Cockpit screen*'. Additionally, the AFS should have the adaptability to be periodically updated, to solve bugs and remain current with the dynamic context of healthcare processes or hospital management.

Respondents indicated that it is important to have a clear division of responsibilities for the AFS or improvement plans. Assigning a certain person or group as responsible for AFS enables the implementation, because healthcare workers know whom to contact with questions and problems. Additionally, several respondents described a bottom-up strategy as a desirable aim for the future, including healthcare workers initiate obtaining data themselves, or OR teams could evaluate and plan improvements themselves. Respondent 8 stated, '*The teams discuss the analyses with each other. I don't have to tell them how to do it better; they know much better how to do that by themselves, but they need data to be able to start that discussion*'.

Table 9. Requirements related to the implementation of AFS

Variable	Code	Sub-code
Enablers	Focus on embedding AFS in practice	Integrate effectively with existing clinical systems (technological facilitator) [2, 5]
		Connect with protocols and quality and safety requirements [2, 5]
		Adaptability of content (updates) [4, 6]
	Divide responsibilities clearly [4, 5, 6]	Assign clearly those responsible for AFS and improvement process [4, 5, 6]
		Employ bottom-up strategy [3, 4, 6]
	Train and test [6]	Allow (pre-implementation) pilot testing [6]
		Provide information manual regarding the usage and interpretation of data [5, 6]
		Provide information regarding expectations from healthcare workers [3, 4, 5, 6]
	Present AFS as a contribution to improvement [1, 2, 3, 4, 5, 6]	
Barriers	Punishing or judging healthcare workers based on results [2, 5, 6]	
	Organisational and timing resources [4, 5]	

Some respondents mentioned pilot testing the AFS before implementation as an enabler because it would allow them to adapt to the system before having to use it in a real-life situation. In healthcare, engaging a new system in a life situation involves patients' lives, and these respondents noted that it could be dangerous to utilise the system without having testing it beforehand. In addition to pretesting, these supervisors also believe that their staff should have the opportunity to become familiar with a system before utilising it for analysis. Training healthcare workers was also mentioned as desirable, not only related to proper usage of the system, but also regarding expectations from them related to the outcomes of AFS. A manual describing the utilisation of the system and interpretation of data was suggested. Respondent 8 said, '*It would be useful to have a manual where people can search for things such as, how does that figure build up, and where does all data come from? I can explain that to them but that will take a lot of time*'.

Every respondent believed that presenting AFS as a means of possible improvements, for example in optimizing working routines and creating awareness, would serve as an enabler for implementation of AFS. Respondents emphasized this because they were concerned that healthcare workers would otherwise have the feeling of being assessed on their performance. Respondent 5 stated, '*It is important how you implement things. You can deploy a technology as an enrichment that will help us improve, but you can also deploy it without further explanation. But then, I think, it often comes across as a threat*'. This concern also explains the barrier that was indicated during the interviews: punishing or judging healthcare workers based on the outcomes of the analyses. When healthcare workers feel judged, they might become resistant. Other indicated barriers are lack of organisational and timing resources, including not considering the workload of healthcare workers.

3.2.3 Requirements related to usage of audit-and-feedback systems in practice

The identified requirements as being related to usage of AFS in practice are displayed in Table 10. A positive attitude towards AFS on the part of healthcare workers is an enabler for successful daily usage, which for example is affected by healthcare workers feeling that they own the system. Respondent 5 said, *'…and then you just have fun, if it is your system*'. Respondent 4 agreed: '*You don't feel it has been forced [on] you*'. Some respondents also suggested that the emotions of healthcare workers should be considered when providing feedback; framing negative feedback with positive feedback, such as compliments, was viewed as an appropriate method.

Table 10. Requirements related to usage of AFS in practice

Variable	Code	Sub-code
Enablers	Positive attitude on the part of healthcare workers	Ownership of AFS assumed by healthcare workers [4]
	Emotional preparation of healthcare workers before providing feedback ('feedback sandwich') [1, 2]	
Barriers	Negative attitude on the part of healthcare workers	Disbelief in AFS usefulness [2, 4, 5, 6]
		Lack of interest in utilising AFS [3, 4, 6]
	Resistance to utilising AFS [2, 3, 4, 5, 6]	
	Negative feelings of judgement [6]	

However, several barriers were indicated, including a negative attitude on the part of healthcare workers towards AFS, caused by, for example, a disbelief in the usefulness of AFS or a lack of interest in utilising such a system. Another indicated barrier is resistance to utilising AFS amongst healthcare workers. Respondents mentioned several reasons for this resistance, for example, doubting the trustworthiness of the system. Respondent 4 stated, '*We have had quite a number of bugs, so they received a bad grade again, so people lose faith in the grade, because, yeah, [it] would probably be wrong*'. This leads to demotivation amongst healthcare workers but also results in ignorance on their part as how the system should be used. Respondent 7 said, '*The fact that they do not report it when the door counter does not work says enough, I guess*'. Some respondents noted that the resistance may not be toward AFS in question but a resistance to new things or a missing personal connection with the system. Respondent 8 posited, '*You always have a few people—I bet you have them everywhere—a small number of people who are less affected by technology. They simply say, "I want to do my work, and that's it. I don't want to interfere with anything else"*'. Moreover, the feeling of being judged can be a barrier for utilising AFS. The respondents in this study were primarily supervisors who emphasised the importance of preventing healthcare workers from feeling judged. Respondent 8 said, '*What I think is very important, and not just me, actually everyone in here, is that it is necessary to prevent creating a situation in which people feel [they are] being personally addressed*'.

4. Discussion

4.1 Summary of results

The aim of this study was to identify which elements can improve the development and implementation of AFS intended to improve healthcare workers' performance practices. Integrating the findings of both methods allows to define which elements are required to improve the development and implementation of AFS.

The results indicate that, in terms of development, AFS should be user-friendly; in addition, they should continuously collect data and connect with other clinical systems. Healthcare workers value the potential to visualize data, obtain a direct overview of information and they prefer not receiving irrelevant information. Furthermore, AFS can be improved by utilising reminders and tailored feedback. Healthcare workers prefer short, positive and non-threatening feedback but also desire an explanation of feedback. Considering the implementation of AFS, it would be profitable to involve healthcare workers throughout the entire development and implementation. Not involving healthcare workers results in not only hindrances in practice, such as not having complete knowledge regarding the usage of AFS or interpretation of data, but also resistance towards the use of such systems because healthcare workers feel judged. Based on the findings of this study, the development and implementation of AFS can be improved by tasking healthcare workers with the responsibility for the improvement process, the so-called bottom-up strategy. Therefore, it is necessary to train healthcare workers in proper usage of AFS and interpretation of the data, as well as to allow them to actively work with the obtained data. Healthcare workers should additionally test an AFS prior to implementation.

4.2 Reflection on results

The following section provides an explanation of the key findings of this mixed-method study and compares them with those of previous published studies. To maintain the structure of the results, the following subsections focus on the design, implementation and usage of AFS in practice.

4.2.1 Reflections on the design of audit-and-feedback systems

There were several findings concerning the design of AFS that correspond with the findings of previous studies (e.g., the desire that such systems can provide suggestions, visualisation and reminders). Reddy et al. (2015) reported that respondents would appreciate feedback from the system regarding actions throughout the procedure that could have improved their performances [63]. Another study showed that healthcare workers confirmed that a tangible sheet of feedback facilitates discussion [64]; the wish to utilise measured data as conversation support for feedback reviews is also mentioned by a respondent in the current study. Previous studies indicated that the usage of reminders is a popular feature of technology [65] and promotes user adherence [66, 67]. Reminders provide recurrent cues and encouragement and motivate users to engage with the system, although it is unclear which type of reminder has the greatest impact (e.g., texts or voice messages) [66]. However, reminders did not always result in action [68]; healthcare workers identified high workloads and a lack of supervision, monitoring and feedback sessions as reasons that discouraged them from acting [68]. This is also seen in the OR-Cockpit case, in which healthcare workers sometimes ignored the suggested tasks, such as completing checklists.

Furthermore, the requirements concerning feedback (e.g., feedback must be simple and short, positive and needs further explanation) are underlined by other studies [64, 69, 70]. Concise feedback is

preferred because of the tension between high workloads and the time required for feedback [64]. Feedback should be positive, which is supported by Lipp, Cho and Kim (2017), who posited that respondents scored better after receiving positive feedback (e.g., praise) because their attitudes and self-efficacies grew [69]. However, this contradicts the findings of another study, which indicated that performance is likely to increase after receiving negative feedback because negative feedback informs the recipient that the goal has not been achieved yet [71]. However, this study was performed in a different setting and involved utilising feedback to promote physical activity. The difference is that, in physical activity, feedback is also provided on the user's performance, but the behaviour of this user had not led to success yet (because the user, for example, had not lost sufficient weight at the time at which feedback is provided). Feedback on a healthcare workers' performance may not indicate that the healthcare workers has performed poorly, and, as mentioned previously, negative feedback can result in the feeling of being judged. It is reported that when feedback recipients felt defensive, they are limited in their ability to accept the feedback because of their emotional reactions [63]; respondents felt more comfortable when the sandwich method is used to provide feedback [64].

Feedback should also be explained later in further detail [64]; however, another study found that users experienced difficulty receiving feedback afterward because of temporal disconnections: when feedback is provided at a later point in time, they may not remember exactly which part of the performance was erroneous [64]. Therefore, it is necessary to strike a balance between providing sufficient feedback for complete understanding at that moment with the possibility of providing further explanation or discussion later. The desire for this balance can differ by organisation or person; this study further illustrates that the timing and frequency of feedback should be adjusted based on user wishes and should therefore be different in every case.

4.2.2 Reflections on the implementation of audit-and-feedback systems

This study shows the importance of interoperability of AFS with existing clinical systems in practice, the goal of which is to connect systems and to share data throughout an organisation and allow healthcare workers to access data [72]. Other studies confirmed this and reported the interoperability of AFS as an increasingly important requirement of effective health systems [73]. Benefits include enhanced communication between healthcare professionals, which leads to improved decision-making, reduction of adverse events and an improved overall quality of care and patient safety [74]. However, integrating health systems in clinical practice also has challenges due to complex issues, including acceptability, data security and quality norms [74]. Adams et al. (2017) revealed that interoperability challenges are primarily in receiving data and not in sending data [75], which was also the challenge in the OR-Cockpit case.

Furthermore, respondents expressed the wish to create a bottom-up strategy in the clinical workplace. In this context, a bottom-up approach means planning improvements based on the wishes and needs of healthcare workers. This strategy has garnered interest over recent years because of its potential to empower and engage clinicians [62]. Research has demonstrated that the usage of a bottom-up strategy provides better, sustainable results than a top-down strategy [76]. This could be due to the shared social and professional norms amongst healthcare workers in bottom-up systems, which are important for behavioural change [77]. In top-down strategies, healthcare workers and management or leadership employees may differ in these social and professional norms; moreover, top-down organisations find challenges to successful improvements because they fail to engage healthcare workers [78].

However, improvement plans should not be limited to only healthcare professionals, but should also involve management teams to achieve desired outcomes [79]. This can be achieved with the so-

called top-down stimulation, which includes organisations stimulating employees to design innovative ideas [80]. This combined with bottom-up championing may increase chances of implementing ideas [80]. However, in a study by Kaunda-Khangamwa et al (2018), healthcare workers criticised the lack of follow-up or supervision, including feedback sessions, which resulted in demotivation among healthcare workers [68]. Healthcare workers notified to expect monthly or quarterly feedback sessions as part of the usage routine of AFS [68]. Therefore, it is important that top-down stimulation includes consistent supervision and feedback.

4.2.3 Reflections on the usage of audit-and-feedback systems in practice

The findings of this study revealed that healthcare workers have a negative attitude towards AFS after implementation in practice, which has also been found in previous studies [81-85]. These studies indicated that negative attitudes on the part of healthcare workers toward various aspects of AFS (e.g., concerns regarding the usage of AFS and fear of an increase of workload) influence whether they are willing to work with AFS [81, 83] and emphasized that efforts should be initiated to enhance the attitude of healthcare workers toward health systems [84].

In this study's investigation into the experiences with the OR Cockpit, the negative attitude on the part of healthcare workers was caused by feelings of judgement, which resulted in resistance. Healthcare workers demonstrate this by minimising their usage of the system or even ignoring it. This behaviour was also been found in previous studies [63, 86], which found that a fear of consequences as a result of performance assessments leads healthcare workers to demonstrate resistance and lack willingness to utilise the system [63]. However, it was reported that resistance may be directed not only towards the system but also the ideas and ways of working that it embodies [86]. This corresponds with the results of the current study, in which respondents indicated that some healthcare workers find it unnecessary to change because, in their opinion, they are already performing well.

In addition, a lack of knowledge regarding the use of AFS and what was expected from them to do (caused by e.g., absent or insufficient training and testing) has been identified as a reason for negative attitudes on the part of healthcare workers. This was underlined by Kaunda-Khangamwa et al. (2018) who reported about healthcare workers complaining that they were required to employ an eHealth intervention without receiving background prior to implementation [68].

4.3 Implications

In this section, implications for the design and implementation, and, usage of AFS in practice, as well as for future research are identified. The following subsections will discuss each of these implications.

4.3.1 Implications for design and implementation

- *Involvement of stakeholder team during development and implementation*

The implementation and usage of AFS in practice are likely to be most successful if the problems identified in this study were prevented before implementation, therefore, a development and implementation team of stakeholders should be created that includes healthcare workers (users) and management or organisational staff. These stakeholders can provide input during the development and implementation phases but can also evaluate AFS after implementation in practice [17]. This is also underlined by Carayon and Hoonakker (2019), who implied stakeholders should be actively involved in the design and implementation of eHealth, to take human factors seriously into account [87].

Because stakeholders' needs differ, it is difficult to provide specific recommendations regarding design and feedback of AFS. However, this study reveals enablers that could be considered during development. The need for a quick overview of information, visualisation of data and provision of positive, nonthreatening feedback were indicated. The system should not be overly present or distract the healthcare workers, and the information should be concise and relevant. To prevent people from feeling judged, grades or percentages should not be utilised to assess the actions of a person or team. Further requirements for the layout of a system and, for example, the timing or frequency of feedback differ per AFS case and should be discussed during stakeholder meetings.

4.3.2 Implications for usage in practice

- *A bottom-up championing with top-down stimulation approach*
- *Training and testing possibilities*

In addition to the implications identified above, based on the findings of this research, it is possible to identify a few implications for the usage of AFS in practice. Involving healthcare workers during the implementation and daily usage of systems can prevent them from adopting negative attitudes. Therefore, implementing a major change in the workplace is recommended, namely, implementing the previously mentioned bottom-up championing and top-down stimulating approach. Healthcare workers can analyse the bottlenecks or problems they experience, after which they can plan, follow-up and evaluate improvement plans by themselves to improve their performances. Supervisors must support and stimulate healthcare workers in this task by, for example, providing data that healthcare workers that can utilise for analysis; in addition, they can convert the findings to action plans. Supervisors must support healthcare workers in many more tasks than those mentioned previously (as they normally do), but the key within this approach is to allow healthcare workers to be responsible for the entire improvement process and to consider supervisors only as facilitators. Implementing these approaches could lead to the active involvement of healthcare workers, which can change their attitudes from negative to positive. The values of this approach are also identified in the results of this current study, in which respondents indicated the need to own the system or process as an enabler of successful implementation. Active involvement can also lead to increased system engagement; healthcare workers are solely responsible for their success and are therefore more willing to engage the system.

Another recommendation is to arrange more detailed training and testing moments to improve healthcare workers' knowledge. This can be organised by system development companies; they can explain the usage of the system and describe the appropriate analytical method. However, within the organisation, it is also important to inform healthcare workers about which aims the organisation desires to achieve and the expectations they have of healthcare workers. Healthcare workers must not only be trained but also be allowed to test the system without directly employing the obtained data in analysis. This trial period is necessary not only to discover the system but also to prevent user resistance, because, for example, human errors in a trial period do not affect the systems' outcomes. Additionally, this trial period also provides the opportunity to discover technological errors in an early stage.

4.3.3 Implications for future research

- *Pilot study for implementing a bottom-up approach in hospitals*
- *Satisfaction survey among healthcare workers working with the OR-Cockpit System*

Based on the findings and earlier discussed implications, two implications are identified for future research. A popular home care organisation in the Netherlands, Buurtzorg, implemented the bottom-up

approach with top-down stimulation and enjoyed successful outcomes in integrated care [88]. In their approach, the perspective of healthcare workers (e.g., nurses) leads, but they are fully supported and facilitated by the head office [88]. However, the combination of bottom-up championing and top-down stimulation has not yet been implemented in Dutch hospitals. Implementing these approaches is recommended previously in this current study, but research is necessary to determine whether these approaches appear feasible and effective in this clinical setting and for which aspects of care. Therefore, it is recommended to perform a pilot study in a hospital department, which leads with the bottom-up championing and top-down stimulating approach. A possible study design is a two-armed RCT comparing a hospital department implementing the bottom-up championing and top-down stimulation approach with a department with usual leadership, with assessments at baseline and after three months. To start with, such a pilot study should include small-scale, non-acute departments in which the risk of patients being harmed is limited.

The OR-Cockpit case demonstrates that, despite the positive side effects of the obtained data, the system was not utilised as intended. This current study provides findings that could aid NewCompliance in improving the imbedding of the OR-Cockpit in practice, which may lead to the intended usage. Therefore, a user satisfaction survey (e.g., via questionnaires) should be performed amongst healthcare workers in the OR departments in which the OR-Cockpit is implemented, at fixed time points (e.g., at baseline and three months post-implementation). With this satisfaction study, conclusions could be drawn regarding whether the recommendations have contributed to an increase in embedding the OR-Cockpit.

4.4 Strengths and limitations

This study has both strengths and certain weaknesses. A strength of this study is the usage of mixed methods, which increases the validity of the findings because the different methods of gathering information supplement the findings and permit an increase in the breadth and depth of understanding the findings, because the findings of the methods could explain each other. Comparing the results of the interview study (the OR-Cockpit case) with other AFS cases in the included studies of the scoping review also demonstrates how the differences are between stakeholders' wishes and the goals for which such systems are designed. This emphasises the importance of involving stakeholders during the development and implementation of AFS.

Another strength was the wide range of eligible studies, which included a variety of clinical settings (hospital, home care, etc.) and healthcare workers (nurses, physicians, etc.). Furthermore, the diversity of the sample of respondents made this sample representative of the target group: respondents were from different hospitals (e.g., academic and peripheral, but also from different sides of the country) and had different jobs and experiences. Although this study focused on patient safety in hospital care (OR department), the advantage of this wide range of selected studies is that the findings of this study can be generalised to other clinical areas and settings.

Although most of the hospitals had implemented the OR-Cockpit system more than three months prior, none of the six hospitals employed the system as intended in daily practice. Causes include lack of organisational resources (e.g. lack of time or staff) but also because hospitals have not yet determined which actions should be conducted or who should perform the tasks. The dashboard is installed in the OR department of every hospital represented, and healthcare workers utilise the real-time feedback during surgeries, but the analysis tool is not utilised optimally if at all. Therefore, none of the hospitals had provided feedback based on the analysis tool to the healthcare workers at the time of the interviews. Therefore, readers should consider that the experiences are based on real-time usage of the OR-Cockpit

and not on the feedback of data from the analysis tool. This does not affect the results of this study, because the real-time feedback allows the systems to function as AFS in practice. Thus, the experiences of the respondents and the requirements they indicated can be compared with the findings from the scoping review. However, this is an important finding which should be reported to NewCompliance.

Finally, although this study focused on involving users during development and implementation as well as improving the match between end-users, technology and the context, the actual users in this case were not the respondents in the interview study. However, as can be seen in Table 7, almost all respondents had a background as OR-nurses and were therefore familiar with the working routines and the bottlenecks that healthcare workers encounter during surgeries. Additionally, the included respondents were contact persons of the healthcare workers and were informed by the healthcare workers during monthly work meetings; therefore, these respondents were able to represent the users of the OR-Cockpit, and therefore the external validity will be little or not affected.

4.5 Conclusion

This study sought to provide insights into elements of best practices of AFS development and implementation. Mixed methods research, combining a scoping review and an interview study, was performed to identify which elements lead to these best practices and achieve an appropriate fit between the user, technology and context. In doing so, important insights were gained regarding requirements related to the design, implementation and usage in practice of AFS. This study identified requirements that were translated into implications for the design and implementation, usage in practice and future research for AFS, but recommendations were also presented to NewCompliance to allow them to improve the imbedding of the OR-Cockpit in daily practice.

Methodologically, this study demonstrates healthcare workers' requirements with regard to AFS and demonstrated the validity of its findings by referring to previous studies. Each method uncovered requirements for AFS design (e.g., wish for providing suggestions, visualisation and reminders; but also tailored feedback), implementation (e.g., considering the interoperability of AFS and implementing a bottom-up strategy) and usage in practice (e.g., providing training and testing possibilities) as well as experiences with existing AFS.

Based on the findings, several implications are recommended to achieve stakeholder involvement, such as a bottom-up approach in combination with top-down stimulation, the provision of training and testing with AFS, not sharing data that could be traced to individuals and the assembling of stakeholder teams, in which healthcare workers and members of organisations' boards should be involved from the first phase of the CeHRes Roadmap [17]. For the design of AFS, recommendations include visualising the data, presenting only concise and relevant information, and providing positive and nonthreatening feedback. Further research should address how the bottom-up approach should be implemented in clinical settings in combination with the usage of AFS. Finally, this research provides further support in emphasising the importance of stakeholder involvement to create a better fit between users, technology and context.

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6. Appendix

6.1 Appendix A: Informed Consent

Titel: Het verbeteren van de ontwikkeling en implementatie van audit-and-feedback-systemen
Verantwoordelijke onderzoeker: F. Sieverink, Universiteit Twente

In te vullen door de deelnemer

Ik verklaar op een voor mij duidelijke wijze te zijn ingelicht over de aard, methode en 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 geluidsmateriaal 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: Britt Bente

Datum: ……Handtekening onderzoeker: ….……

Contactgegevens onderzoeker: b.e.bente@student.utwente.nl

6.2 Appendix B: Interview scheme for healthcare workers

Bedankt dat u wilt meewerken aan het onderzoek. Ik voer dit onderzoek uit in opdracht voor NewCompliance, en daarnaast is het onderdeel van mijn masteronderzoek voor de opleiding Health Sciences aan de Universiteit Twente. NewCompliance heeft mij gevraagd om onderzoek te doen naar de implementatie rondom de Cockpit. Door dit onderzoek krijgt NewCompliance inzicht in wat er wellicht ontbreekt (of juist als goed wordt ervaren), rondom de Cockpit, waardoor NewCompliance in de toekomst de inbedding van de Cockpit binnen de context kan verbeteren.

Het interview zal beginnen met een aantal algemene vragen over uw functie. Vervolgens zullen we ons verder in de Cockpit verdiepen, om achter uw ervaringen met het systeem te komen. Binnen dit onderzoek zal ik mij vooral richten op hoe we de context of omgeving van de Cockpit kunnen verbeteren, daarom zullen wij niet specifiek op de inhoud van de cockpit ingaan. Dit houdt in dat we het niet gaan hebben over wat de Cockpit precies meet, maar bijvoorbeeld wel over uw ervaringen met het systeem in het algeheel.

Voorafgaand aan het onderzoek wil ik u eerst vragen het toestemmingsverklaringsformulier te ondertekenen. Door dit formulier te ondertekenen geeft u mij toestemming om alles wat u binnen dit gesprek verteld, te mogen gebruiken voor mijn onderzoek. Uiteraard zal ik uw gegevens anoniem verwerken, er zullen dus geen gegevens binnen het onderzoek verschijnen die naar u als persoon verwijzen. Als laatste geeft u door te tekenen ook toestemming voor het vocaal opnemen van dit gesprek. Deze opname zal uitsluitend gebruikt worden voor het onderzoek en na 1 jaar na afronding van het onderzoek verwijderd worden.

Als voor u alles duidelijk is, kunnen we beginnen met het interview. Indien er voor u nog iets onduidelijk is of als u nog vragen heeft kunt u deze nu stellen.

Om een indruk te krijgen van uw functie wil ik u de volgende algemene vragen stellen.

1. Algemene vragen

Wat is uw leeftijd? (*Geslacht zelf noteren)*

Wat is precies uw functie?

- *Wat voor werkzaamheden verricht u?*
- *Hoe bent u zo in deze functie terecht gekomen? (Bent u via iets anders hier gekomen/vooropleiding)*
- *Kunt u mij misschien een inschatting van hoeveel procent van uw tijd u stopt in de Cockpit?*

Hoe lang bent u al werkzaam binnen deze functie?

- *Hoeveel jaar binnen dit bedrijf/locatie*

De volgende onderdelen zullen gaan over de Cockpit. De Cockpit is een real-time feedback systeem. Dit betekent dat het direct feedback geeft op de OK-medewerkers over hun praktijk prestaties. Ik heb nu eerst een aantal vragen voor u over het gebruik van de Cockpit binnen jullie ziekenhuis.

2. De Cockpit – het gebruik

Sinds wanneer is de Cockpit in jullie ziekenhuis geïmplementeerd?

Op welke manieren gebruiken jullie de cockpit?

- *Hoe vaak (dag/week)*
- *Bij alle soorten operaties (of specifieke afdelingen?)*

Voor het volgende onderdeel wil ik u vragen terug te denken aan de weken vlak voor én na implementatie van de cockpit binnen jullie ziekenhuis. Dus het moment dat OK-medewerkers eigenlijk voor het eerst gingen werken met de Cockpit.

3. De Cockpit – terug in de tijd

Was u destijds betrokken bij de ontwikkeling en/of implementatie van de Cockpit?

- *Hoe? Waarom juist u (als in, uw functie)?*
- *En was u wellicht ook betrokken bij de ontwikkeling of implementatie van de analysetool achter de Cockpit?*

Is uw werkroutine verandert bij implementatie van de Cockpit?

- *Indien persoon niet zelf werkzaam is met Cockpit: En hoe is het werkroutine van bijv. OK-managers, assistenten, chirurgen etc. veranderd?*

Hoe werden OK-medewerkers destijds op de hoogte gebracht van hoe u de Cockpit moest gebruiken?

- *Door wie? (Door een leidinggevende/het ziekenhuis/NewCompliance)*
- *Hoe? (Uitgebreide voorlichting/zelf ontdekken etc.)*

Was het voor OK-medewerkers hierdoor meteen duidelijk hoe zij met het systeem moesten werken?

- *Zo niet, wat miste er voor hen?*
- *Hoe zou dit opgelost kunnen worden?*

Kunt u zich verder nog herinneren dat u of OK-medewerkers ergens tegenaan liepen in de periode rondom de implementatie van de cockpit?

- *Ontbrak er voor uw gevoel iets/was er iets onduidelijk?*
- *Wat zou eventueel kunnen helpen om dit op te lossen/voorkomen?*

Het laatste onderdeel zal gaan over de feedback van de Cockpit en de manier waarop jullie deze feedback verwerken of bespreken. Met feedback bedoel ik de scores en de kleuren die de Cockpit toont tijdens operaties.

4. De Cockpit – heden

De Cockpit geeft real-time feedback tijdens operaties, hoe is uw ervaring hiermee?

- *Vindt u het fijn dit van een systeem te ontvangen/liever collega's of leidinggevende?*

Bespreken jullie deze feedback ook nog op een ander moment?

- *Hoe gebruiken jullie de analyse-tool hiervoor (maken jullie grafieken etc.?/wie doet dat)*
- *Zijn hier periodiek vergadermomenten voor?*
- *Welke personen (functies) zijn hier dan aanwezig/bespreken feedback*
- *Zijn er nog andere manieren waarop de feedback aan de OK-medewerkers teruggekoppeld worden?*

Wat zijn volgens u de pluspunten van het systeem in het algemeen, en de manier waarop het feedback geeft?

- *Waarom?*

Zijn er op het gebied van feedback of feedbackverwerking misschien nog dingen waartegen u aanloopt op dit moment, die verbeterd zouden kunnen worden?

- *Analyseren van gegevens*
- *Terugkoppelen van informatie*
- *Uitleg over feedback → worden medewerkers voldoende toegelicht over feedback*
- *Aanspreekpunt voor feedback; is er iemand hiervoor verantwoordelijk?*
- *Invloed op relaties tussen collega's*
- *Betrokkenheid van alle werknemers (iedereen even betrokken)*

En dan nu eigenlijk de minpunten van het systeem. Heeft u het idee dat er iets mist in de huidige situatie, of op een manier gaat die niet wenselijk is?

- *Is er iets waarvan u vindt waar een effectief feedbacksysteem echt aan moet voldoen?*
- *Waarom?*
- *En voldoet de Cockpit aan alles wat u zegt?*
- *Hoe zouden we dit kunnen verbeteren/oplossen/voorkomen?*

Omdat u aangaf dat u …. mist/ondanks dat u aangaf niks te missen, denkt u dat er iets aangepast of toegevoegd moet worden in de omgeving van de Cockpit om het gebruik of de effecten van de cockpit te verbeteren? (werkelijke omgeving, voorlichting, scholing, etc.)

- *Waarom (wel/niet)?*

**Bonusvraag indien maar beperkte verbeterpunten worden genoemd tijdens interview*: U geeft aan dat u eigenlijk wel tevreden bent met hoe het systeem nu functioneert, zou u misschien ook kunnen aangeven waar een systeem volgens u echt wél of niet aan moet voldoen? Dit kan qua vormgeving of qua wijze van feedback geven? Kortom, wat zijn uw wensen of behoeftes.

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5. Afsluiting

U heeft alle vragen beantwoord, daarmee komen we aan het einde van ons gesprek. Zijn er nog dingen die wij niet besproken hebben, maar die u nog graag kwijt wil?

Ik wil u heel erg bedanken voor uw medewerking aan dit onderzoek.