Building an infrastructure to improve cardiac rehabilitation: from guidelines to audit and feedback
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SUMMARY AND GENERAL DISCUSSION
INTRODUCTION

The overall aim of this thesis was to use the principles of the Learning Health System (LHS) to realise an infrastructure to connect physicians, other health professionals, managers, professional associations, electronic patient record (EPR) developers, patients and researchers to continuously improve professional performance in the field of cardiac rehabilitation (CR) in the Netherlands. The infrastructure integrates both technical and organisational components. The technical components allow the co-use of data collected in the EPR with clinical decision support (CDS), and realise an audit and feedback (A&F) system. The organisational components concern the active involvement of all stakeholders to receive their necessary input and commitment for the optimal functioning of the technical infrastructure, and support services for multidisciplinary CR teams during outreach visits to actually use the A&F system and improve their performance by executing the LHS learning cycle (see Figure 1 in Chapter 1).

In the introduction in Chapter 1 we addressed three research aims; in this concluding chapter we will present a summary and discussion of the main findings for each research aim followed by our recommendations for researchers, decision-makers and other stakeholders from both inside and outside the field of CR.

RESULTS PER AIM

1) To assess current improvement challenges in the field of CR

Summary of main findings
Within the field of CR an EPR system with computerized clinical decision support (CDS) functionalities was previously developed to stimulate concordance with guideline recommendations for CR. In Chapter 2 we described the results of a qualitative study after the implementation of this system to assess reduced and persistent barriers for improvement [1]. We found that the CDS system improved guideline implementation by increasing its users’ familiarity with the recommendations and decision logic of the guidelines. Furthermore, by overcoming users’ inertia to previous practice, and reducing guideline complexity by for example facilitating assessment result calculation and interpretation, guideline adherence was improved. However, although the CDS has proven to be effective, implementation barriers related to a lack of time or resources, organisational constraints, and a lack of reimbursement in combination with guideline related barriers (e.g., ambiguities, omissions, and contradictions) were not solved by the CDS system implementation [1].

In Chapter 3 we designed a continuous improvement strategy directed at both organisational barriers and guideline related barriers identified in Chapter 2 [2]. Two learning cycles were designed to be embedded within computerized CDS in a continuous improvement strategy. First, to address barriers related to practicability of the underlying guidelines, a guideline-maintenance cycle was proposed. This cycle used routinely collected EPR data to serve as input for a guideline...
revision process. Second, barriers within teams and organisations were addressed by a benchmark-feedback cycle. Within this cycle, the EPR data was used to periodically aggregate performance feedback for professionals and their managers. A case study with 21 CR teams receiving one feedback iteration on their performance resulted in positive responses. Several centres reported that viewing personal performance within a context of peer performance together with their manager, was effective to create necessary facilities to improve their CR program. However, many centres found it difficult to make time to discuss the report [2].

Chapter 4 demonstrates that, among patients who were diagnosed with an acute coronary syndrome (ACS: myocardial infarction [MI] and unstable angina pectoris [AP]) and/or therapeutic intervention (coronary artery bypass graft surgery [CABG], percutaneous coronary interventions [PCI] or valve surgery), only 28.5% received CR within the following year [3]. Factors associated with low CR uptake included female gender, older age (70+), elective PCI as compared to acute PCI or CABG, unstable AP as compared to MI, long travelling distances to the nearest CR provider (>15 km), and comorbidities [3].

Discussion of main findings – continuously improving care by combining multiple interventions
The results of Chapter 2 suggest that a CDS system implementation alone is insufficient to realise changes in clinical practice that users consider beyond their tasks, influence, and responsibilities. This is in line with other studies, emphasising that many different types of barriers to guideline implementation exist and suggesting that improvement is possible, but generally requires comprehensive approaches at different levels (professional, team, organisation, wider environment), tailored to specific settings and target groups [4-6]. After the implementation of the CDS system tailored to improve knowledge and behaviour of the individual professional, we identified remaining barriers related to teams and organisations and the underlying guidelines (wider environment). However, there is limited evidence concerning which combination of strategies is effective under which circumstances [5, 6]. As the LHS principles emphasise the need of implementing simultaneous learning cycles across all levels in a health system, we developed two learning cycles (see Figure 1) which extend beyond the level of learning from the individual professional using CDS at the point of care. First, with the guideline-maintenance cycle (inner cycle in Figure 1) we aimed to implement a learning cycle for revising clinical guidelines by collecting EPR data from multiple centres (step 1), in a central data registry (step 2) to analyse compliance levels (step 3), which are combined with knowledge from professionals and domain experts (step 4), to formulate the revisions (step 5), and implement them through the knowledge base of the CDS system (step 6). Second, the benchmark-feedback cycle, focuses on improving an organisation’s underlying processes to overcome the identified barriers at the decision-making level of the team and organisation (outer cycle in Figure 1). Here the collected EPR data from multiple centres (step 1), that is available in the data registry (2), provides input for feedback reports with benchmark information (step 3), to steer discussions in team meetings, including managers (step 4), to formulate (step 5) and implement actions to improve care process and patient outcomes (step 6). A caveat of such a feedback approach,
revealed in the case study, was the assumption that a conferring structure with regular team meetings is present or realised at participating centres, to discuss the feedback and decide how to act upon it. Since such an organisational structure did not exist in several CR centres, these reports were simply not discussed, and as such, did not affect the clinical practice. To stimulate actual execution of the efferent steps from the LHS learning cycle, we proposed to extend our strategy with educational meetings as they are known to improve feedback effectiveness [7]. Furthermore, in our case study we only applied one feedback iteration; ongoing data collection and analyses are required for long-term efficacy assessment of our strategy, and guarantee continuous performance improvement over time.

Finally, Chapter 4 underlines the need for such instant improvement strategies, since we showed that only a minority of Dutch patients that are eligible for CR actually received it. These results were the reason for the Dutch Health Care Inspectorate to force CR centres to improve their performance by stimulating them to work with an EPR with CDS instead of paper-based records [10]. They emphasised the necessity of collecting digital EPR data from multiple centres as input for learning cycles and also to make e.g. CDS for automatic referral at discharge possible [10]. In addition, several CR professional associations, especially the Netherlands Society of Cardiology, recognized the need to update the guidelines and actively participated in the revision process [11]. They also stimulated their members to take part in the guideline-maintenance and benchmark-feedback learning cycles as we proposed. The collaboration with these national organisations appeared to be essential to convince CR centres to start working on improving their performance. Although not yet facilitated by a technical infrastructure, the data analysis and publication on CR uptake rates did in fact result in a first iteration of the CR uptake learning cycle (see Figure 2).
Figure 1 – Learning cycle of continuous improvement [8, 9] completed with the technical and organisational components of the infrastructure we developed for the guideline-maintenance cycle (inner cycle) and benchmark-feedback cycle (outer cycle) in the field of CR.
Figure 2 – Learning cycle of continuous improvement [8, 9] completed with the technical and organisational components of the infrastructure we developed to improve CR uptake rates.
Recommendations – to address multiple improvement challenges in the field of CR

We defined the following recommendations for national organisations, researchers and other stakeholders in the field of CR to address the improvement challenges from the first part of this thesis. The recommendations are based on the findings from Chapter 2, 3 and 4, their discussion within a wider context of the LHS principles, and our experiences during and after performing these studies. The recommendations might also serve as input to assess and start improvement upon challenges in other domains of health care.

- Based on the effect of computerized CDS on guideline concordance [12] by optimizing the knowledge and attitude of CR professionals [1], the use of CDS in the CR EPR should be continued and stimulated. As underlying guidelines and work processes of professionals may change over time, the EPR with CDS should regularly be updated by the developers, together with the users, to guarantee optimal use during daily care data collection and effect on care processes and patient outcomes in the future.

- After implementation of a guideline, regular analysis of implementation barriers should be performed, serving as input for a guideline-maintenance cycle to optimize concordance [2]. According to this learning cycle, CR guidelines should be regularly updated, using recent evidence from the literature, and experience from daily practice to overcome ambiguities, omissions and contradictions.

- An intervention with a continuous character [2] to engage CR teams, their managers and organisation in the learning cycle is expected to support them to understand and reduce persistent organisational barriers [1, 4] to improve professional performance.

- To overcome barriers for improvements within each domain of health care, collaboration with national organisations, like professional associations or the Health Care Inspectorate, can assist in gaining national attention. Data collection, analyses and publication is required to inform those organisations about current challenges, like our publication indicating low CR uptake rates [3]. Regular provision of information to, and communication with, national organisations should be performed to receive their commitment to collaborate in a learning cycle to solve the challenge.
2) To develop an infrastructure to facilitate continuous improvement

Summary of main findings

To facilitate continuous improvement in the field of CR we developed a multiple-component infrastructure which connects the stakeholders and fragmented repositories of data and knowledge. The four chapters in this part of the thesis each address a different component of the infrastructure, either technical, organisational or both, necessary to implement the guideline-maintenance cycle and benchmark-feedback cycle as designed in the previous part. According to the LHS principles, both cycles start with, and rely on routinely collected EPR data to generate new knowledge as an ongoing, natural by-product of the daily care process. This indicates complete and high quality EPR data on CR care processes and patient outcomes as an essential starting point.

In Chapter 5 we assessed and developed recommendations to improve the usability of the data entry interface in the current EPR for CR to optimize the data collection [13]. Figure 3 gives an overview of this separate learning cycle. Based on our results, the EPR developers organised the data entry navigational structure in the redesigned system version in a flexible way around an overview screen. This better mimics users’ former paper-based daily routines of collecting patient data. In the redesign we assessed that the changes had resulted in an increased number of completed data register tasks and a decrease in navigation actions. Remaining problems concerned flexibility (e.g. lack of customization options) and consistency (mainly with layout and position of items on the screen), indicating room for further improvement to minimize the data collection effort of professionals [13].

In Chapter 6 we implemented the guideline-maintenance cycle as proposed in Chapter 3. We revised the Dutch clinical CR algorithm, a practical procedure for assessing patient needs, to further improve guideline implementation [14]. We used a combination of the routinely collected EPR data, knowledge from academic experts and experience from field experts. A large variation in assessment of patient needs was observed between CR centres. The algorithm was extended with assessment instruments for anxiety and depression, cardiovascular risk factors, stress, absence of partner and lifestyle parameters (smoking, physical activity and alcohol consumption), and limits the option of using only clinical judgement to assess CRSP needs (e.g. only when a patient encounters language or cognition problems) [14].

To enable implementation of the benchmark-feedback cycle from Chapter 3, we developed a set of indicators to monitor and evaluate the quality of CR care in Chapter 7 [15]. These indicators were needed to support the data analysis and interpretation steps from the learning cycle, and had not yet been developed for CR care in the Netherlands. As we aimed to receive input from multiple sources and stakeholders, we combined strengths from multiple development methods. Using this comprehensive method, referred to as a modified Rand method [15], we combined results from a literature and guideline review with knowledge of an expert and patient panel in an extensive rating and consensus procedure. All sources contributed to the final set of 18 quality indicators for CR (e.g. including processes indicators like ‘Complete data collection during needs assessment’ and outcome indicators as ‘Successful smoking cessation’) [15].
Figure 3 – Learning cycle of continuous improvement [8, 9] completed with the technical and organisational components of the infrastructure we developed to improve data registration in CR EPR.
In Chapter 8 we developed an A&F system to implement the entire benchmark-feedback cycle from Chapter 3 to improve decision-making at the team and organisational level [16]. To facilitate all learning cycle steps, we developed a back-end system, which collects CR EPR data, to calculate results on the indicators from Chapter 7 and present them in an A&F system to deliver tailored messages and support action to change. In more detail, the A&F system, named CARDSS Online, promoted four tasks:

1) Monitoring clinical performance,
2) Selecting specific care processes and patient outcomes for improvement,
3) Goal setting and action planning, and
4) Revising selected processes and outcomes, goals and actions in the plan during follow-up iterations to guarantee a continuous character.

The system was designed to be primarily employed during quarterly outreach visits during where an external quality assessor met the centre’s local multidisciplinary team to support them continuing all steps of the learning cycle [16].

Discussion of main findings – the challenge of building an LHS infrastructure by involving multiple stakeholders

To develop an infrastructure which connects multiple stakeholders for continuous improvement of healthcare system, all of them should be willing to get involved, committed to the same goals and able to allocate dedicated resources. Unfortunately there is no handbook on how to recruit stakeholders with different interests and make them cooperate. To improve usability of data collection in the EPR for CR, which is essential to start a learning cycle, cooperation between the EPR developers, usability researchers and the first end-users from CR centres was required. Even after explicit commitment of the EPR team, due to unexpected technical difficulties as well as resource and time constraints, software iterations based on observed usability issues and final system implementation exceeded two years. After implementation of the redesigned EPR, we found that usability issues were solved but also that new usability issues were introduced. This indicates that the effort needed from CR professionals for data collection can still be further decreased during future iterations of the EPR usability learning cycle (see Figure 3). Using human centred design processes from the requirements phase on, is generally advised for development of all health information systems, including EPRs, but also applies to development of CDS and A&F systems [17].

During the revision of the CR guidelines, getting input of representatives of all professional associations involved in CR was also more time-consuming than anticipated. Although we tried to address as many barriers as we could identify from the compliance data and field experts, unavoidable compromises were necessary to complete the interpretation step of the learning cycle and reach consensus within the expert group. Furthermore, when the update of the guideline was finished, within a year new issues arose related to measures for the psychosocial assessment of the patient (e.g. to determine anxiety and depression, social support and expected problems during work resumption). In addition to a second iteration of
the guideline-maintenance cycle, resulting in the release of a second update, we underlined the need for a continuous guideline-maintenance cycle. However, as guideline updates in the field of CR are commonly financed by incidental grants, a continuous update process is difficult to achieve. When developing an LHS infrastructure it is essential to not only support national data collection, but also identify responsible organisations who have the funds to analyse the data and translate the results into clinical practice guidelines on a routine basis.

For the development of the indicator set to monitor and evaluate the quality of CR care, again we collaborated with an expert panel, complemented with a patient panel. Although we received detailed input from both stakeholders’ with respect to characteristics of quality of CR, not all characteristics could be included in our indicator set. For instance, indicators of long-term outcomes were not included simply because data of these outcomes was unavailable. For optimal use and interpretation of the results on a quality indicator set, professionals should be aware that indicators do not cover all aspects of the quality of health care. And, similarly to the guideline-maintenance cycle, preferably one organisation is responsible for regularly updating the indicator set in a indicator-maintenance cycle. Only then can up-to-date measures, which adequately represent care quality according to the latest guideline and knowledge from experts in the field, be guaranteed.

The developed A&F intervention, includes both technical (e.g. the data registry and web-based A&F system) and organisational components (e.g. outreach visits) to support all six steps of the iterative learning cycle. Although the first experiences with the system presented in Chapter 8 were promising, wider implementation and evaluation is required to assess whether actual improvements of clinical performance in a national setting can be realised (as we did in Chapter 11). Besides this quantitative information, the evaluation of A&F systems, like ours, should also take qualitative information into account (Chapter 12). Many context specific factors may influence the uptake of interventions in daily practice, e.g. organisation-professional processes such as culture and workflow. Information on these factors is usually not provided by quantitative studies [18]. Yet, information on such contextual factors, is essential both to interpret RCT results and to facilitate future implementation of improvement interventions.

A limitation of our A&F intervention is that improvement of CR uptake is not specifically addressed. In Chapter 4 we found this to be an important improvement challenge. However, although CR professionals recognized the importance of improving CR uptake, CR uptake was not adopted in the final quality indicator set. To gain insight into CR uptake at individual patient levels, information from departments outside the CR (e.g. the cardiology department) should be collected and analysed. The burden of gathering this necessary data to be included in our data registry was found too high within available resources of local CR teams. In addition, professional CR associations prepared other measures to increase CR uptake rates: a change in the national finance and declaration structure for CR and improving patient’s awareness on CR benefits (see Figure 3). The Netherlands Society of Cardiology (NVVC) actively contacted involved financial organisations to realise this reimbursement change. In 2014 the updated financial structure was introduced. The Cardiovascular Patients Organisation (H&V) developed new educational
materials to inform patients. Also these two associations, together with the Dutch Health Care Inspectorate, discussed the problem and possible solutions in national publications for both CR professionals (and patients), and on national meetings and congresses. As a result of this national awareness, CR teams often discussed improving CR uptake in their own institution during the outreach visits. Although not being part of presented feedback, goals and actions to improve uptake regularly ended up in the improvement plans. The current situation is that CR uptake rates are progressing steadily [19]. However, the issue needs ongoing national awareness to reach acceptable levels in the near future [20]. A future technical infrastructure including patient data on CR uptake in the EPR export to a central data registry can optimize the learning cycle to improve CR uptake (see the additions to step 2 and 3 in Figure 2).

**Recommendations – to build an infrastructure which stimulates improvement in continuous learning cycles**

We defined the following recommendations for researchers and decision-makers within the field of CR for instituting an infrastructure to stimulate improvement by continuous learning cycles. The recommendations can also be used within other fields of health care to build such an infrastructure. The recommendations are based on the findings from Chapter 5, 6, 7 and 8, their discussion within the wider context of the LHS principles and our experiences during and after performing these studies.

- Data collection is an essential first step of each learning cycle [9, 21]. To support high quality data collection as an ongoing, natural by-product of the care experience, the usability of EPR’s should be continuously optimized [13]. Therefore, collaboration between EPR developers, usability experts and end users should be organised in a learning cycle (see Figure 3). This process starts with the requirement phase and lasts until regular updates to solve remaining or new issues after implementation [13]. This recommendation can also be applied in a broader context towards optimizing the usability of other health information systems, e.g. CDS and A&F systems [17].

- When developing an LHS infrastructure it is essential to not only support national data collection but also to identify responsible organisation(s) who have the funds to analyse the data, interpret the results into knowledge and translate that knowledge into tailored messages in e.g. clinical practice guidelines [14] and accompanying quality indicators [15] on a routine base. The organisation should explicitly be capable to invite, motivate and collaborate with all stakeholders in this process [14, 15]. Without data analyses and tailored messages, the step to take action to improve practice is a difficult task for professionals collecting the data during their daily care routine [9, 21].

- To optimize the learning cycle to improve CR uptake, efforts from other stakeholders are needed since it is not specifically addressed in our A&F intervention. To obtain the necessary patient level data for analysis, collaboration between EPR developers, CR centres and the organisations they work within, and an analysing organisation is needed (see Figure 2). As long as patient level information is lacking, other national
sources (e.g. health insurance databases) can be used to provide realistic results on CR uptake in population based cohort studies to inform the CR uptake learning cycle [3, 19, 22].

3) To assess the effect of a web-based audit and feedback system with outreach visits on professional performance

Summary of main findings

The efferent side of our infrastructure supports the decision-making and taking action to change practice by multidisciplinary teams. To assess the effectiveness, we conducted a cluster-randomized trial in 18 CR centres with the web-based A&F system in combination with educational outreach visits. Chapter 9 describes the study protocol for this RCT [23] with details on the intervention and its rationale. The intervention is based on a combination of the framework of Cabana et al., defining internal and external barriers for guideline adherence [4], and the learning cycle from the Model for Improvement from Langley et al. [24]. All CR centres working with an EPR for CR with CDS during the needs assessment were able to participate in the study. Outcome measures of the study included improvement of professional performance; both measured as change on care processes and patient outcomes in the quality indicator set, and changes in concordance of the four CR therapies with guideline recommendations [23].

In Chapter 10 our preliminary results focus solely on the concordance with guideline recommendations [25]. No significant differences were found for any of the four CR therapies (education, physical exercise, lifestyle modification and relaxation) [25].

The final results in Chapter 11 describe all outcome measures [26]. During the trial a total of 233 quality improvement goals were identified by participating teams, of which 49 (21%) were achieved during the study period. Our intervention modestly increased data completeness in the CR EPR (4.5% improvement per year; 95% CI 0.65 to 8.36) and engaged teams to set improvement goals, but it yielded no improvement of clinical performance of multidisciplinary CR teams. No significant differences were found for any of the measured care processes and patient outcomes from the indicator set, or for concordance for the four CR therapies [26].

In Chapter 12 a concept mapping study among CR professionals, who participated in the trial, identified five thematic clusters with factors for successful implementation of an improvement intervention in a multidisciplinary setting [27]. While presence of a web-based A&F system and external quality assessor as used in the trial of Chapter 10, were seen as instrumental for gaining insight into clinical performance and formulating improvement actions, team commitment and organisational readiness were perceived as essential to actually implement and carry these actions out. Identified barriers relating to feasibility of the team commitment included: lack of mandate to carry out defined improvement actions; lack of an improvement coordinator who can motivate the team; and lack of commitment of all involved disciplines to carry out their own actions (especially the manager and cardiologist). Identified barriers related to feasibility of the own organisation included: lack of time and expertise with
data recording in recently implemented new CR EPR; lack of perceived commitment to improve CR from the hospital board and lack of time caused by e.g. a merger with another organisation or austerity measures [27].

Discussion of main findings – from setting improvement goals to completing the required actions

We found that our intervention successfully encouraged teams to define local performance improvement goals, but it largely failed to support them with actually completing the actions needed to achieve those goals: 79% of planned improvement actions remained uncompleted until the end of the study [26]. These results can be interpreted using Control Theory; an increasingly recognised theory in A&F literature that offers an explanation of how this feedback mechanism works [28]. This theory reveals two steps in the feedback mechanism essential to improve upon indicator results:

1) Healthcare professionals must recognise achievable room for improvement before setting improvement goals (e.g. develop intentions to change), and
2) They must formulate and actually perform effective improvement actions (e.g. translate intentions into actions) [28].

Combining Control Theory with the LHS learning cycle results in a specification of the ‘Take action to change practice’ step, in two separate steps: intention and actual action to change. Recently, we investigated the first step using data from our trial [29], showing that care processes and patient outcomes with more room for improvement (yellow or red icons) were more likely to be selected. Yet, in more than 25% of the cases professionals did not select indicators with obvious improvement opportunities, or selected indicators without apparent improvement opportunity (green icon) because they disagreed with benchmarks, deemed improvement unfeasible, or did not consider the indicator an essential aspect of care quality. These phenomena impede intentions to improve practice, and are thus likely to have diluted our A&F intervention.

To improve the translation of intention to change into effective actions, previous research [30-33] suggest that failures to complete improvement actions may be due to a lack of organisational support, e.g. competing priorities, or due to a shortage of individual skills or knowledge, e.g. to translate population-level quality targets into effective improvement actions in local clinical practice. These suggestions are reinforced with the results of our concept mapping study [27], indicating organisational readiness and team commitment as most important factors to actual achieve change; however indicating low feasibility of especially organisational readiness in the participating centres during our trial. As proposed by other authors [30, 34], extending our intervention with ready-to-use improvement tools could likely have addressed some of the barriers. The few A&F studies that incorporated such support did this in various ways. For instance, through facilitated group discussions to reflect upon the feedback and identify improvement strategies [35], or by including suggestions in the feedback reports for how to address deficiencies in practice [36]. Specific suggestions and practical tools for improvement might have assisted the improvement teams in effectively translating
their improvement intentions into action. However, as the surplus value of adding supportive improvement tools to A&F interventions has not yet been investigated, this should be a focus of future research.

In addition, other theoretical, more socio-technical frameworks have recently been proposed to design and evaluate A&F interventions, such as the Triangle Model [37], Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS) framework [38], the Systems Engineering Initiative for Patient Safety (SEIPS) model [39] and the 8-dimension socio-technical model [40]. Such socio-technical models typically approach the implementation process as consisting of multiple components that continuously interact with and change each other, including people, teams, tasks, tools and technologies, underlying organisational conditions, and the surrounding context. For example, the TeamSTEPPS framework [38] emphasises that a thorough needs analysis should be performed to determine organisational readiness before initiating change. This might uncover underlying issues within the institution (e.g. equipment problems or staffing shortages) which first should be resolved to make the improvement effort succeed [38]. In addition, the SEIPS model [39] focusses on system design and its impact on processes and outcomes. This model describes how all the interacting components should be addressed to understand how they are related to each other and affect both work (e.g. maintenance and supply chain management) and clinical (e.g. direct patient care) processes; as these two processes in turn influence the patient, employee, and organisational outcomes of care [39]. To address the socio-technical complexity of an implementation process and its effectiveness, future studies could consider using the suggested models as the underlying theoretical framework to guide the development, implementation and evaluation of A&F interventions.

**Recommendations – to increase the impact of A&F interventions on professional performance**

We defined the following recommendations for researchers within the field on A&F on how the impact A&F interventions on professional performance might be improved in future research. The recommendations are based on the findings from Chapter 9, 10, 11 and 12, our experiences during these studies and the discussion of the results within the broader context of both the principles from the LHS and Control Theory. Researchers, decision-makers and other stakeholders from the field of CR can use the recommendations to stimulate further improvement of CR professionals’ performance.

- Future A&F studies should focus on individually addressing the ‘Develop intention to change’ and ‘Translate intentions into actions’ steps as revealed by Control Theory [28], during the ‘Take action to change practice’ step from the LHS learning cycle (specification of step 6). When doing so in both the design and evaluation of their interventions, further insights can be gained into which interventions influence each step of the feedback mechanism.
- As the surplus value of adding supportive improvement tools to A&F interventions on improving professionals skills and knowledge on how to translate intentions
into effective actions has not yet been investigated, this should be a focus of future research.
- To address complexity within an implementation process consisting of multiple components that continuously interact with and change each other, future studies could consider using socio-technical models [37-40] as the underlying theoretical framework to guide the development, implementation and evaluation of A&F interventions.

CONCLUSION

The work in this thesis shows how we build a LHS principles based infrastructure to improve professional performance in multiple continuous learning cycles. In our conclusion we state that in order to be effective such an infrastructure needs to successfully:

a) Aid professionals to collect (step 1 of the learning cycle) and assemble (step 2) data as an ongoing, natural by-product of the care experience, to gain knowledge (step 3) and make accurate self-assessments of their clinical performance (step 4),
b) Deliver tailored messages (step 5) to create adequate intentions among professionals to improve their practice where it does not meet the standard (first step feedback mechanism, specification of step 6), and
c) Provide professionals with the necessary skills and knowledge to start and actual achieve effective improvement actions (second step feedback mechanism, specification of step 6).

For each of these steps all involved stakeholders should be willing to get involved, committed to the same goals, and be able to allocate dedicated resources to guarantee continuous improvement by the infrastructure over time. Such an infrastructure must be systematically planned, unanimously governed, and reciprocal for all involved stakeholders.

During the development of our infrastructure to improve professional performance in the field of CR, we successfully assembled routinely collected EPR in a central data registry. We also succeeded in connecting with multiple stakeholders to translate the data into knowledge and tailored messages. We did so both on a national level in a guideline-maintenance cycle, and on a centre level with the web-based A&F system and the educational outreach visits. Concerning the final step of the learning cycle, our A&F intervention engaged teams to define local performance improvement goals, but failed to support them in actually completing the improvement actions required to achieve those goals. Future research should therefore focus on improving the actionability of feedback on clinical performance, and on more extensively addressing the socio-technical context during the development, implementation and evaluation of A&F interventions.
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