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From in-silico to in-reality: the value of simulation to healthcare improvement

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TITLE PAGE

Title

From in-silico to in-reality: the value of simulation to healthcare improvement

Authors

Helena Hvitfeldt-Forsberg*, PhD. Department of Learning, Informatics, Management and Ethics, Medical Management Centre, Karolinska Institutet, Tomtebodavägen 18A, 17177, Stockholm, Sweden. E-mail: helena.hvitfeldt.forsberg@ki.se; Telephone number: 0046 852483783

Pamela Mazzocato PhD. Department of Learning Informatics Management and Ethics and Medical Management Center (MMC), Karolinska Institutet, Stockholm, Sweden.

Daniel Glaser MSc, Department of Learning Informatics Management and Ethics and Medical Management Center (MMC), Karolinska Institutet, Stockholm, Sweden.

Christina Keller PhD. Department of Informatics, Jönköping, International Business School, Jönköping, Sweden.

Maria Unbeck RN, PhD. Department of Orthopedics, Danderyd Hospital, Stockholm, Department of Clinical Sciences, Danderyd Hospital, Karolinska Institutet, Stockholm, Sweden.

*Corresponding author: Helena Hvitfeldt Forsberg.

Keywords

Simulation modeling, healthcare improvement, focus group, rheumatology, orthopedic care, emergency care.

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3153.

Abstract

Objectives

To explore healthcare staffs' and managers' perceptions of how and when simulation modeling can be used as a decision support in improvement efforts.

Design

Two focus group discussions were performed.

Setting

Two contexts were included; a rheumatology department and an orthopedic section both situated in Sweden.

Participants

Healthcare staff and managers from the two contexts (n=14).

Interventions

Two workshops were performed, one at each setting. Workshops were initiated by a short introduction to simulation modeling. Results from the respective simulation model were then presented and discussed in the following focus group discussion.

Main outcome measures

The outcome measures were how and when simulation modeling could be used as a decision support in improvement efforts.

Results

Categories from the content analysis are presented according to the research questions how and when simulation modeling can assist healthcare improvement. Regarding how, the participants mentioned that simulation modeling can act as a tool for support and a way to

visualize problems, potential solutions and their effects. Simulation modeling was considered to possibly be used both locally and by management and as a pedagogical tool to develop and test innovative ideas and to get everyone involved in the improvement work.

Conclusions

The potential as an information- and communication tool and as an instrument for pedagogic work within healthcare improvement render a broader application and value of simulation modeling than previously reported.

Strengths and limitations of this study

- The focus group discussions were conducted in close connection to real healthcare improvement efforts in two different settings.
- This is one of the few studies studying the value of simulation modelling to healthcare improvement.
- We draw conclusions from limited empirical data gathered from two FGDs only. Nevertheless, an exploratory study like this could serve as a pilot for further similar research.

Introduction

Healthcare improvement can be defined as joint efforts to improve patients' health, healthcare operations and staff development [1]. The complexity of healthcare improvement includes for example the size and scope of the initiative and the numerous contextual factors which have made the outcomes of healthcare quality improvement to be questioned [2-4]. Improvement work often builds on testing changes, initially in small scale, to build knowledge on how changes are implemented and affecting practice [5-6]. This strategy may make it difficult to predict outcomes not in close connection in time or space [7].

Simulation modeling of healthcare systems and processes has been proved as a valid tool to attend to problems in healthcare such as resource allocation, patient flows, epidemiological concerns and utilization of resources [8-12].

All types of simulation aim to imitate reality to test, educate and learn. Regardless of the many models developed to elucidate important healthcare related issues, there is little research concerning the use, implementation and value of simulation in the everyday context of healthcare, in reality [13-15]. However, research has shown that simulation modeling can enable informed decisions, develop system knowledge, determine critical factors for the development of an organization, supply scenario analysis and options to choose from, help understand complex problems, facilitate communication and form plans and directions for future work [11]. More research is needed to fully understand the impact of simulation modeling in the improvement of healthcare [8, 12, 14, 15].

Aim

The aim of this study was to explore healthcare staffs' and managers' perceptions of how and when simulation modeling can be used as a decision support in improvement efforts.

Method

Study design and setting

A qualitative study design was chosen to explore healthcare staffs' and managers' perceptions of simulation modeling in two healthcare organizations: a rheumatology department and an orthopedic section at a central surgical unit (including the Orthopedic department, the Anesthetic and Intensive care unit department, and the Surgical and Urological department) further referred to as orthopedic section. The two units were part of two hospitals located in two different county councils in Sweden. An overview of the two organizational settings is presented in Table 1.

[INSERT TABLE 1 HERE]

Table 1. Overview of the included organizational settings

Cases	Activity data	Hospital setting
Rheumatology department	1,400 new referrals and 6,000 outpatient visits per year.	Publicly owned and financed county hospital with 2,300 employees. The hospital serves a population of 270,000 inhabitants.
Orthopedic section	In total 10,574 surgeries were performed at the central surgical unit in 2014 of which 4,512 were orthopedic surgeries (2,230 emergency and 2,282 elective surgeries) and 653 hip fracture surgeries.	Publicly owned and financed university hospital with 3,700 employees and has a catchment area of approximately 500,000 inhabitants.

The Regional Ethics Committee in Stockholm has granted ethical approval for the study.

Study participants

Purposeful sampling was used to select the study participants. Thus, healthcare staff and managers involved in the ongoing improvement efforts were deemed suitable to participate in this study because of their knowledge of the routines and needs of the organizations. Study participants were contacted via telephone and e-mail. Nine employees at the rheumatology

department were invited. Of those, seven agreed to participate in the study. Two declined the invitation due to time constraints. At the orthopedic section, eight employees were invited. Of those, seven accepted the invitation, and one of those had a late cancellation due to acute illness and one declined due to a planned vacation. An overview of the study participants is presented in table 2.

[INSERT TABLE 2 HERE]

Table 2. Study participants

Case	Professional background and organizational role
Rheumatology department	Four specialists in rheumatology and three registered nurses. Of those, one was a nurse manager and one the head of the department.
Orthopedic section	One orthopedic surgeon (also head of the trauma section at the Orthopedic department) and five registered nurses of whom two were nurse managers and one a section leader.

Data collection

Data was collected through two focus group discussions (FGDs) at the two units. Focus groups can be defined as organized interactive group discussions that aim to explore a certain topic [16]. The method was chosen since focus groups are very suitable when investigating experiences, attitudes and emerging ideas from a group [17-18]. According to Morgan [19, p. 2], "the hallmark of focus groups is their explicit use of group interaction to produce data and insights that would be less accessible without the interaction found in the group."

For both cases, customized simulation models were developed by the research team to address the units' specific needs. At the rheumatology department improvement efforts aimed to improve the referral process for newly diagnosed patients. At the orthopedic section improvement efforts aimed to improve access to care for patients with hip-fracture.

The process of developing the two simulation models was somewhat different in the two cases. In the rheumatology case, the participants were introduced to the simulation model at a workshop where they had the opportunity to test the model and its included variables. Immediately after the workshop, the FGD was performed.

In the orthopedic case, the participants were included in the building and validation of the simulation model during several meetings. The workshop and FGD were held at the end of the project time.

In both cases, the workshops were initiated by a short introduction to simulation modeling. The researchers then presented the findings of the simulation model and led the FGDs discussion on how and when simulation modeling could be used as a decision support in improvement efforts.

The FGD was conducted at the respective unit during one hour and two researchers acted as moderators (CK and HHF in the rheumatology case and HHF and PM in the orthopedic case). One of the two researches moderating the FGDs led the discussion and the other took notes and asked follow-up questions. The interviews were also recorded.

The FGDs were initiated by asking all participants to comment briefly on their experience of the simulation model and their work with their specific questions. This ensured that all participants got a chance to talk and for the recordings to represent each participant. Following this start, the contents of the moderators' guide of questions guided the rest of the FGD. The following themes were included in the moderator's guide:

- The experience of using the simulation model and the results.
- What problems/issues/questions are suitable to address with simulation modeling in healthcare?

- How can simulation modeling connect to improvement work?
- What are the value and trustworthiness of simulation modeling?

Data analysis

The FGDs were transcribed verbatim by transcribers. The transcripts were analyzed using qualitative content analysis. Content analysis is commonly used in social sciences [20] and is a systematic analysis of text [21]. Two researchers (HHF and PM) conducted the coding and categorization together following the three general steps of performing content analysis outlined by Graneheim and Lundman [22]. The transcripts were first read through before meaning units were extracted and coded, and finally the codes were organized into categories. Each step was performed individually and were then reviewed and discussed, ending up in consensus.

Findings

Results presented below are organized according to the different categories derived from the qualitative content analysis.

When can simulation modeling be used

Improvement support

Simulation was described by the FGD participants as a tool that could be used to motivate the need to implement certain changes both for staff and for management. This included also changes that are difficult to motivate either due to budget constraints, big investments or changes that have been tried before and that staff didn't believe in. Simulation modeling can support by visualizing both problems and potential solutions. Simulation completes the picture of only financial or process aspects by visualizing effects that are different dimensions of the same change.

Test and evaluate ideas for improvement

Participants expressed repeatedly in both FGDs that simulation modeling can be used to evaluate the effect of changes that have either been implemented or that are under development or at an idea stage. Simulation modeling was considered a quicker and more efficient ways to test ideas of changes not yet implemented compared to testing in reality. Furthermore, changes can be tested without influencing patient care.

"It is exciting to be able to test a hypothesis in a computer environment to see what results you can anticipate. It is often difficult to test changes in real life, it takes time, costs money and results are sometimes uncertain".

Participants emphasized that simulation modeling can be a way to more systematically test change ideas and evaluating them, rather than just implementing changes without follow up. Furthermore, they expressed that the model can be a pedagogical tool to develop and test ideas that can help staff getting engaged and involved in the improvement work.

"A pedagogical tool to use in our work team in improvement work. By thinking that nothing is forbidden to suggest, we can test many different things and start thinking outside the box. It is so easy to get stuck in patterns".

Testing of ideas got some of the participants to think about existing work routines and new improvement ideas were created and previous ideas were rejected.

"We thought that if we just had more rooms, all our problems would go away. But we saw no substantial change when we tested it in the model. It all depends on the number of doctors that are available after all, that is the answer we got. We even saw that, right now, we are not using all the rooms efficiently".

How can simulation modeling be used

Questions suitable for simulation modeling

Simulation modeling can be used to address concrete and measureable questions such as for planning, resource allocation and staff scheduling. One area of application that was raised several times during the FGDs was related to cost efficiency.

"The future will be more about budgets and finances due to our expensive treatments. This [simulation model] can be a way to present financial figures to the management".

"It is easier to connect numbers with a cause rather than to just talk about the cause itself".

This includes showing the cost efficiency of changes implemented and to make staff more aware of costs related to certain operations. Further on, it can be used to find ways to use resources in a more efficient way.

Validity

Participants expressed the importance of building the model on valid and reliable data. Using incorrect data or data in an incorrect way will undermine the simulation model and the staff´s trust in the model. The simulation model must reflect the organization and real processes and data. Input from staff is important to ensure the validity of the model as they are the ones with knowledge of processes and operations.

"The method is fine, the difficult part is what you put into the model"

Participants stressed that in order to use any simulation model, it is important that all processes and logics incorporated in the model are well known to the user. This is to prevent from misinterpreting model output and results. Relying on and trusting the model requires a deep and profound understanding of the model and participation during the process of building the model.

"Users must be familiar with the model in order to critically evaluate results. [It's] dangerous if results are interpreted in the wrong way".

Conducting simulation modeling projects

Results from the FGDs revealed two aspects of use of simulation modeling; local use at the clinic in their improvement work and to guide management on planned changes or responses to changes suggested by management. Staff must be involved from the beginning to inform the building of the model with data and questions to test in the model. Involving staff from the beginning is important to develop trust for the simulation model.

"A simulation project must be approved by management and well supported by the staff".

"In improvement work, involvement from everyone is essential, perhaps simulation modeling can act as a tool to inform and inspire colleagues".

Simulation modeling projects must be approved by management and staff and be well communicated within the organization. The group working with the simulation model cannot be too big and there must be a person in charge of the work. The importance of using the simulation model together, in multi-disciplinary teams, was emphasized. Specific persons holding positions, such as schedulers, nurse managers and heads of departments, were mentioned as potential users.

"Simulation modeling should be used locally, at our clinic and by us. It should be used to show how we work and our results, at meetings and externally as marketing".

"A good tool to show management what we do and our plans".

Value and opportunities

Participants expressed an overall positive attitude towards simulation modeling. They identified different opportunities where simulation modeling can add value to the

development of their organization. These include identifying trends and understanding complex relationships between processes and systems. Moreover, simulation can help to face future challenges.

"Simulation modeling at the right time can be very valuable, when initiating improvement it is beneficial to see how small changes can have great effects".

"You get an overview, you see the overall picture that can be used to stimulate improvement work".

"Simulation modeling can help you find new models and aid the individual learning when seeing the relation to their respective work. To the organization it might be more on how to accomplish goals and see how the overall picture is affected?"

Discussion

This study set out to explore healthcare staffs' and managers' perceptions of how and when simulation modeling can be used as a decision support in improvement efforts. Simulation was described as a tool that could be used to evaluate and develop improvement ideas and help motivate the need to implement certain changes both for staff and for management. Also, simulation modeling can motivate difficult change, visualizing effects and also financial aspects. Simulation modeling was best valued to address concrete and measureable questions such as for planning, resource allocation, staff scheduling and cost efficiency. Two areas of use of simulation modeling in healthcare improvement were stressed in the two focus groups: locally in the clinical improvement work and to guide management on planned changes or responses and effects to changes suggested by management. The early involvement of staff in the simulation project and use of correct data to validate the model is crucial to staff to trust and use the model.

When comparing the results to previous literature, there are several evident similarities. Concerning the potential users of the simulation model, at the clinical level or in management, it is important to consider model knowledge and the ability to present it to others, data availability and support from leadership [14]. Regarding the testing part and exploring what is outside of the box, Pidd describes simulation as a vehicle for experimentation where trial and error can be performed without concerns for reality but with a great opportunity to learn [23]. Simulation modeling offers a holistic view on addressing change and improvement in complex systems and its inherent components by displaying the effects of change immediately [7]. Visualizing the problem and a potential solution was, in the FGDs, considered powerful in engaging healthcare staff in improvement work. This interactive opportunity has been proposed to make staff more willing to embrace change [7]. However, the formation of a representable clinical team to involve in the simulation modeling work is not always easy [15]. Our first simulation focus group revealed the responders wish to include management and the second focus group wanted to include the staff further. Co-producing the model with staff, managers and modelers are important to build a step by step understanding of the model logic and its validity [23-27]. Depending on the identified users, simulation models can be used to aid communication in creating a shared mental model [25, 28-30].

Drawing from our results we can see values emerging from simulation modeling as a way to work with change and improvement, especially when initiating improvement work, a way to visually communicate planned changes and operations and subsequent consequences. Simulation modeling can be a tool to be used at different levels of healthcare but according to our findings it might suit best at the local clinical improvement and for management planning and allocating resources. Before initiating a simulation modeling project, the formation of the project team is essential to ensure model validity and reliability. Bringing in the aspects of

implementation, evaluation and research requires even greater consideration of the project team but might enable the transition from in-silico to in-reality and create value for the health care organization.

Limitations in our design regard the fact that we draw conclusions from limited empirical data gathered from two FGDs only. Nevertheless, an exploratory study like this could serve as a pilot for further similar research. FGDs themselves can be subject to different impediments if not moderated well. The group dynamics are essential and allowing everyone to talk and present their opinion [17, 31, 32]. Using a moderator's guide and introductory questions for everyone to answer may have facilitated the FGDs.

Conclusions

The emerging categories from the content analysis are presented according to the research questions how and when simulation modeling can assist healthcare improvement. Regarding how, the participants mentioned that simulation modeling can act as a tool for support and a way to visualize problems and potential solutions, as an information- and communication tool to show management planned improvements and their effect. Simulation modeling was considered to possibly be used both locally and by management, but the user should be familiar with model logic and data to interpret results correctly. Relating to when, participants thought simulation modeling could be used as a pedagogical tool to develop and test ideas, to think outside the box and to get everyone involved in the improvement work.

This study showed that simulation modeling has more to offer than has previously been described in the literature. The potential as an information- and communication tool, as an instrument for pedagogic work within healthcare improvement and allowing thinking outside the box render a broader application and value of simulation modeling.

Contributorship statement

HHF, PM, MU, DG and CK designed the study. HHF, PM, MU and CK collected the data. HHF, MU, PM and CK drafted the manuscript. Everyone have been involved in reading and critically revising the manuscript. All authors approved the final manuscript and are accountable for all parts of the work.

Competing Interests

The authors declare that they have no competing interests.

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Data sharing statement

FGD moderators guide are available upon request to the authors.

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Section	Topic	Item	Where in the article the item is addressed
Title abstract			
	Title	Concise description of the nature and topic of the study Identifying the study as qualitative or indicating the approach (e.g., ethnography, grounded theory) or data collection methods (e.g., interview, focus group) is recommended	The title meets these criteria, see page 1.
	Abstract	Summary of key elements of the study using the abstract format of the intended publication; typically includes background, purpose, methods, results, and conclusions	Done, see pages 2-3.
Introduction			
	Problem formulation	Description and significance of the problem/phenomenon studied; review of relevant theory and empirical work; problem statement	Addressed in the last section in the introduction, see page 4.
	Purpose or research question	Purpose of the study and specific objectives or questions	See Aim in the paragraph in the intro page 4.
Methods			
	Qualitative approach and research paradigm	Qualitative approach (e.g., ethnography, grounded theory, case study, phenomenology, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g., postpositivist, constructivist/interpretivist) is also recommended;	Qualitative content analysis was explained and motivated, see pages 5 and 8.
	Researcher characteristics and reflexivity	Researchers' characteristics that may influence the research, including personal attributes, qualifications/experience, relationship with participants, assumptions, and/or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results, and/or transferability	No specifically characteristics addressed.
	Context	Setting/site and salient contextual factors;	See "Study design and setting" section in the methods, pages 5-6.
	Sampling strategy	How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g., sampling saturation);	Second paragraph in the methods section, pages 5-6
	Ethical issues pertaining to human subjects	Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues	Last sentence in the first paragraph of the methods section, page 5.
	Data collection methods	Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of data collection and analysis, iterative process, triangulation of sources/methods,	See "Data collection section in methods, page 6.

		and modification of procedures in response to evolving study findings; rationaleb	
	Data collection instruments and technologies	Description of instruments (e.g., interview guides, questionnaires) and devices (e.g., audio recorders) used for data collection; if/how the instrument(s) changed over the course of the study	Last paragraph in "Data collection" section, page 7.
	Units of study	Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)	See "Study participants" in the methods section, page 5-6.
	Data processing	Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and anonymization/deidentification of excerpts	See "Data Analysis" in the methods section, page 8.
	Data analysis	Process by which inferences, themes, etc., were identified and developed, including the researchers involved in data analysis; usually references a specific paradigm or approach; rationale b	Last three sentences in "Data Analysis" in the methods section, page 8.
	Techniques to enhance trustworthiness	Techniques to enhance trustworthiness and credibility of data analysis (e.g., member checking, audit trail, triangulation); rationaleb	See "Data Analysis" in the methods section, page 8.
Results/findings			
	Synthesis and interpretation	Main findings (e.g., interpretations, inferences, and themes); might include development of a theory or model, or integration with prior research or theory	Yes.
	Links to empirical data	Evidence (e.g., quotes, field notes, text excerpts, photographs) to substantiate analytic findings	Examples of from the data analyzed are reported throughout the findings section, pages 8-12.
Discussion			
	Integration with prior work, implications, transferability, and contribution(s) to the field	Short summary of main findings; explanation of how findings and conclusions connect to, support, elaborate on, or challenge conclusions of earlier scholarship; discussion of scope of application/ generalizability; identification of unique contribution(s) to scholarship in a discipline or field	Yes, throughout the discussion, pages 12-14.
	Limitations	Trustworthiness and limitations of findings	Yes, see last paragraph in the discussion, page 14.
Other			

	Conflicts of interest	Potential sources of influence or perceived influence on study conduct and conclusions; how these were managed	Conflicts of interest statement included in the article, page 15.
	Funding	Sources of funding and other support; role of funders in data collection, interpretation, and reporting	Funding sources have been mentioned, page 15.

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Staffs' and managers' perceptions of how and when discrete event simulation modeling can be used as a decision support in quality improvement: a focus group discussion study at two hospital settings in Sweden

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Authors

Helena Hvitfeldt-Forsberg*, PhD. Department of Learning, Informatics, Management and Ethics, Medical Management Centre, Karolinska Institutet, Tomtebodavägen 18A, 17177, Stockholm, Sweden. E-mail: helena.hvitfeldt.forsberg@ki.se; Telephone number: 0046 852483783

Pamela Mazzocato PhD. Department of Learning Informatics Management and Ethics and Medical Management Center (MMC), Karolinska Institutet, Stockholm, Sweden.

Daniel Glaser MSc, Department of Learning Informatics Management and Ethics and Medical Management Center (MMC), Karolinska Institutet, Stockholm, Sweden.

Christina Keller PhD. Department of Informatics, Jönköping, International Business School, Jönköping, Sweden.

Maria Unbeck RN, PhD. Department of Orthopedics, Danderyd Hospital, Stockholm, Department of Clinical Sciences, Danderyd Hospital, Karolinska Institutet, Stockholm, Sweden.

*Corresponding author: Helena Hvitfeldt Forsberg.

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Simulation modeling, healthcare improvement, focus group, rheumatology, orthopedic care, emergency care.

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3200 excluding title page, abstract, strengths and limitations section, tables and references.

Abstract

Objective

To explore healthcare staffs' and managers' perceptions of how and when discrete event simulation modeling can be used as a decision support in improvement efforts.

Design

Two focus group discussions were performed.

Setting

Two settings were included: a rheumatology department and an orthopedic section both situated in Sweden.

Participants

Healthcare staff and managers (n=13) from the two settings.

Interventions

Two workshops were performed, one at each setting. Workshops were initiated by a short introduction to simulation modeling. Results from the respective simulation model were then presented and discussed in the following focus group discussion.

Results

Categories from the content analysis are presented according to the following research questions: how and when simulation modeling can assist healthcare improvement? Regarding how, the participants mentioned that simulation modeling could act as a tool for support and a way to visualize problems, potential solutions and their effects. Regarding when, simulation modeling could be used both locally and by management, as well as a pedagogical tool to develop and test innovative ideas and to involve everyone in the improvement work.

Conclusions

Its potential as an information and communication tool and as an instrument for pedagogic work within healthcare improvement render a broader application and value of simulation modeling than previously reported.

Strengths and limitations of this study

- Customized simulation models were developed by the research team to address the specific needs of two hospital settings.
- Focus group discussions were conducted in close connection to real healthcare improvement efforts.
- The trustworthiness of the findings was strengthened by the fact that trained facilitators conducted the focus group and used a moderator guide, and that two researchers conducted the qualitative analysis.
- The study includes two clinical settings, which limit the transferability of the findings.

Introduction

Healthcare improvement can be defined as joint efforts to improve patients' health, healthcare operations and staff development.[1] The complexity of healthcare improvement includes the size and scope of the initiative and the numerous contextual factors, which have caused the outcomes of healthcare quality improvement to be questioned.[2-4] Improvement work often builds on testing changes, initially on a small scale, to foster knowledge of how changes are implemented and affecting practice.[5-6] This strategy may make it difficult to predict outcomes not in close connection in time or space.[7]

Computer simulation modeling, such as discrete event simulation of healthcare systems and processes, has been proved as a valid tool for attending to problems in healthcare such as resource allocation, patient flows, epidemiological concerns and utilization of resources.[8-12]

All types of simulation aim to imitate reality in order to test, educate and increase learning. Regardless of the many models developed to elucidate important healthcare related issues, little research has been done on the use, implementation and value of simulation in the everyday context of healthcare.[13-15] However, research has shown that simulation modeling can enable informed decision-making, develop system knowledge, determine critical factors for the development of an organization, supply scenario analysis and options to choose from, help understand complex problems, facilitate communication and form plans and directions for future work.[11 16]

In the context of healthcare improvement, simulation modeling can help generate not only diagnostic data, but also knowledge and perspectives that can lead to predictive capacity.[7] Even so, the uptake of simulation modeling and other operation research tools have been slow in healthcare rendering few actual model implementation cases to learn from.[13] More research is needed to fully understand the impact and value of simulation modeling on the improvement of healthcare.[8 12 14 15]

The aim of this study was to explore healthcare staffs' and managers' perceptions of how and when discrete event simulation modeling can be used as a decision support in improvement efforts.

Method

Study design and setting

A qualitative study design was chosen to explore healthcare staffs' and managers' perceptions of discrete event simulation modeling, hereafter called simulation modeling, in two healthcare organizations: a rheumatology department and an orthopedic section at a central surgical unit (which includes an orthopedic department, an anesthetic and intensive care unit, and a surgical and urological department). The two units were part of two hospitals located in two different county councils in Sweden. An overview of the two organizational settings is presented in Table 1.

Table 1 Overview of the included organizational settings

Cases	Activity data	Hospital setting
Rheumatology department	1,400 new referrals and 6,000 outpatient visits per year	Publicly owned and financed county hospital with 2,300 employees. The hospital serves a population of 270,000 inhabitants.
Orthopedic section	In total, 10,574 surgeries were performed at the central surgical unit in 2014, of which 4,512 were orthopedic surgeries (2,230 emergency and 2,282 elective surgeries) and 653 hip fracture surgeries.	Publicly owned and financed university hospital with 3,700 employees, and which has a catchment area of approximately 500,000 inhabitants.

The Regional Ethics Committee in Stockholm has granted ethical approval for the study.

Study participants

Purposeful sampling was used to select the study participants. Thus, all healthcare staff and managers involved in the project groups of the respective ongoing improvement efforts were deemed suitable to participate in this study because of their knowledge of the routines and needs of the organizations. All potential study participants were contacted via telephone and e-mail. Nine employees at the rheumatology department were invited. Of those, seven agreed to participate in the study. Two declined the invitation due to time constraints. At the orthopedic section, eight employees were invited. Of those, seven accepted the invitation, and one of those had a late cancellation due to acute illness and one declined due to a planned vacation. An overview of the study participants is presented in Table 2.

Table 2 Study participants

Case	Professional background and organizational role
Rheumatology department	Four specialists in rheumatology and three registered nurses. One participant was a nurse manager and one the head of the department.
Orthopedic section	One orthopedic surgeon (also head of the trauma section at the orthopedic department) and five registered nurses, of whom two were nurse managers and one a section leader.

Data collection

Data was collected through two focus group discussions (FGDs) at the two units. Focus groups can be defined as organized, interactive group discussions that aim to explore a certain topic.[17] The method was chosen because focus groups are quite suitable when investigating experiences, attitudes and emerging ideas from a group.[18-19] According to Morgan,[20, p. 2] "the hallmark of focus groups is their explicit use of group interaction to produce data and insights that would be less accessible without the interaction found in the group."

For both cases, customized simulation models were developed by the research team to address the units' specific needs. At the rheumatology department, improvement efforts aimed to improve the referral process for newly diagnosed patients. At the orthopedic section, improvement efforts aimed to improve access to care for patients with hip-fracture. Both contexts had previous research and improvement collaborations with the authors.

The process of developing the two simulation models for the two contexts was somewhat distinct. In the rheumatology department, where authors had been involved in the improvement work, the participants were introduced to simulation modeling during that work as an optional tool for improvement. During a workshop, they had the opportunity to test a simulation model representing the processes in focus of the ongoing improvement and its included variables. Immediately after the workshop, the FGD was performed.

In the orthopedic context, the participants were included in the simulation model building and validation of the simulation model during several meetings. The workshop and FGD were held at the end of the project time.

In both cases, the workshops began with a short introduction to simulation modeling and the researchers focus and questions. The researchers then presented the findings of the simulation model and led the FGDs on how and when simulation modeling could be used as a decision support in improvement efforts.

The FGD was conducted at the respective unit during one hour, and two trained researchers acted as moderators (CK and HHF in the rheumatology case and HHF and PM in the orthopedic case). The more experienced researcher moderated the FGD, and the other took notes and asked follow-up questions. The interviews were also recorded.

Before the initiation of the FGD, the participants were informed that the model developer would only be observing the FGD to let the participants freely discuss the model given their experience. The FGDs were initiated by asking all participants to comment briefly on their experience of the simulation model and their work with their specific questions. This ensured that all participants had a chance to share, and that the recordings included each participant. Following this introduction, the moderator's questions guided the rest of the FGD. The following themes were covered in the moderator guide:

- How was your experience of using the simulation model and the results?
- What problems/issues/questions are suitable to address with simulation modeling in healthcare?
- How can simulation modeling connect to improvement work?
- What are the values and trustworthiness of simulation modeling?

Data analysis

The FGDs were transcribed verbatim by transcribers, which were then analyzed using qualitative content analysis. Content analysis is commonly used in social sciences [21] and is a systematic analysis of text.[22] Two researchers (HHF and PM) conducted the coding and categorization together following the three general steps of performing content analysis outlined by Graneheim and Lundman.[23] The transcripts were read through before meaning units were extracted and coded, and, finally, the codes were organized into categories. Each step was performed individually before collaboratively reviewing the analyzed content and reaching a consensus.

Findings

Results presented below are organized according to the different categories derived from the qualitative content analysis.

When can simulation modeling be used?

Improvement support

The FGD participants described simulation as a tool that could be used to motivate change for staff and management. This included changes that present challenges when implementing because of budget constraints, big investments, staff resistance or lack of consensus. Simulation modeling can support change implementation by visualizing both problems and potential solutions. Simulation completes the picture of the limited financial or process aspects of change by visualizing effects that are different dimensions of the same change.

Test and evaluate ideas for improvement

Participants expressed repeatedly in both FGDs that simulation modeling could be used to evaluate the effect of changes that have either been implemented or that are under development or at an idea stage. Simulation modeling was considered a quicker and more efficient way to test new ideas, compared to testing in reality. Furthermore, changes can be tested without influencing patient care.

"It is exciting to be able to test a hypothesis in a computer environment to see what results you can anticipate," said one FGD participant. "It is often difficult to test changes in real life; it takes time, costs money and results are sometimes uncertain."

Participants also emphasized that simulation modeling could more systematically test change ideas and evaluate them, rather than just implementing changes without following up. In addition, they also shared how the model could be used as a pedagogical tool to develop and test ideas that could motivate staff to get engaged and involved in the improvement work.

"It´s a pedagogical tool to use in our work team in improvement work. By thinking that nothing is forbidden to suggest, we can test many different things and start thinking outside the box. It is so easy to get stuck in patterns," another participant commented.

Moreover, testing of ideas got some of the participants to think about existing work routines, and new improvement ideas were created, while previous ideas were rejected.

"We thought that if we just had more rooms, all our problems would go away," a participant said. "But we saw no substantial change when we tested it in the model. It all depends on the number of doctors that are available after all; that is the answer we got. We even saw that, right now, we are not using all the rooms efficiently."

How can simulation modeling be used?

Questions suitable for simulation modeling

Simulation modeling can be used to address concrete and measureable questions, including questions related to planning, resource allocation and staff scheduling. One area of application that was raised several times during the FGDs was related to cost efficiency.

"The future will be more about budgets and finances due to our expensive treatments. This [simulation model] can be a way to present financial figures to the management," commented one participant.

"It is easier to connect numbers with a cause rather than to just talk about the cause itself," said another participant.

This [simulation model] includes showing the cost efficiency of changes implemented and to make staff more aware of costs related to certain operations. Further on, it can be used to find ways to use resources more efficiently.

Validity

Participants stressed the importance of building the model from valid and reliable data. Using incorrect data or data in an incorrect way will undermine the simulation model and the staff´s trust in the model. The simulation model must reflect the organization and real processes and data. Input from staff is important to ensure the validity of the model as they are the ones with knowledge of processes and operations.

As one participant put it, "The method is fine; the difficult part is what you put into the model."

Participants expressed that in order to use any simulation model, it is important that all processes and logics incorporated in the model are well known to the user. This is to prevent misinterpretation of the model output and results. Relying on and trusting the model requires a deep understanding of the model and participation during the process of building the model.

"Users must be familiar with the model in order to critically evaluate results. [It's] dangerous if results are interpreted in the wrong way," expressed one participant.

Conducting simulation modeling projects

Results from the FGDs revealed two aspects of simulation modeling use: local use at the clinic in their improvement work, and to guide management on planned changes or responses to changes suggested by management. Staff must be involved from the beginning to inform

the building of the model with data and questions to test in the model. Involving staff from the beginning also helps develop trust in the simulation model.

"A simulation project must be approved by management and well supported by the staff," said one participant.

"In improvement work, involvement from everyone is essential, perhaps simulation modeling can act as a tool to inform and inspire colleagues," commented another.

Simulation modeling projects must be approved by management and staff and be well communicated within the organization. The group working with the simulation model cannot be too big and there must be a person in charge of the work. The importance of using the simulation model together, in multi-disciplinary teams, was emphasized. Specific persons holding positions, such as schedulers, nurse managers and heads of departments were mentioned as potential users.

"Simulation modeling should be used locally, at our clinic and by us," a person said. "It should be used to show how we work and our results, at meetings and externally as marketing.".

Another participant described the simulation model as, "a good tool to show management what we do and our plans."

Value and opportunities

Overall, participants expressed a positive attitude towards simulation modeling. They identified different opportunities for simulation modeling to add value to the development of their organization. These include identifying trends and understanding complex relationships between processes and systems. Moreover, simulation can help the staff face future challenges collaboratively.

The following quotes help illustrate the overall outlook of simulation modeling among the participants:

"Simulation modeling at the right time can be very valuable. When initiating improvement, it is beneficial to see how small changes can have great effects."

"You get an overview; you see the overall picture that can be used to stimulate improvement work."

"Simulation modeling can help you find new models and aid the individual learning when seeing the relation to their respective work. To the organization, it might be more on how to accomplish goals and see how the overall picture is affected?"

Discussion

This study set out to explore healthcare staffs' and managers' perceptions of how and when simulation modeling can be used as a decision support in improvement efforts. Simulation was described as a tool that could be used to evaluate and develop improvement ideas and help motivate the need to implement certain changes both for staff and for management. Also, simulation modeling can motivate difficult change by visualizing effects and also financial aspects. Simulation modeling was best valued as a way to address concrete and measureable questions related to planning, resource allocation, staff scheduling and cost efficiency. Two areas of simulation modeling use in healthcare improvement were stressed in the two focus groups: locally in the clinical improvement work and to guide management on planned changes. Also, the early involvement of staff in the simulation project and use of correct data to validate the model is crucial for staff to trust and use the model.

When comparing the results to previous literature on simulation modeling, there are several evident similarities. Concerning the potential users of the simulation model, at the clinical level or in management, it is important to consider model knowledge and the ability to present it to others, data availability and support from leadership.[14] Regarding testing and exploring what is outside of the box, Pidd describes simulation as a vehicle for experimentation where trial and error can be performed without concerns for reality, but with a great opportunity to learn.[23] Simulation modeling offers a holistic view on addressing change and improvement in complex systems and its inherent components by displaying the effects of change immediately.[7] Visualizing the problem and a potential solution was, in the FGDs, considered powerful in engaging healthcare staff in improvement work. This interactive opportunity has been proposed to help motivate staff to embrace change.[7] However, the formation of a representable clinical team to facilitate the simulation modeling work is not always easy.[15] Our first simulation focus group revealed a wish to include management, and the second focus

group wanted to include the staff further. Co-producing the model with staff, managers and modelers, also known as facilitated modeling, are important to build a step-by-step understanding of the model logic and its validity.[24-29] The early and continuous involvement of stakeholder in a structured model development process increases stakeholders trust in the model.[30] Depending on the identified users, simulation models can be used to aid communication in creating a shared mental model.[26 31-33]

Drawing from our results, we can see values emerging from simulation modeling, such as providing a way to work with change and improvement (especially when initiating improvement work), and visually communicate planned changes, operations and the subsequent consequences. Simulation modeling can be a tool to be used at different levels of healthcare, but according to our findings, it might be best suited for local clinical improvement and management planning and allocating resources. Before initiating a simulation modeling project, the formation of the project team is essential for ensuring model validity and reliability. Bringing in the aspects of implementation, evaluation and research requires even greater consideration of the project team, but might enable the transition from in-silico to in-reality and create value for the healthcare organization.

Limitations in our study design include the fact that we have drawn conclusions from limited empirical data gathered from two FGDs only. Nevertheless, an exploratory study like this could serve as a pilot for further research. All staff and managers involved in the improvement project teams were invited to attend the FGDs and thus the concept of saturation was not applicable. FGDs themselves can be subject to different impediments if not moderated well. The group dynamics are essential for allowing everyone to talk and present their opinion.[18 34 35] Using trained facilitators, a moderator guide and introductory questions for everyone to answer may have helped participants feel free to share their perceptions openly.

Conclusions

The emerging categories from the content analysis are presented according to the research questions of how and when simulation modeling can assist healthcare improvement. Regarding how, the participants mentioned that simulation modeling can act as a tool for support and a way to visualize problems and potential solutions, as an information and

communication tool to show management planned improvements and their effect. Simulation modeling could be used both locally and by management, but the user should be familiar with model logic and data to interpret results correctly. Relating to when, participants thought simulation modeling could be used as a pedagogical tool to develop and test ideas, to think outside the box and to get everyone involved in the improvement work.

This study showed that simulation modeling has more to offer than has been described in previous literature. Its potential as an information and communication tool, an instrument for pedagogic work within healthcare improvement, and as a way to allow thinking outside the box, render a broader application and value of simulation modeling.

Contributorship statement

HHF, PM, DG, CK and MU designed the study. HHF, PM, CK and MU collected the data. HHF, PM, CK and MU drafted the manuscript. All authors have been involved in reading and critically revising the manuscript. They have approved the final manuscript and are accountable for all parts of the work.

Competing interests

The authors declare that they have no competing interests.

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Data sharing statement

FGD moderators guide are available upon request to the authors.

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

No. Item	Guide questions/description	Comment
Domain 1: Research team and reflexivity		
Personal Characteristics		
1. Inter viewer/facilitator	Which author/s conducted the inter view or focus group?	Please see Methods and Data collection, p 7
2. Credentials	What were the researcher's credentials? E.g. PhD, MD	Please see Title page CK: PhD HHF: MSc and PhD PM: PhD
3. Occupation	What was their occupation at the time of the study?	CK: Researcher HHF: Doctoral student and post doc PM: Post Doc
4. Gender	Was the researcher male or female?	Research team was a mix.
5. Experience and training	What experience or training did the researcher have?	Please see Methods and Data collection, p 7.
Relationship with participants		
6. Relationship established	Was a relationship established prior to study commencement?	Yes, please see Methods and Data collection, p 7
7. Participant knowledge of the interviewer	What did the participants know about the researcher? e.g. personal goals, reasons for doing the research	Please see Methods and Data collection, p 7.
8. Interviewer characteristics	What characteristics were reported about the inter viewer/facilitator? e.g. Bias, assumptions, reasons and interests in the research topic	Please see Methods and Data collection, p 7
Domain 2: study design		
Theoretical framework		
9. Methodological orientation and Theory	What methodological orientation was stated to underpin the study? e.g. grounded theory, discourse analysis, ethnography, phenomenology, content analysis	Please see Methods and Data Analysis, p 8.
Participant selection		
10. Sampling	How were participants selected? e.g. purposive, convenience, consecutive, snowball	Please see Methods and Study participants, p 6
11. Method of approach	How were participants approached?	Please see Methods

	e.g. face-to-face, telephone, mail, email	and Study participants, p 6
12. Sample size	How many participants were in the study?	Please see Methods and Study participants, p 6
13. Non-participation	How many people refused to participate or dropped out? Reasons?	Please see Methods and Study participants, p 6
Setting		
14. Setting of data collection	Where was the data collected? e.g. home, clinic, workplace	Please see Methods and Study deign and setting, p 5
15. Presence of non-participants	Was anyone else present besides the participants and researchers?	No
16. Description of sample	What are the important characteristics of the sample? e.g. demographic data, date	Please see Methods and Study participants, p 6
Data collection		
17. Interview guide	Were questions, prompts, guides provided by the authors? Was it pilot tested?	The interview guide was not pilot tested but developed in the research team. Please see Methods and Data collection, p 7.
18. Repeat interviews	Were repeat inter views carried out? If yes, how many?	No
19. Audio/visual recording	Did the research use audio or visual recording to collect the data?	Audio recording. Please see Methods and Data collection, p 7
20. Field notes	Were field notes made during and/or after the inter view or focus group?	Please see Methods and Data collection, p 7
21. Duration	What was the duration of the inter views or focus group?	The duration was approx. 1 hour
22. Data saturation	Was data saturation discussed?	Yes in the limitation part of the Discussion, p 13. Participants were not recruited until data saturation was achieved since this was not applicable due to that all healthcare staff and managers involved in the project groups of the respective ongoing improvement efforts

		were invited.
23. Transcripts returned	Were transcripts returned to participants for comment and/or correction?	No
Domain 3: analysis and findings		
Data analysis		
24. Number of data coders	How many data coders coded the data?	Please see Methods and Data Analysis on p 8.
25. Description of the coding tree	Did authors provide a description of the coding tree?	No
26. Derivation of themes	Were themes identified in advance or derived from the data?	Please see Findings on p 8.
27. Software	What software, if applicable, was used to manage the data?	No software was used.
28. Participant checking	Did participants provide feedback on the findings?	No
Reporting		
29. Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified? e.g. participant number	Please see the Findings, p 9-11. Quotes were used, no identification number were used.
30. Data and findings consistent	Was there consistency between the data presented and the findings?	Yes, please see the outline of the Findings p 8-11.
31. Clarity of major themes	Were major themes clearly presented in the findings?	Yes, please see Findings p 8.
32. Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	Yes as an integrated part of the Findings section, p 8-11