PEER REVIEW HISTORY

ARTICLE DETAILS

TITLE (PROVISIONAL)	Operational strategies to manage non-elective orthopaedic surgical flows. A simulation modelling study
AUTHORS	Persson, Marie; Hvitfeldt Forsberg, Helena; Unbeck, Maria; Sköldenberg, Olof; Stark, Andreas; Kelly-Pettersson, Paula-Therese; Mazzocato, Pamela

VERSION 1 - REVIEW

REVIEWER	Maartje E. Zonderland, PhD. Center for Healthcare Operations Improvement and Research, University of Twente, Enschede, the Netherlands Medtronic Integrated Health Solutions, Heerlen, the Netherlands
REVIEW RETURNED	09-Sep-2016

GENERAL COMMENTS	The paper 'Operational strategies to manage non-elective orthopaedic surgical flows. A simulation study' uses Discrete Event Simulation to evaluate the effects of two different strategies on the waiting time for orthopedic surgery for non-elective patients. The study addresses an important topic, has been carried out in collaboration with a hospital and is novel in a way that it uses DES to optimize non-elective patient flow. It is well written and very readable. However, I do have some concerns. 1. Your results are very location specific and depend on the situation of the hospital (patient mix and volume, physical set up of ORs etc). Also, the possibility of 20 min reduction in changeover time is specific to this hospital. I think it would be of added value if you could elaborate on how this result could be generalized to an arbitrary hospital. 2. To me it is not clear in what sense the time gained through the decrease in changeover time is used. Can you provide more information on the average number of (non-)elective surgeries carried out per OR per day, the average surgery duration and the actual planning & scheduling process? 3. You compare scenario 2&3 with the baseline scenario 1, which generates data from the model. What about data from the actual situation? Can you compare scenario 2&3 with that? I would also appreciate it if you can compare your baseline scenario with data from the actual situation, to test the validity of your simulation model. 4. What did the hospital do with your results? Did they change their way of working? 5. The number of scenarios you consider is limited. You might want to add one or two additional scenarios, such as allocating part of an elective OR to non-elective patient demand.

REVIEWER	Dr. M. van Beuzekom
	Leiden University Medical Center, the Netherlands
REVIEW RETURNED	21-Sep-2016

GENERAL COMMENTS	Operational strategies to manage non-elective orthopaedic surgical flows. A simulation modelling study
	A more efficient surgical schedule may reduce patient cancellation and waiting time for the patients these while keeping the allocated surgical resources constant. When you want to manage surgical flows there allocation of capacity within surgical department and optimization of the surgical schedule in the department. These two aspects are incorporated in the model by reduced turnover time between surgeries by 20 minutes and one extra OR during day time.
	Simulation modeling on the OR is a very important issue even though it is not completely separated from other capacity issues in the hospital. The problem I have with the study that it is focused on waiting time for surgery, the outcome is known when you reduce turnover time you get more operation time. The study gets more value when the model is expanded with more variables, perhaps this is the case but I do not read it in the manuscript.
	The questions
	It is not clear which other variables are included in the model, for example, mean duration of surgery because the total operating time also determined how many surgeries you can perform
	Reducing turnover times has an effect on increases in caseload, how many cases to you have: two ORs were dedicated during day shift to serve non-elective orthopaedic surgeries and one OR during night shift. At weekends there was one OR dedicated during both the day and night shift. In 2014, a total of 10,574 surgeries were performed at the operating department; of these 4,512 were orthopaedic surgeries, 2,230 non-elective and 2,282 elective surgeries. Does this mean you have two ORs for about 6 patients? (2230/365).
	Unexpected incidents such as patient health status or employee sick leave were not included in the simulation model. The study gets more value when you incorporate this in the model.
	A reduction in turnover time by 20 minutes in an OR can yield the same level of improvement as adding an extra OR during daytime, but how do you manage the reduction?
	The results simulated, both baseline and the comparing scenarios, are somewhat overestimated. I don't understand this. The purpose of the modelling is nevertheless also going to apply it in the scheduling.

Reviewer 1

Operational strategies to manage non-elective orthopaedic surgical flows. A simulation modelling Study

A more efficient surgical schedule may reduce patient cancellation and waiting time for the patients these while keeping the allocated surgical resources constant. When you want to manage surgical flows there allocation of capacity within surgical department and optimization of the surgical schedule in the department. These two aspects are incorporated in the model by reduced turnover time between surgeries by 20 minutes and one extra OR during day time.
Simulation modeling on the OR is a very important issue even though it is not completely separated from other capacity issues in the hospital. The problem I have with the study that it is focused on waiting time for surgery, the outcome is known when you reduce turnover time you get more operation time. The study gets more value when the model is expanded with more variables, perhaps this is the case but I do not read it in the manuscript.

Reply: Thank you for this comment. In the introduction and in the discussion we sought to clarify that the contribution of this study lies in the comparison between two strategies to improve the performance of non-elective patient flows. Indeed, to our knowledge simulation modelling has mainly been applied to elective patient flows. Non-elective patient flows are different because patients arrive 24 hours a day; for non-elective patients, such as patients with hip-fracture, timely access to surgical services is of pivotal importance for the clinical outcomes. For all these theoretical and practical reasons, we believe this study adds to the current knowledge on how to improve the planning of non-surgical patient flows to ensure timelines to care delivery and we sought to clarify this in the introduction (first, third, and fifth paragraph) and in the discussion .

Specific comments
1. It is not clear which other variables are included in the model, for example, mean duration of surgery because the total operating time also determined how many surgeries you can perform

Reply: All the variables included in the model are presented in Table 1, including the mean duration of surgery. According to the simulation modelling approach, we use the mean to simulate the planned surgery duration, and a generated random value following a lognormal distribution with specified mean and variance to simulate the actual surgery duration. The simulation model first uses the mean value for a specific surgery when simulating the planning phase; this is important when simulating the decision on whether the surgery can be performed within the today's OR opening hours or have to be planned for, the day after. Then, when simulating what really occurred, the simulation model uses the lognormal distribution to generate the surgery duration. The motivation for this is to capture the differences in what is planned for and what really happens. We sought to explain this more clearly in the third paragraph of the methods section under the heading "simulation model".

2. Reducing turnover times has an effect on increases in caseload, how many cases to you have: two ORs were dedicated during day shift to serve non-elective orthopaedic surgeries and one OR during night shift. At weekends there was one OR dedicated during both the day and night shift. In 2014, a total of 10,574 surgeries were performed at the operating department; of these 4,512 were orthopaedic surgeries, 2,230 non-elective and 2,282 elective surgeries. Does this mean you have two ORs for about 6 patients? (2230/365).

Reply: Thank you for this comment. While the productivity of the OR may seem low, one may take into account that this study was conducted in the context of non-elective patient flows, and that the

main goals of the strategy tested was to reduce time to surgery, i.e. improve process efficiency, rather than improving resource efficiency. Timely access to surgical services is of pivotal importance for the clinical outcomes. We further elaborated on the differences and rationales for these two perspectives on how to manage health care demand in the in introduction and in the discussion and hope thereby to have clarified the contribution of the paper.

3. Unexpected incidents such as patient health status or employee sick leave were not included in the simulation model. The study gets more value when you incorporate this in the model.

Reply: In the second paragraph in the methodological considerations we clarified why, while the lack of data on patient health status and employee sick leave may influence the waiting time to surgery, we did not expect these variables to have an effect on the relative performance.

4. A reduction in turnover time by 20 minutes in an OR can yield the same level of improvement as adding an extra OR during daytime, but how do you manage the reduction?

Reply: The simulation model itself does not provide specific recommendations for how the reduction in turnover time can be achieved. Nevertheless, in the third paragraph in the discussion we made some suggestions for how this reduction could be achieved based on the literature. We have now further developed the discussion (see paragraph four) to clarify that the specific solutions implemented to reduce turnover time must be developed for each specific context of application.

5. The results simulated, both baseline and the comparing scenarios, are somewhat overestimated. I don't understand this. The purpose of the modelling is nevertheless also going to apply it in the scheduling.

Reply: We clarified in the last paragraph of the section "simulation experiment with scenarios" why the simulated data appeared to over-perform reality, as well as in the last paragraph under "setting". Concerning, scheduling, the topic is not addressed in this study, but rather suggested for future studies.

Reviewer 2
The paper 'Operational strategies to manage non-elective orthopaedic surgical flows. A simulation study' uses Discrete Event Simulation to evaluate the effects of two different strategies on the waiting time for orthopedic surgery for non-elective patients. The study addresses an important topic, has been carried out in collaboration with a hospital and is novel in a way that it uses DES to optimize non-elective patient flow. It is well written and very readable.

However, I do have some concerns.
Specific comments
1. Your results are very location specific and depend on the situation of the hospital (patient mix and volume, physical set up of ORs etc). Also, the possibility of 20 min reduction in changeover time is specific to this hospital. I think it would be of added value if you could elaborate on how this result could be generalized to an arbitrary hospital.

Reply: Thank you for this comment. In the discussion we have elaborated further on the generalizability of the approach and findings, which we believe lies in how simulation modelling can be used to support decision making processes in healthcare.

2. To me it is not clear in what sense the time gained through the decrease in changeover time is used. Can you provide more information on the average number of (non-)elective surgeries carried out per OR per day, the average surgery duration and the actual planning & scheduling process?

Reply: "To me it is not clear in what sense the time gained through the decrease in changeover time is used". We are not sure how to interpret this comment. In this article, we did not investigate how turnover time can be decreased, nor what can be done with the time saved. Nevertheless, in the third paragraph in the discussion we provide some suggestions for how turnover times could be reduced. In the revised version of the paper, we also discussed the importance of developing such solutions together with managers and professionals in the specific setting of application.

"Can you provide more information on the average number of (non-)elective surgeries carried out per OR per day, the average surgery duration and the actual planning & scheduling process". Information on number of non-elective surgeries carried out per day and OR was not available. However the average number of non-elective surgeries carried out per day (given the resources available in terms of OR) is easy to calculate with the information provided in the paper. According to the simulation modelling approach, we used the mean to simulate the planned surgery duration, and for the simulated actual surgery duration we generated random values drawn from a lognormal distribution with specified mean and variance. This is now explained in more detail. Concerning the planning and scheduling routines, the procedures used are summarized in the last raw of table 1.

3. You compare scenario 2&3 with the baseline scenario 1, which generates data from the model. What about data from the actual situation? Can you compare scenario 2&3 with that? I would also appreciate it if you can compare your baseline scenario with data from the actual situation, to test the validity of your simulation model.

Reply: We clarified in the last paragraph under the heading "simulation experiment with scenarios" that he baseline scenario that was developed based on real-world data was discussed together with professionals, i.e, it was validated in this way. According to the professionals the baseline scenario reached a higher level of performance comparted to reality. Part of the explanation is that the simulation model is based on the mean of the 20 fastest patients for the time from arrival to the time for surgery. The reason for this, is that we had no access to data that could explain the variation in time from arrival to declare ready for surgery. Some patients have to undergo necessary investigations prior to the surgery that possibly could result in surgery delay, sometimes for several days. This delay is not relevant to this study and hence not included in the study.

4. What did the hospital do with your results? Did they change their way of working?

Reply: In the discussion we have added information on how the results of the simulation analysis influenced research and development activities at the hospital.

5. The number of scenarios you consider is limited. You might want to add one or two additional scenarios, such as allocating part of an elective OR to non-elective patient demand.

Reply: In the introduction and the discussion we sought to clarify why we chose the two specific scenarios and how they are grounded both in the literature and in the concrete needs of the hospital studied. The scenario suggested by this reviewer is similar to how the hospital organized surgical activities before the elective and non-elective patient flows were separated. Sharing resources between patient flows turned out not to be an effective strategy, which is also corroborated in the literature. Therefore, we decided not to include this extra scenario.

VERSION 2 – REVIEW

REVIEWER	M.E. Zonderland
	Center for Healthcare Operations Improvement and Research, University of Twente, the Netherlands
REVIEW RETURNED	12-Dec-2016

GENERAL COMMENTS	I am not very satisfied with the efforts of the authors to address the point I raised in my review. In my opinion, the authors cannot pose such generic, bold conclusions based on a single case study. Therefore they should at least add (on multiple instances) in the discussion and conclusions sections something like 'at the OR department of hospital X'.
	Also, the entire paper is about decreasing turnover time. I am very confused by the author's reply to my second point, stating that they did not investigate how the turnover time can be decreased. So what is your paper about then?
	The authors should address these points first, otherwise I do not want to spend time on performing a detailed review.

REVIEWER	M. van Beuzekom
	Leiden University Medical Center
	the Netherlands
REVIEW RETURNED	14-Dec-2016

GENERAL COMMENTS	The comments which I have made by the first review, are incorporated in this version of the manuscript

VERSION 2 – AUTHOR RESPONSE

Reviewer 1
1. Comment 1: I am not very satisfied with the efforts of the authors to address the point I raised in my review. In my opinion, the authors cannot pose such generic, bold conclusions based on a single case study. Therefore they should at least add (on multiple instances) in the discussion and conclusions sections something like 'at the OR department of hospital X'.
a. Reply to comment 1: Thank you for this valuable comment. We made changes in the discussion and conclusion in accordance with this recommendation. We sought to clarify that the observed effects of two operational strategies, i.e. reduction of turnover time by 20 minutes and the addition of one OR, may be limited to the studied hospital. We also stressed that the key finding of this paper lies in showing how simulation modelling can be used to support improvement efforts in the context of non-elective care, an area that has received only limited attention previous research.

2. Comment 2: Also, the entire paper is about decreasing turnover time. I am very confused by the author's reply to my second point, stating that they did not investigate how the turnover time can be decreased. So what is your paper about then?
a. Reply to comment 2: We are afraid this comment is due to a misunderstanding and we are a bit confused on how to address it in the best possible way. The purpose of this paper was to explore the value of using simulation modelling to evaluate the effects of strategies to reduce waiting time to surgery for non-elective patient flows. The specific strategies we chose, i.e. reduction of turnover time by 20 minutes and adding one OR, were developed together with staff and managers at the hospital, based on their perception of what could be done to improve. The questions addressed by this reviewer, of how turnover time could be reduced or how the time saved could be used, were outside the scope of this study. We can only make suggestions for how this reduction can be achieved, which we did in the third paragraph in the discussion.

As mentioned in the reply to the previous comment, we have now tried to clarify that the main contribution of this paper lies in showing how simulation modelling can be used to support operational improvement in the context of non-elective patient flows, and that the results obtained in the different scenarios may be specific to the case organization. We hope that this reply can help clarifying this issue.

3. Comment 3: The authors should address these points first, otherwise I do not want to spend time on performing a detailed review.
a. Reply to comment 3: See reply to comment above.

Reviewer 2
1. Comment 1: The comments which I have made by the first review, are incorporated in this version of the manuscript.
a. Reply to comment 1: thank you!

VERSION 3 – REVIEW

REVIEWER	Maartje Zonderland University of Twente, Netherlands
REVIEW RETURNED	07-Feb-2017

GENERAL COMMENTS	The authors have fully addressed my concerns, I have no further comments.