USABILITY EVALUATION OF A DISCRETE EVENT-BASED VISUAL HOSPITAL MANAGEMENT SIMULATOR

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ABSTRACT

Hospital Management is a complex and dynamic organisational challenge. Hospital managers (HMs) are responsible for the effective use of valuable resources and assets, which is a significant issue in healthcare. Due to factors such as the increase in health care costs and political pressure, HMs have been compelled to examine new ways to improve efficiency and reduce healthcare delivery costs whilst improving patient satisfaction. Healthcare managers require tools that will allow them to review the current system or identify areas of improvement and quantify the possible changes.

This paper covers an evaluation of a hospital simulator developed by the authors. A usability test of the simulator was carried out with hospital managers to provide real-world feedback on the simulator. This has provided lessons to be applied in the development and use of such a tool. For instance, use of traffic light colours in assisting management of hospital areas and Sensitivity Analysis supporting multiple or more complex scenarios.

KEYWORDS

Usability evaluation, Simulation, Hospital management, Hospital simulator, World Wide Web

1. INTRODUCTION

Hospital Management is a complex and dynamic organisational challenge. Hospital managers (HMs) are responsible for the effective use of valuable resources and assets, which is a significant issue in healthcare. HMs have a challenging task of planning, implementing and monitoring strategies and also evaluating current systems as well as improving performance. Given the complex they task face, HMs can appreciate advances in technology that assist in ameliorating health care delivery, such as in the management of hospital activities.

Simulation tools can assist HMs in their endeavours. To apply simulation to health care, it is very important to recognise the problems or decisions that can be best analysed using simulation. Simulation is a technique that HMs can use to assess the efficiency of the current health care delivery systems, patient flow, forecast the impact of changes to existing system, to ask “what if” questions and design a new system. The applications of simulation methods can be very useful in addressing the complex challenges faced by healthcare and has been used in

DOI: 10.5121/hiij.2014.3101

modelling healthcare system for over 40 years [1]. There is a clear belief with modellers that general models are the requirement of the future. Works such as [2, 3, 4, 5] demonstrate example of general models that can be easily configured for different domains.

Simulation is not accepted by some as a viable modelling tool. One major stumbling block has been the time and cost involved in setting up detailed models before HMs can see benefits from such implementations. A general attitude among healthcare managers is that spending money on such technology is diverting funds from patient care.

Historically simulation tools have been used in hospitals to analyse specific problems. Building complex simulation models using complex simulation software requires technical experts to define and maintain such systems. It is also an expensive and time-consuming exercise which is likely to be deterrent for HMs to invest in such tools.

Two of the authors of this paper have developed a web-based, discrete event simulation modelling tool. The generic design of this tool can be used to model various scenarios and analyse the following:

- capacity planning (staff and resources like beds, operation theatres, etc.)
- impact on the patient flow with regard to staff utilisation and patient waiting times, if changes are made to the current procedures
- impact of increased patient numbers into the hospital
- identifying areas of improvement

The simplistic simulator makes it easy to define models, quick to run the simulation and view the results. This will help HMs in:

- making informed decisions with greater accuracy
- better utilisation of the staff and hospital resources
- more satisfied patients
- better planning for the future
- better use of hospital funds

This tool is discussed in [6] with regard to its functionality and how it is used in hospital management. The reader is suggested to peruse [6] to understand how the tool operates before reading the current paper. However, it does not cover evaluation of the tool. The current paper describes our usability evaluation of the tool and provides findings from trialling the tool with HMs employed at hospitals in Melbourne, Australia.

The evaluation of the tool addresses the questions of:

- Is this a useful tool for HMs in its current form?
- What would they like to see in the future versions of such tools?
- Is the simulation results data presented in the reporting module useful to them?
- What reporting tool do they prefer (simple text, Heat Map or Sensitivity analysis)
- How can the reporting module be improved?
- What features do they like or not in this tool?

It is important that not only are such hospital management tools developed, but that they are also evaluated effectively. It must be determined whether their functionality and capabilities are suitable to hospital management, whether HMs will accept and use such tools in the real world and what other possibilities they can provide for support of hospital management. Hence, we have undertaken such an evaluation of our tool to learn about these matters.

Section 2 covers a review of the literature, both with respect to research on hospital simulation and simulation tools developed by industry for use in health care. Section 3 explains the design of the usability evaluation of the tool. The results of the evaluation and findings for application are addressed in Section 4.

2. LITERATURE REVIEW

This coverage of literature deals with both academic research that has been conducted on hospital simulation (section 2.1) and software tools, particularly developed by vendors and other organisations, currently available for hospital simulation (section 2.2). Although simulation has been researched in partial contexts within hospitals, for example, a Radiology department or the Intensive Care Unit, the following coverage focuses on "whole-of-hospital" simulation with regards to patients and beds. Additionally, generic simulation solutions exist that can be applied to the domain of hospitals. Since the interest of the authors lies in software specific to hospital management, only such specific tools are considered here.

2.1. Research On Hospital Simulators

The work of Hutzschenreuter [7] is to "Develop methods and techniques for decision support for hospital patient flow logistics taking into account the high degree of uncertainty, heterogeneity and decentralization present in the hospital domain, to facilitate an efficient usage of hospital resources" ([7, p. 12]). Her work involves development of an agent-based simulation for coordination of patient flows. In order to develop the simulation, a case study involving interviews with experts from Catharina Hospital Eindhoven (the Netherlands) was carried out. In the work of the authors of this paper, interviews were carried out with experts (hospital managers) to evaluate the effectiveness of the hospital simulator and not as input into settings of simulation, which is the case in Hutzschenreuter's work. Like the authors of this paper, Hutzschenreuter uses sensitivity analysis in her work. However, sensitivity analysis is used in her work to evaluate prediction with regard to resource allocation by use of an artificial neural network. In the work of the authors, artificial neural networks are not used, and instead discrete event simulation is applied.

Ashby, Ferrin, Miller and Shahi [8] describe a discrete event simulation model used to study an existing hospital of 640 beds and design a new facility that houses 600 patients. The new facility housed 600 beds, diagnostic and treatment services centre, outpatient specialty services clinic and a central plant. Management was uncertain as to how the current operations translate into the new facility and the impact it has on patients. The main focus of this project is to enable the hospital to place patients optimally in the appropriate bed based on their acuity and in a timely manner.

With the reduction of total beds (640 to 600) and wards (48 to 26) as compared to the existing facility the biggest challenge was the ward mapping while building the model. The current patient mix and bed allocation process was determined after extensive consultation with physicians and the administrative staff. Some of the improvements are centred on discharge time of the day, bed management and patient transfer process. The researchers demonstrated that by decreasing the non-value added procedures (e.g., excessive patient internal transfers, distributed bed management) and applying best practices (e.g., Point of Care Testing, use of discharge lounges and early discharge time of day, earlier physician rounding practices) the same level of service can be delivered in a smaller capacity hospital.

A simulation model of all the departments of the outpatient department in a university hospital is covered by Takakuwa and Katagiri [9]. The hospital has 29 clinical departments and 30 central clinics. The existing building is superannuated and is replaced with a new one. The main focus of this study was to examine patient flows, waiting times and congestion areas in the planned new building. The actual patient data based on electronic medical records (PAS) is used to simulate and study the current system. A special purpose data generator (developed using Excel and Visual Basic for Applications) is used to analyse various other scenarios.

Patvivatsiri, Montes Jr, and Xi [10] describe a simulation model for public health systems contained within Lubbock County, Texas, USA, used to evaluate a hospital's preparedness against bioterrorism attack. The research addresses execution of three scenarios, one for current operations and the other two for medium- and high-level bioterrorism attacks. Using patient length of stay and staff utilisation as performance indicators the model will allow hospital manager to determine staff and resources required to process high patient volumes without building long queues and delay in patient treatment. The results indicate that patients tend to stay longer in the system when a higher number of patients arrive, hence higher staff utilisation. The system would crash once the staff utilisation reached 100%. The researchers claim that the model built is extremely flexible and can be easily customised by changing the parameters in a Microsoft Excel file without accessing the simulation software.

2.2. Hospital Simulation Systems

The Simcad Pro® Dynamic Process Simulator [11] is a patented system for improving efficiency and quality of hospital operations. The system supports identification of the most efficient patient flow and optimises staffing of the hospital. Coding is not required to build models. Visualisation and animation can be both in two and three dimensions. Monte Carlo simulation and analysis may be carried out with the system. Building, visualising and analysis of models can all be done on-the-fly.

TeleTracking Technologies Inc. is a company addressing patient flow automation that has developed Bed Management Suite™ [12]. This system informs staff of the occupation of beds, their availability, if beds are undergoing sanitation or the current situation of the patient. The system monitors patients and beds in real-time. One of the capabilities of this system is that it "allows Nursing, Admissions and Emergency Departments (ED) to more efficiently plan, manage and expedite and optimize patient flow, as well as help project clinical resource requirements necessary to provide proper patient care" [12]. Aims of the system are to decrease patient wait times and overcrowding of emergency departments and increasing flow of patients.

Access Bed Control™ (ABC) [13] is a system that shares similarity with Bed Management Suite™. ABC also addresses bed status and cleaning issues, as well as decreased patient wait times, overcrowding of emergency departments and increasing flow of patients. ABC has the two components of bed tracking, for determining where patients will be placed, and bed management, for "bed turnover".

The final system covered here to convey what sorts of systems are available for hospital management is Hospital Navigator [14]. This system uses a discrete-event simulation model, can be used for "What if?" analysis and is web-based just like our own system. Hospital Navigator also employs an operations research-based approach in its operation and is applied to the management of beds, planning of operating theatres and management of waiting lists. The system has been used by the National Health Service in the UK to learn more about and predict the effects of policies concerning provision of care and utilisation of resources.

Although much research and development has occurred in the space of hospital simulation or computer-based support of hospital management, as shown above, to our knowledge the evaluation of modern systems (particularly applying usability evaluation techniques) providing scientific results is more difficult to find. Our research has evaluated our own hospital simulator using selected usability evaluation techniques, and it is this important aspect that reflects uniqueness of this work.

3. DESIGN OF EVALUATION

Before covering the methods used and the results from evaluation, there is the issue of the functionality and operation of the hospital simulator. The hospital simulator has been explained in [6], therefore, functionality is not discussed in the current paper. In assuming that the reader has perused that paper, if they are indeed interested in the simulator's functionality, the evaluation is now covered here.

Our simulation tool we are evaluating is a planning tool that will be used by hospital management for resource and capacity planning in the healthcare industry. HMs are the target users of this system. HMs are very busy people and getting access to such senior management people is a very difficult affair. Since this tool is designed for a specialised group, they are a very small community; this makes it even more difficult to find the minimum required number of representative users for evaluation by usability testing method. We also considered those who have been HMs in the past, but may not currently be employed as such. Given how busy HMs are in Australian hospitals like in the city of Melbourne, we were aware that half-an-hour is about the maximum we could expect from them in terms of their time to evaluate the tool. Therefore, it will be indicated in the experimental design later that half-an-hour was used in the usability experiment to interact with HMs for evaluating the tool.

This is a pilot study to explore the functionality HMs would like to see in such tools and also gain feedback on the current design. Considering the constraints for availability of HMs and the limited time they can spare, we found we had to adapt one of the inquiry methods of usability evaluation. Since the HMs are not familiar with this tool, we have to first introduce them to it before we can ask their views about it. We need the simulation tool and some printed material (flow charts and pictures) for the demonstration. A meeting with the HM also provides an opportunity to use printed material that will aid in better understanding of the tool.

Given these considerations we decided to use a face-to-face interview with each HM. The first half of the meeting was used to demonstrate the simulation tool and the functionality it has, that could benefit HMs in their planning activity. In the second half of the meeting we requested the HM to answer a questionnaire about the simulation tool.

The questionnaire has both open-ended and close-ended questions. Close-ended questions are to obtain quantitative data on the existing functionality and responses based on a six-point scale. Open-ended questions are to explore the thoughts of the HM towards such tools and identify factors that will make this tool more useful for HMs.

The meetings between the first author of this paper, who carried out the usability experiments, and HMs—involving both software demonstration and surveys—were conducted at the work place of the HM. The first author took a laptop computer, that has the simulation software installed on it, to the meetings for demonstrating its operation. The demonstration was based on hypothetical projects using dummy data. Two scenarios depicting how this tool can be used to investigate real problems in hospitals were set up before visiting the HM. Minor changes were made to existing models to demonstrate how easy it is to create or modify models and to run simulation against them.

The objectives of this evaluation are to:

- Determine if the data presented in the Heat Map analysis is useful in decision-making.
- Determine if the data presented in Sensitivity analysis is useful in decision-making.

- Determine if the interface is easy to understand and use.
- Capture any new functionality the HMs would like to see in this tool.
- Determine if the current version of the tool is useful for HMs.
- Determine the satisfaction of the HMs with the current design and functionality.

3.1. Participant Profile

Human Research Ethics approval was sought due to the nature of our study. This was sought from the Faculty of Health, Engineering and Science Human Research Ethics Committee at Victoria University, Melbourne, Australia, which is from where the study was conducted.

After tremendous efforts to find and recruit HMs for our study, ten HMs from hospitals in our city of Melbourne agreed and participated. All participants held senior positions in large government hospitals. Relevant details about these HMs are shown in Table 1.

Table 1. Profile of Hospital Managers participating in study.

Hospital Manager	**Position**	**Hospital**	**Tasks**
HM1	Manager	Austin Health Services	Service development, service improvement and project management.
HM2	Director	Royal Melbourne Hospital	Patient flow and bed management. Clinical overview.
HM3	Manager	Department of Health	Supervising bed allocation. Supervising scheduling of elective and emergency admissions.
HM4	Assistant Director	WCMICS	Performance management, service planning, service development and operational management.
HM5	General Manager	Southern Health	Elective surgery access management, including waiting lists and theatre allocation. Quality and patient safety governance in clinical areas. Operational services, project management and physiotherapy management.
HM6	Director	Royal Melbourne Hospital	Managing operating suite, capacity, scheduling, balancing elective and emergency mix.
HM7	Executive Director	Eastern Health	Strategic service and business management. Quality and safety governance and management. Risk management & incident management systems. Continuous improvement and patient experience of care.
HM8	General Manager	Alfred Hospital	Staff Management, education, risk management and health IT.
HM9	Director	Alfred Hospital	Operational management of clinical program. Multiple outpatient services, inpatient wards.
HM10	Director	Barwon Health	Developing contingency plans to manage demand surges. Determining prioritisation in the many queues to enter acute/subacute sectors. Negotiating with clinical units in relation to supply and demand.

3.2. Simulator Preparation

The simulation tool demonstration to HMs was based on two hypothetical projects set up before the meeting. These projects depict two realistic problems in healthcare that HMs would possibly encounter as part of their job. These projects do not represent any particular organisation and are set up using dummy data. The two projects are described in Scenario 1 and Scenario 2 that were presented to the HMs. These scenarios are explained in [6], and the reader is referred to this first paper of the authors to know how the simulator was demonstrated to the HMs. The scenarios are not covered here again to prevent overlap of content with [6].

3.3. Simulator Demonstration

Two artifacts were used to explain the simulator to the HM. They are:

1. a model representing how patient flow occurs in the hospital (shown in Figure 4 of [6]), and
2. a flow chart indicating how projects are set up and run in the simulator (shown in Figure 3 of [6])

Therefore, a meeting with the HM involves the following:

- laptop with the simulation tool installed and running on it
- copy of the questionnaire, flow charts mentioned above and some details about the input program of the simulator
- copies of the information sheet and consent form

The demonstration and survey are conducted in the HM's office. This is conducted on a one-on-one basis. When there is more than one HM in the meeting, group dynamics could prevail, which means dominant people could tend to drive their views and make it difficult to capture all HMs' views given the limited time of 30 minutes available. Since all the HMs are asked to fill in the same survey it is important that the demonstration given to them is consistent across all managers. We decided to use a script to ensure that all HMs are given the same information, using the same vocabulary and scenarios and in the same order.

3.3. Survey

There are three categories of questions in this survey. The first category deals with participant details that provide us some background on the HMs with regard to their qualifications and their experience in computers and computer languages. The second category of questions is mainly focused on gauging HM's previous experience with simulation tools. The final category of questions addresses the main research problem, which is the presentation layer of the simulation tool. This simulation tool offers two modes in which the simulation results can be viewed— Heat Map Analysis (HMA) and Sensitivity Analysis (SA). We are interested in knowing if the data presented in the resulting simulation is easy to understand, meaningful and useful for HMs in their decision making. We would also like to explore the changes required in this simulation tool that would make it more attractive to HMs.

Sixteen closed-ended questions and six open-ended questions form the last two categories of questions in the survey. Closed-ended questions were formulated so that some questions are asked in the negative and the others are asked in the positive. This was to avoid leading questions that provoke positive responses all through the survey, i.e., avoid bias in responses.

4. RESULTS OF USABILITY EVALUATION

It must be stated at the outset that since the sample size of HMs is not large, results that reflect mainly agreement or disagreement with a closed-ended question only can be reported and only they will have any meaning in our study. The following sections display the results of analysis of closed-ended questions, providing descriptive, qualitative results along with them from associated open-ended questions.

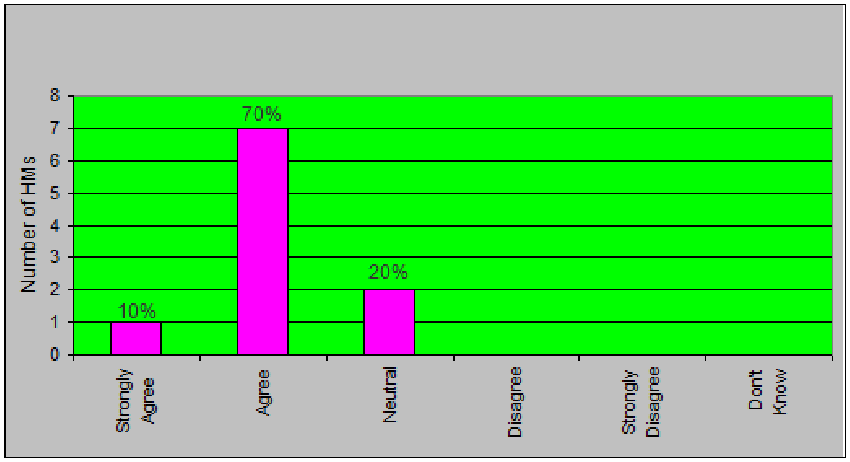

Figure 1. Responses to “Data in SA is easy to understand and useful in decision making”

4.1. Ease Of Understanding Of Usefulness Of Sensitivity Analysis

Question: “Data in SA is easy to understand and useful in decision making”

As seen in Figure 1, 80% of the HMs agree that SA is easy to understand and useful in decision making. There is only one strong agreement indicating more work is required to improve SA. A mean of 3.9 indicates a positive response to the question. 20% of HMs are neutral in their responses. HMs who provided these responses have not used any simulation tools before. This is the first simulation tool they have seen working. They liked what was presented and agreed it is useful in decision making. HM5 said SA is useful in decision making but found difficult to understand. HM6 indicated that SA has an effective combination of graphical and data points. HM1, HM4, HM7 and HM8 suggested that it is beneficial but limited with its restriction to changing resources (beds). Suggestions to improve SA include better labelling and features to handle complex variables around rostering, calendar changes and resources.

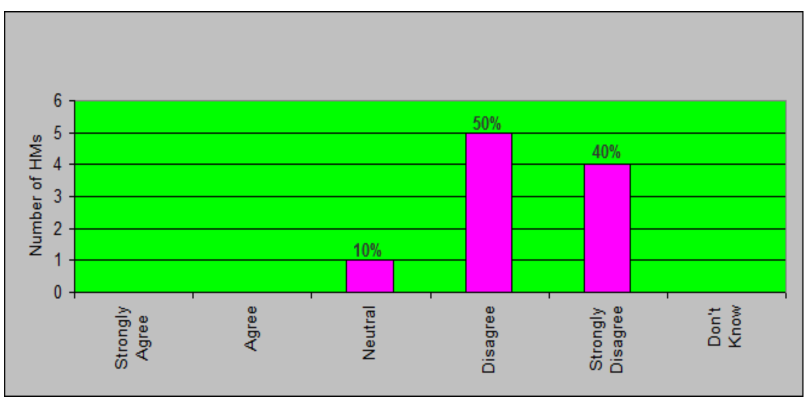

Figure 2. Responses to “SA is not easy to interpret results”

4.2. Interpreting Results Of Sensitivity Analysis

Question: “SA is not easy to interpret results”

It is very important that HMs be able to read and understand results. 90% of HMs found SA easy to read and to interpret its results (Figure 2). Only 40% strongly agreed that it is easy to interpret suggesting there is room for improvement. A mean response of 1.7 is a helpful indication that SA is easy to interpret results. HM10 found it very easy to interpret the results and mentioned that SA is "really simple graphical presentation". Three HMs agreed that SA is easy to understand but needed to handle more complex scenarios.

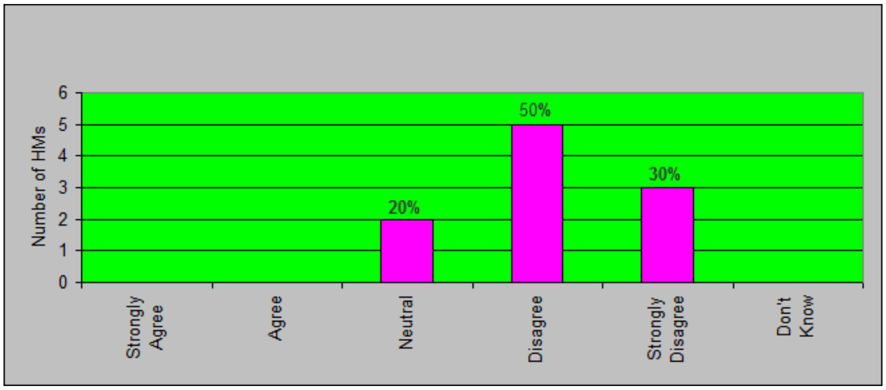

Figure 3. Responses to "SA is not a good summarised view of the results"

4.3. Sensitivity Analysis As A Summarised View

Question: "SA is not a good summarised view of the results"

For a report to be useful to HMs, it must summarise the results of all the scenarios and also have the facility to compare and contrast scenarios. This is vital for the success of such reports. The results in Figure 3 indicate 80% of HMs agree that SA does provide a useful summary of the scenarios. The arithmetic mean response of 1.9 indicates a negative response to the question written in the negative. HM9 stated "Results are summarised well but limited in capacity to introduce multiple scenarios". HM5 and HM9 also indicated that SA must be able to support more complex scenarios. Given the feedback from participants, we have derived certain features that can be incorporated in this simulation tool to make it more suitable for HMs.

4.3.1. Variable Length Of Stay

In a typical large hospital there are various departments catering for different patient categories. Using our research simulation tool it is easy to define a model for dedicated patient categories because the resources and length of stay (LOS) will be similar within a range. There are general wards that cater for different categories of patients. The resources required and LOS changes for each category of patients. This requires a separate model to be defined for each category of patients.

Example. A patient recovery ward supports patients who have undergone surgery. Patients experiencing knee surgery, heart surgery, hip replacement, accidents, etc. are cared for in these wards. The numbers of wards dedicated for each patient category changes with demand. With the design of the current tool, HMs will have to define new simulation models every time this happens. HMs indicated that they work on percentage of hospital capacity. For example, 10% of wards will cater for knee surgery, 25% of wards for heart surgery, etc. Since the number of beds in a hospital is unlikely to change during a day-to-day planning cycle, the allocations of beds do change. A simulation tool that could work from such principles will be more suitable.

4.3.2. Multi-Level Modelling

The simulation tool supports single level of modelling, i.e., a single point of patient entry and exit for the hospital model. In reality, patient may be transferred between departments before they are discharged. For example, a patient with open heart surgery will go to the intensive care unit immediately after surgery and will move into general wards before being discharged from the hospital. A multi-level modelling will allow modelling of more realistic scenarios

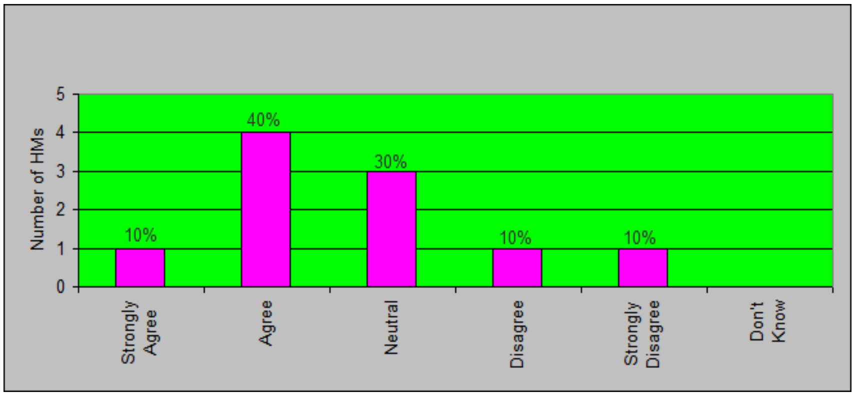

Figure 4. Responses to “It is a useful tool for capacity planning”

4.4. Relevance To Capacity Planning

Question: It is a useful tool for capacity planning

As seen in Figure 4, HMs were divided in their responses. 30% are neutral about this matter while 20% disagree in some manner. The HMs responses were a reflection of whether this tool fits into their current role of responsibility. HM6 is responsible for the planning and scheduling of operations and managing the surgical theatre in a large hospital. HM6 needs a scheduling tool that provides an optimal operation booking schedule that allows the best utilisation of operation theatres. The current simulation tool is not suitable for this purpose. HM5 suggested that this tool must demonstrate scenarios for different hospital areas that HMs know well. HM4 and HM6 also indicated that they need to see more tangible examples to provide a better response to our question. HMs were given a demonstration of the simulation tool based on two preset scenarios, but they wanted to see examples that were relevant to their daily tasks. HM7 stressed that such simulation tools cannot be standalone applications and have to integrate with a hospital’s management tools and systems. Based on the qualitative data we conclude that the research simulation tool needs more functionality for HMs to see the benefit of this tool in capacity planning.

4.5. Usefulness in “What if” analysis

Question: It is a useful tool to carry out “What if” analysis

As illustrated in Figure 5, 3 HMs are neutral about simulation being useful in conducting what-if analysis. Some of the HMs mentioned that this tool is effective in handling single parameter variation, for example, length of stay or change in beds. HM8 responded that it is suitable for bed-based analysis with no other data changing. HM3 suggested it is a valuable tool to view different relevant factors than direct detailed analysis.

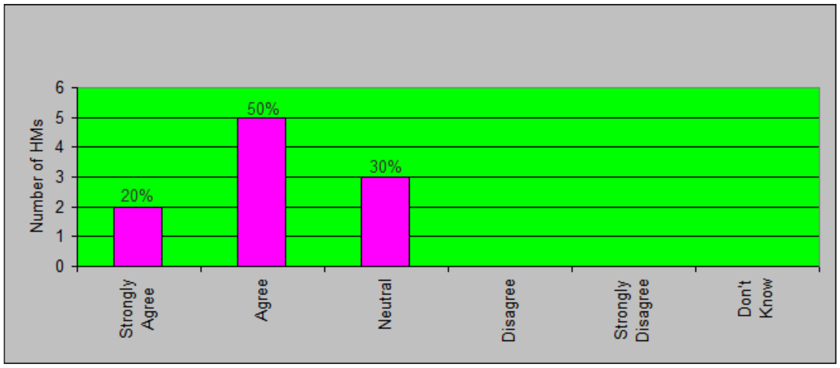

Figure 5. Responses to “It is a useful tool to carry out ‘What if’ analysis

HM7 stated, "What if scenarios in health care are often multifunctional- for example, number of beds, length of stay, staff availability, would be better if the simulation tool could address all these issues”. HM4, HM9 and HM10 also suggested that the tool should be capable of simulating complex scenarios supporting additional variables along with length of stay. HM5 suggested the use of terminology used in healthcare, for example “working%” can be replaced with “occupancy rate”. HM1 suggested the use of more commentary (text interpretative statements) about the data presented in HMA and SA to make the reports more informative. HMA and SA are both parameter-driven; a text message will therefore be useful. For example, if bed working% is selected in SA, a message “Comparison of bed occupancy between scenarios” will reinstate what is presented.

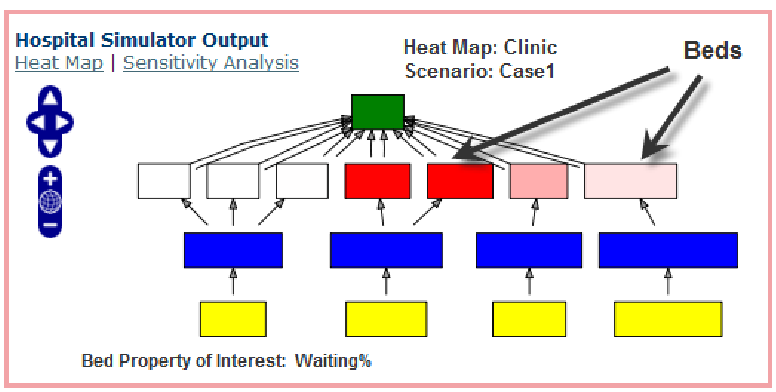

Figure 6. Heat Map Analysis representing Bed Waiting %

4.4. Improving Use Of Colours In Symbolising Aspects Of Hospital

The values of selected parameters in HMA are represented by the intensity of colours associated with those parameters. Figure 6 shows the user interface of HMA currently in the tool reflecting the bed waiting percentage for one of our two scenarios, whilst Figure 7 shows the bed working percentage (occupancy) in the same scenario.

As seen in both Figures, the colours presented are either red or light pink. The selection of colours is reversed between the Figures. Some of the HMs indicated that this is a confusing use of colours, that is, which colour represents desired results and which colour represents a situation that needs attention.

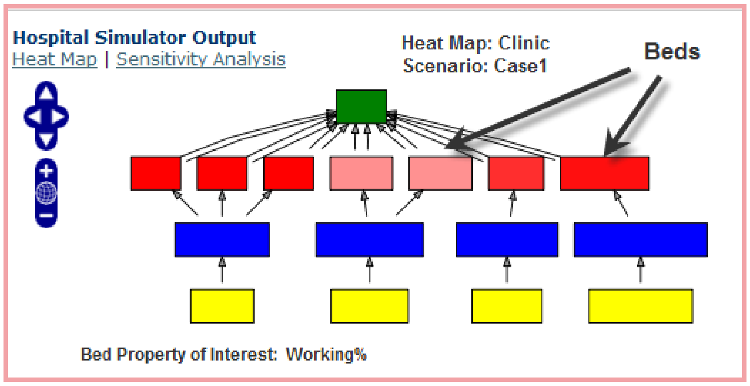

Figure 7. Heat Map Analysis representing Bed Working %

Our study found that healthcare works on a traffic signal (Figure 8) concept. Green represents desired results and red reflects trouble that needs immediate attention. HMs would like a similar colour representation in HMA that will be consistent with colours with which they are familiar.

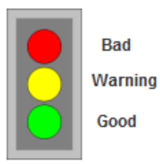

Figure 8. Traffic light concept

Figure 9 represents a sample of proposed changes in which all troublesome areas are represented in red and green represents favourable results. The cardiology clinic is very busy in operating to its full capacity; the maximum queue limit has been reached and as a consequence 34 patients are sent back without treatment. All these areas need attention as shown in red. The main reception is represented in yellow, representing a warning situation. There is no problem as such but attention is required in terms of queue capacity or waiting times. With this modified colour representation HMs will have a system that is consistent with other systems and at the same time easily detect and address areas that need attention.

4.5. Applying Health Care Symbols

Simulation tools can be used to model different scenarios for different departments in healthcare, for example, hospital beds, operation theatres and clinics. HMs suggested the use of appropriate symbols in Heat Map Analysis rather than the current rectangular boxes. As seen in Figure 10, work centres can be replaced with the symbols of beds. This will make it easier for the HMs to identify the department in a glance without having to refer to labels. This will be very useful when used to model a large hospital with many departments in a single model.

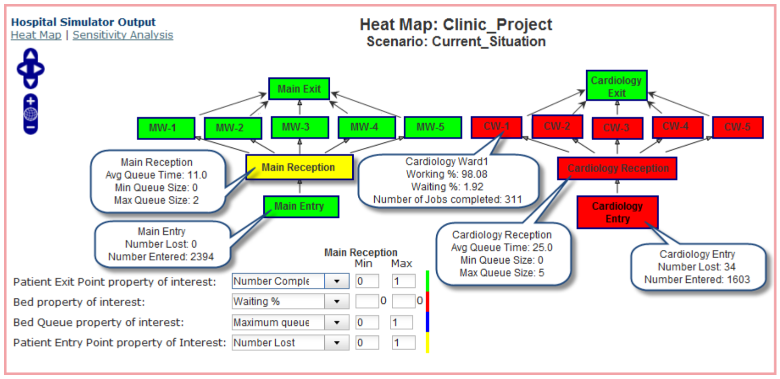

Figure 9. Heat Map Analysis applying the traffic light concept

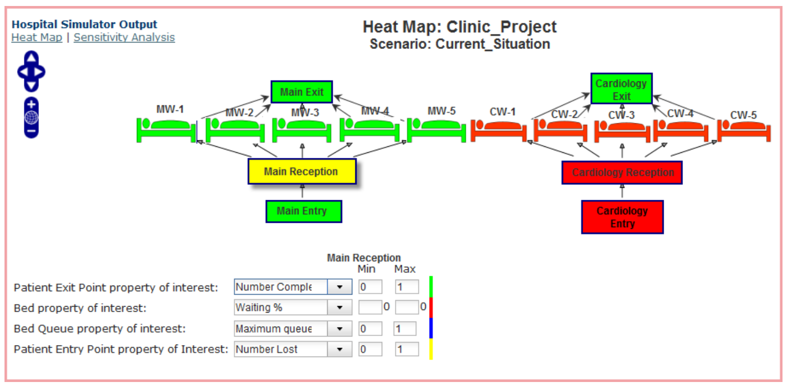

Figure 10. Heat Map Analysis using symbols to represent hospital departments

Universal symbols for healthcare are developed for hospital administrators and designers of way finding systems [15]. Some of the symbols commonly used in healthcare are shown on p. 1:6 of [15]. The symbols are user-friendly, provide clear and consistent information for patients and are independent of language. Use of such symbols obviously will improve Heat Map Analysis.

5. CONCLUSIONS

This paper has presented an evaluation, by applying usability experimentation, of our discrete event-based hospital management simulator. Hospital managers from hospitals in the city of Melbourne, Australia, participated in the evaluation, providing us feedback from a demonstration of the tool based on two different scenarios. Analysis of the data generated from our survey accorded us a variety of findings from which we learnt more about the use of such a simulator and what can be done to improve it.

It was found that support for more complex scenarios and multiple scenarios would make the tool more suitable for real-world use. This was not an unexpected result, given that we aimed to develop a simulator that supports straightforward scenarios, understandable to all types of hospital managers. We believed that this prototype was a useful start in assisting managers and knew that its current functionality is not all that was possible in such a tool.

Given the relevance of such a simulator in "what-if" analysis in the hospital context, the evaluation has been successful in determining various amendments that are required to better support analysis. Multiple variables clearly need support, such as length of stay, staff availability, number of beds, and so forth, to analyse a scenario adequately. Further textual descriptions in conveying parameters to the manager and in commentary that makes reports more informative will better assist managers.

Sensitivity Analysis was determined to be successful overall from this small sample size. The user interface for Sensitivity Analysis was generally easy to understand and useful in decision making, easy to use in interpreting results and an effective summarisation of the results. Variable length of stay and multi-level modelling were two improvements to Sensitivity Analysis found from the study.

It was appreciable that suggestions improving the user-friendliness of the tool were provided, particularly in applying visual concepts associated with traffic lights and symbols used in health care. These two improvements related to the Heat Map Analysis capability of the tool. Such improvements are expected to make a simulator much easier to use in a decision-making situation involving immediacy of response.

We would be interested in applying the various changes arising from this study to the simulation tool and re-evaluating with hospital managers. The results and findings from such further study would be interesting and evolve the tool further toward a system that can be applied in real-world healthcare.

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APPENDIX – SURVEY

Participant Profile

1. What is your age?
   - 18 – 24 Years
   - 25 – 34 Years
   - 35 – 44 Years
   - 45 – 54 Years
   - 55 – 64 Years
   - 65 or Older
2. What is your current job title or job title when you worked in hospital management role?
   - ____
2. What are the common tasks you carry out or carried out in your hospital management role?
   - ____
3. How long have you or did you spend in hospital management?
   - Under 3 Years
     i. If Under 3 How many ____________________________
   - 4-6 Years
   - 7-10 Years
   - 11-15 Years
   - 16-20 Years
   - More than 20 Years

Qualification

4. What is the highest level of qualification you have completed?
   - Less than High School
   - High School
   - TAFE or 2 Year Degree (Associates)
   - 3 Year Bachelor Degree
   - Degree
   - Honours or Course work Masters
   - Master by Research
   - Doctoral Degree

Decision Support Software

5. Do you currently or did you use any Decision Support Software (DSS) Tool for hospital capacity or staffing planning activity?
   - Yes
   - No

   If Yes:
   - What are the names of the DSS Tools?
     ____
   - What do use them for?
     ____
   - How often do you or did you use these tools?
     i. Once a Day or More
     ii. 2-6 Times a Week
     iii. About Once a Week
     iv. About Once a Month

v. About Once in Three Months
vi. About Once in Six Months
vii. About Once a Year

- How does this tool compare to the new (Simulation Tool) tool?

  ____

New Simulation Tool
(Question 7 to 28 refer to the new Simulation Tool being evaluated)

6. Please indicate the extent to which you agree or disagree with the following statements?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
Product is not easy to understand	☐	☐	☐	☐	☐	☐

If Agree / Strongly Agree:

- What needs to change to make it useful?

  ____

If Neutral / Disagree / Strongly Disagree:

- What can be done to make it better?

  ____

7. Please indicate the extent to which you agree or disagree with the following statements?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
It is a not a useful tool for hospital managers in its current form.	☐	☐	☐	☐	☐	☐

If Agree / Strongly Agree:

- What needs to change to make it useful?

  ____

If Neutral / Disagree / Strongly Disagree:

- What can be done to make it better?

  ____

8. Please indicate the extent to which you agree or disagree with the following statements?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
It is a useful tool for Capacity Planning	☐	☐	☐	☐	☐	☐

If Agree / Strongly Agree:

- What can be done to make it better?

  ____

If Neutral / Disagree / Strongly Disagree:

- What needs to change to make it useful?

  ____

9. Please indicate the extent to which you agree or disagree with the following statements?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
It is a useful tool to carry out "What if" analysis	☐	☐	☐	☐	☐	☐

If Agree / Strongly Agree:

- What can be done to make it better?

  ____

If Neutral / Disagree / Strongly Disagree:

- What needs to change to make it useful?

  ____

10. Please indicate the extent to which you agree or disagree with the following statements?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
It is easy to learn	☐	☐	☐	☐	☐	☐

If Agree / Strongly Agree:

- What can be done to make it better?

  ____

If Neutral / Disagree / Strongly Disagree:

- What needs to change to make it useful?

  ____

11. Rate the following reports in the order of your preference.
    (e.g. 1- First Choice, 2- Second Choice and 3 – Last Choice)
    - Text Report ______
    - Heat Map Analysis ______
    - Sensitive Analysis ______

    State Reasons:____

12. Please indicate the extent to which you agree or disagree about "Sensitive Analysis" and "Heat Map Analysis".

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
Data presented is Heat Map Analysis and Sensitivity Analysis is complementary to each other.	☐	☐	☐	☐	☐	☐

If Agree / Strongly Agree:

- What can be done to make it better?

  ____

If Neutral / Disagree / Strongly Disagree:

- What needs to change to make it useful?

  ____

13. Please indicate the extent to which you agree or disagree about "Sensitivity Analysis"

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
Data presented is easy to understand and useful in decision-making.	☐	☐	☐	☐	☐	☐

If Agree / Strongly Agree:

- What can be done to make it better?

  ____

If Neutral / Disagree / Strongly Disagree:

- What needs to change to make it useful?

  ____

14. Please indicate the extent to which you agree or disagree about "Sensitivity Analysis"

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
Cannot compare results with other scenarios on the project	☐	☐	☐	☐	☐	☐

If Agree / Strongly Agree:

- What needs to change to make it useful?

____

If Neutral / Disagree / Strongly Disagree:

- What can be done to make it better?

____

15. Please indicate the extent to which you agree or disagree about "Sensitivity Analysis"

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
It is not easy to interpret the results	☐	☐	☐	☐	☐	☐

If Agree / Strongly Agree:

- What needs to change to make it useful?

____

If Neutral / Disagree / Strongly Disagree:

- What can be done to make it better?

____

16. Please indicate the extent to which you agree or disagree about "Sensitivity Analysis"

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
It is a not a good summarised view of the result	☐	☐	☐	☐	☐	☐

If Agree / Strongly Agree:

- What needs to change to make it useful?

____

If Neutral / Disagree / Strongly Disagree:

- What can be done to make it better?

____

17. Please indicate the extent to which you agree or disagree about "Heat Map Analysis"

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
Data presented is easy to understand and is useful in decision-making.	☐	☐	☐	☐	☐	☐

If Agree / Strongly Agree:

- What can be done to make it better?

____

If Neutral / Disagree / Strongly Disagree:

- What needs to change to make it useful?

____

18. Please indicate the extent to which you agree or disagree about "Heat Map Analysis"

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know

It is not easy to interpret the results	☐	☐	☐	☐	☐	☐

If Agree / Strongly Agree:

- What needs to change to make it useful?

____

If Neutral / Disagree / Strongly Disagree:

- What can be done to make it better?

____

19. Please indicate the extent to which you agree or disagree about "Heat Map Analysis"

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
It is not useful to find problem areas	☐	☐	☐	☐	☐	☐

If Agree / Strongly Agree:

- What needs to change to make it useful?

____

If Neutral / Disagree / Strongly Disagree:

- What can be done to make it better?

____

20. Please indicate the extent to which you agree or disagree about "Heat Map Analysis"

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
The balloon speech information does not provide adequate information about the objects	☐	☐	☐	☐	☐	☐

If Agree / Strongly Agree:

- What needs to change to make it useful?

____

If Neutral / Disagree / Strongly Disagree:

- What can be done to make it better?

____

21. Please indicate the extent to which you agree or disagree about "Heat Map Analysis"

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Don't Know
It is useful summary of the simulation results	☐	☐	☐	☐	☐	☐

If Agree / Strongly Agree:

- What can be done to make it better?

____

If Neutral / Disagree / Strongly Disagree:

- What needs to change to make it useful?

____

22. What do you think about the history view of various scenarios on the left hand side of the panel?
    - Excellent
    - Good
    - Fair
    - Poor
    - Not Sure

State Reasons:____

23. What aspects, if any, do you like about this tool?

____

24. What aspects, if any, don't you like about this tool?
    ____

25. What other features would you like to see in this tool?
    - Useability
      ____
    - Functionality
      ____
    - Presentation
      ____
26. If you have opportunity to change this product, what would that be?
    ____
27. Do you have any comments or suggestion about this tool?
    ____

<u>Modelling Background</u>

28. Do you have any exposure to mathematical modelling? Example: *Biomedical Science, Weather Prediction, Population at a given point in time, Patient Distribution*
    - Yes
    - No

    If Yes:
    a. What is the name of the modelling tool?
       ____
    b. What do you use it for?
       ____
    c. How often do you use it? *If someone generates the output, how often do you use the output from such models?*
       i. Every Day or More
       ii. 2-6 Times a Week
       iii. About Once a Week
       iv. About Once a Month
       v. About Once in Three Months
       vi. About Once in Six Months
       vii. About Once a Year

<u>Computer Background</u>

29. How often do you use your email?
    - Once a Day or More
    - 2-6 Times a Week
    - About Once a Week
    - About Once a Month
    - About Once in Three Months
    - About Once in Six Months
    - About Once a Year
    - Never: Why ____-
30. How often do you use the Internet?
    - Once a Day or More
    - 2-6 Times a Week
    - About Once a Week
    - About Once a Month
    - About Once in Three Months
    - About Once in Six Months
    - About Once a Year
    - Never: Why____
31. How would you rate your computer skills?
    - Basic *(use of email, internet)*
    - Intermediate *(use computer applications like word processing, spreadsheet, accounting packages, patient history (PAS), etc).*

- Advance *(Programming is software languages, writing macros).*

32. Have you ever programmed? Example: Macro’s programming in Excel, Visual Basic, Java, PL/SQL, COBOL, FORTRAN, etc.
    - Yes or No