PATIENT FLOW MODEL USING HYBRID DISCRETE EVENT AND AGENT-BASED SIMULATION IN EMERGENCY DEPARTMENT

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DOCTOR OF PHILOSOPHY

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We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy.

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Jabatan Kecemasan (ED) adalah salah satu jabatan yang paling penting dalam hospital. ED memainkan peranan penting dalam mempromosikan tujuan utama hospital iaitu untuk meningkatkan kecekapan perkhidmatan. ED merupakan sistem yang kompleks disebabkan tingkah laku stokastik termasuk aliran operasi pesakit, ketidakpastian rawatan yang diperlukan oleh pesakit dan persekitaran jabatan yang kompleks. Aliran operasi pesakit ED juga merujuk kepada pemindahan pesakit ke pelbagai lokasi yang berkaitan dengan kemudahan kesihatan. Kaedah simulasi merupakan alat yang berkesan untuk menganalisis dan mengoptimum aliran operasi pesakit ED yang kompleks. Walaupun model simulasi aliran operasi pesakit ED yang sedia ada telah dipertingkatkan prestasinya secara ketara dalam memastikan kepuasan para pesakit dan perkhidmatan rawatan yang berkesan, namun masih banyak kekurangan wujud dalam menangani masalah utama dalam ED, iaitu daya pemprosesan pesakit dimana daya pemprosesan masa pesakit yang panjang. Isu daya pemprosesan masa pesakit dipengaruhi oleh faktor seperti waktu menunggu rawatan, tempoh menerima rawatan (LoS) dan daya membuat keputusan. Tujuan penyelidikan ini adalah untuk memperbaiki aliran operasi pesakit yang di ED dengan mencadangkan Model Simulasi Aliran Operasi Pesakit untuk ED (SIM-PFED) yang baharu untuk menangani masalah utama yang dilaporkan mengenai daya pemprosesan masa pesakit. SIM-PFED memperkenalkan proses baharu untuk aliran pesakit ED berdasarkan aliran operasi pesakit yang baru dicadangkan dengan menggabungkan simulasi peristiwa diskrit dan simulasi berdasarkan ejen, dan mengimpliminkan kaedah membuat keputusan yang pelbagai atribut, iaitu teknik urutan keutamaan dengan persamaan penyelesaian ideal (TOPSIS). Eksperimen ini dilakukan pada empat set data ED yang sebenar untuk menilai tahap keberkesanan SIM-PFED. Hasil eksperimen menunjukkan kecemerlangan SIM-PFED berbanding model alternatif lain dalam mengurangkan daya pemprosesan masa pesakit di ED dengan mengurangkan waktu menunggu rawatan dan tempoh menerima rawatan di hospital yang lebih pendek. Hasil eksperimen menunjukkan berlaku peningkatan peratusan dari segi daya pemprosesan masa pesakit (waktu menunggu rawatan dan LoS). Tahap kemahiran model waktu menunggu rawatan SIM-PFED ialah 35.45%, 89.21%, 87.64% and 86.00% lebih bagus jika dibandingkan dengan Model Simulasi Keselamatan, Model ABS, IS-BDSF dan SEDO-UCC. Di samping itu, secara umumnya purata prestasi waktu menunggu rawatan SIM-PFED terhadap keempat-empat model tersebut menunjukkan bahawa prestasi SIM-PFED adalah yang lebih baik berbanding dengan Model Simulasi Keselamatan, Model ABS, IS-BDSF dan SEDO-UCC berkenaan waktu menunggu dengan nilai peratusan sebanyak 74.58%. Keberkesanan LoS SIM-PFED ialah sebanyak 74.4%, 85%, 91.6% dan 87.4% lebih tinggi daripada Model Simulasi Keselamatan, Model ABS, IS-BDSF dan SEDO-UCC. Di samping itu, secara umumnya purata prestasi LoS SIM-PFED terhadap keempat-empat model tersebut menggambarkan bahawa prestasi SIM-PFED adalah lebih meningkat berbanding dengan Model Simulasi Keselamatan, Model ABS, IS-BDSF dan SEDO-UCC berkenaan dengan waktu menunggu dengan nilai peratusan sebanyak 85.6%. Hasil penyelidikan ini juga menunjukkan keberkesanan SIM-PFED dalam membantu pemutus keputusan ED dalam memilih situasi yang terbaik yang akan dilaksanakan di ED untuk memastikan daya pemprosesan masa yang minimum disamping menjimatkan kos.

ABSTRACT

The hospital emergency department (ED) is one of the most crucial hospital areas. ED plays a key role in promoting hospitals' goals of enhancing service efficiency. ED is a complex system due to the stochastic behaviour including the operational patient flow, the unpredictability of the care required by patients, and the department's complex nature. ED operational patient flow refers to the transferring of patients throughout various locations in specific relation to a healthcare facility. Simulations are effective tools for analysing and optimizing complex ED operational patient flow. Although existing ED operational patient flow simulation models have substantially improved ED operational patient performance in terms of ensuring patient satisfaction and effective treatment, many deficiencies continue to exist in addressing the key challenge in ED, namely, patient throughput issue which is indicated to the long patient throughput time in ED. The patient throughput time issue is affected by causative factors, such as waiting time, length of stay (LoS), and decision-making. This research aims to improve ED operational patient flow by proposing a new ED Operational Patient Flow Simulation Model (SIM-PFED) in order to address the reported key challenge of the patient throughput time. SIM-PFED introduces a new process for patient flow in ED on the basis of the newly proposed operational patient flow by combining discrete event simulation and agent-based simulation and applying a multi attribute decision making method, namely, the technique for order preference by similarity to the ideal solution (TOPSIS). Experiments were performed on four actual hospital ED datasets to assess the effectiveness of SIM-PFED. Experimental results revealed the superiority of SIM-PFED over other alternative models in reducing patient throughput time in ED by consuming less patient waiting time and having a shorter length of stay. The results of the experiments showed the improvement `of percentage in terms of patient throughput time (waiting time and LoS). SIM-PFED's waiting time proficiency is 35.45%, 89.21%, 87.64% and 86.00% advanced than Safety Simulation Model, ABS Model, IS-BDSF and SEDO-UCC correspondingly. In addition, the general average waiting time performance of SIM-PFED against the four models ascertains that the performance of SIM-PFED's is largely improved than that of the Safety Simulation Model, ABS Model, IS-BDSF and SEDO-UCC in regard to the waiting time at a percentage of 74.58%. SIM-PFED's LoS effectiveness is 74.4%, 85%, 91.6% and 87.4% higher than Safety Simulation Model, ABS Model, IS-BDSF and SEDO-UCC correspondingly. The general average LoS performance of SIM-PFED against the four models illustrated that the performance of SIM-PFED's is largely improved than that of the Safety Simulation Model, ABS Model, IS-BDSF and SEDO-UCC in regard to the LoS at a percentage of 85.6%.The findings also demonstrated the effectiveness of SIM-PFED in helping ED decision-makers select the best scenarios to be implemented in ED for ensuring minimal patient throughput time while being cost-effective.

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