UNIVERSITI PUTRA MALAYSIA

DEVELOPMENT OF ORTHOPAEDIC OUTPATIENT CLINIC SCHEDULING INFORMATION SYSTEM FOR PERFORMANCE IMPROVEMENT

PAH PIN SHANG

FK 2014 20

DEVELOPMENT OF ORTHOPAEDIC OUTPATIENT CLINIC SCHEDULING INFORMATION SYSTEM FOR PERFORMANCE IMPROVEMENT

By

PAH PIN SHANG

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

May 2014

© COPYRIGHT UPM

All material contained within the thesis, including without limitation text, logos, icons, photographs and all other artwork, is copyright material of Universiti Putra Malaysia unless otherwise stated. Use may be made of any material contained within the thesis for non-commercial purposes from the copyright holder. Commercial use of material may only be made with the express, prior, written permission of Universiti Putra Malaysia.

Copyright © Universiti Putra Malaysia

© COPYRIGHT UPM

DEDICATION

This thesis is dedicated to my parents and family.

© COPYRIGHT UPM

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

DEVELOPMENT OF ORTHOPAEDIC OUTPATIENT CLINIC SCHEDULING INFORMATION SYSTEM FOR PERFORMANCE IMPROVEMENT

By

PAH PIN SHANG

May 2014

Chairman : Tang Sai Hong, PHD
Faculty : Engineering

Long patients' waiting time (PWT) and clinic overtime are common problems encountered in outpatient clinics. These usually occur in high demand clinics such as orthopaedics and cardiology. The Orthopaedic Specialist Outpatient Clinic of Hospital Serdang, Malaysia (OSOC) is facing same problems. In 2010, OSOC was successful in achieving its targeted average PWT, as prescribed in its Key Performance Index (KPI) in only three months of the year. The current study was conducted in OSOC with the aim of reducing PWT and overtime works of its staff through computer-based modelling and simulation. Problem areas requiring improvement include appointment system, resources allocation and patients flow. First, the processes in the OSOC were studied based on interviews, observation and research to ensure the system was well understood before the modelling commenced. Through this approach, the underlying causes within the system that contribute to long PWT were identified. Next, over a two-week period, data collections were performed in the clinic to obtain required data for modelling and simulation. Concurrently, additional patient data over the survey period were obtained from the OSOC. Based on these data, a computer model simulating the current operations within the OSOC, named "Current Orthopaedic Outpatient Clinic" (hereafter referred to as the "Current System") was generated using the SIMUL8 computer software package (SIMUL8 Corporation). Validation and verification of these outputs were conducted on Current System models to ensure the integrity and accuracy of the system and its input parameters. Furthermore, baseline benchmarks on several key performance indicators were obtained.

Through this process, the causes of current problems in OSOC were identified. Subsequently, a new computer simulated model, named "Improved System" was

© COPYRIGHT UPM

generated in which the constraints identified within the Current System have been eliminated or modified. The KPI of the Improved System was next compared with that of the Current System to determine whether the implemented changes indeed result in improvement the performance of OSOC. To this end, sensitivity analyses were carried out to determine the responsiveness of the Improved System to the changes, such as number of appointments, "no-show" rate or forced booking.

Based on these simulations, these modifications would reduce the PWT significantly in the Improved System, compared with existing system. Furthermore, the entire simulated clinic sessions satisfied the criteria outlined in the clinic's KPI. As an additional benefit, 90% of the clinic sessions simulated under Improved System's parameters greatly improved clinic end time. In the sensitivity analyses, the new model demonstrates an ability to respond differently under various input parameters. In conclusion, the results of this study demonstrate that PWT in outpatient clinic can be significantly reduced by 53.7-97% after applying the improved settings revealed by computer-assisted modelling.

© COPYRIGHT UPM

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PEMBANGUNAN SISTEM MAKLUMAT PENJADUALAN KLINIK ORTOPEDIK PESAKIT LUAR BAGI PENINGKATAN PRESTASI

Oleh

PAH PIN SHANG

Mei 2014

Pengerusi : Tang Sai Hong, PHD
Fakulti : Kejuruteraan

Tempoh penungguan pesakit (PWT) yang panjang dan kerja lebih masa merupakan masalah umum yang dihadapi oleh klinik-klinik rawatan pesakit luar. Masalah-masalah ini biasanya berlaku di klinik yang di bawah permintaan ramai seperti klinik ortopedik dan kardiologi. Klinik Kepakaran Ortopedik Rawatan Luar, Hospital Serdang, Malaysia (OSOC) turut mengalami masalah yang sama. Pada tahun 2010, OSOC telah berjaya mencapai purata PWT seperti yang dinyatakan dalam Indeks Prestasi Utama hanya dalam jangka masa tiga bulan. Kajian ini dijalankan di OSOC dengan tujuan mengurangkan tempoh penungguan pesakit (PWT) melalui sistem pemodelan dan simulasi berasaskan komputer. Antara masalah-masalah yang perlu diperbaiki termasuk sistem temujanji, peruntukan sumber dan aliran pesakit. Pertama, proses-proses dalam OSOC dikaji secara temuduga, pemerhatian dan penyelidikan bagi memastikan ia difahami sepenuhnya sebelum pemodelan dimulakan. Melalui kaedah ini, faktor-faktor asas dalam sistem tersebut yang menyebabkan penangguhan masa penungguan pesakit dikenal pasti. Seterusnya, pengutipan data dijalankan di dalam klinik selama dua minggu bagi memperoleh data-data yang diperlukan untuk pemodelan dan simulasi. Di samping itu, data-data tambahan pesakit semasa kajian juga diperoleh dari OSOC. Berdasarkan data-data ini, sebuah model komputer, dengan nama "Klinik Ortopedik Rawatan Luar Sedia Ada" (Selepas ini dirujuk sebagai "Sistem Sedia Ada") dimodelkan melalui SIMUL8 (SIMUL8 Corporation) bagi mensimulasikan operasi terkini OSOC. Validasi dan verifikasi keluaran dijalankan melalui model sistem terkini bagi memastikan kejituan sistem dan parameter masukan. Selain itu, garis dasar penanda aras bagi beberapa petunjuk prestasi utama turut diperoleh.

© COPYRIGHT UPM

Melalui proses ini, faktor-faktor masalah yang dihadapi OSOC dikenal pasti. Di samping itu, sebuah model simulasi komputer yang bernama "Sistem Diperbaiki" dimodelkan di mana batasan yang dikenalpasti melalui Sistem Sedia Ada diselesaikan atau diubahsuai. Petunjuk indeks prestasi Sistem Diperbaiki seterusnya dibandingkan dengan petunjuk indeks prestasi Sistem Sedia Ada bagi menentukan sama ada perubahan yang dilakasanakan membawa sebarang peningkatan terdadap prestasi OSOC. Bagi tujuan tersebut, analisis kepekaan turut dijalankan bagi mengenal pasti tindak balas sistem yang dicadangkan terhadap perubahan seperti nombor temujanji, kadar "ketidakhadiran" atau penempahan secara paksa.

Berdasarkan simulasi-simulasi ini, pengubahsuaian mampu mengurangkan PWT secara efektif dalam Sistem Diperbaiki berbanding dengan Sistem Sedia Ada. Tambahan pula, semua sesi perawatan yang disimulasi memenuhi garis panduan Indeks Prestasi Utama klinik. Sebagai kelebihan tambahan, 90% daripada sesi perawatan yang dimodelkan telah berjaya mengurangkan penangguhan masa penamatan. Dalam analisis kepekaan, model yang dicadangkan berjaya menunjukkan kebolehan untuk bertindak balas secara berbeza terhadap pelbagai perubahan dalam parameter masukan. Secara kesimpulan, hasil kajian ini menunjukkan bahawa PWT di klinik rawatan pesakit luar dapat dikurangkan secara 53.7-97.0% dengan mengaplikasikan penetapan yang diperbaiki melalui pemodelan dan simulasi berbantukan komputer.

© COPYRIGHT UPM

ACKNOWLEDEGEMENTS

I would like to take this opportunity to express my sincere appreciation to all of the people who have provided encouragement, help and support during my Master process. First of all, I would like to thank my supervisor Associate Professor Dr. Tang Sai Hong for his inspirations, professional guidance, constructive comments and untiring support. He is the best mentor I have ever had during my journey in Universiti Putra Malaysia. I would not have achieved this far without his support and help.

I would like to express my thanks to my co-supervisor Associate Professor Dr. Manohar Arumugam for his interest in my proposal. His input into this thesis with his knowledge in healthcare was very helpful in guiding me into the right direction.

My sincere appreciation is also extended to Professor Dr. Rosnah Mohd Yusuff for her guidance, effort and encouragement throughout this research.

Moreover, I would like to thank Mr. Ang Kim Leong, manager of Clinical Research Centre, Hospital Serdang for assisting in getting approval for this thesis project. Besides, thanks for all cooperation and help from Orthopaedic Specialist Outpatient Clinic (OSOC) staff: Tuan Haji Ramli (Clinic Manager), Mr. Suhaimi (Assistant Clinic Manager) and all other staff in clinic. Without their help and support, I would not have completed this project successfully.

Also, thanks to Universiti Putra Malaysia for providing the funding (04-01-11-1175RU) for this project. The fund enables me to hire some students to run data collection in OSOC. In addition, I would like to thank Mr. Jim Holtman and Mr. Jorge Villacampa for their help in Simul8 software.

Finally, I would like to express my heartiest gratitude and appreciation to my family and all my friends who helped me throughout my research. With their company, my journey in Universiti Putra Malaysia has finally completed with a perfect ending.

© COPYRIGHT UPM

I certify that a Thesis Examination Committee has met on 29th May 2014 to conduct the final examination of Pah Pin Shang on his thesis entitled "Development Of Orthopaedic Outpatient Clinic Scheduling Information System for Performance Improvement" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science

Members of the Thesis Examination Committee were as follows:

Faieza binti Abdul Aziz, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Mohd Khairol Anuar bin Mohd Ariffin, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Nuraini binti Abdul Aziz, PhD
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Shamsuddin Ahmed, PhD
Associate Professor
Universiti Malaya
Malaysia
(External Examiner)

NORITAH OMAR, PhD
Associate Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 21th July 2014

© COPYRIGHT UPM

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

Tang Sai Hong, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Manohar Arumugam
Associate Professor
Faculty of Medicine and Health Sciences
Universiti Putra Malaysia
(Member)

Rosnah binti Mohd Yusuff, PhD
Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

© COPYRIGHT UPM

_____
BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or concurrently for any other degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-owned by Universiti Putra Malaysia, as according to the Universiti Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Deputy Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings, seminar papers, manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated in the Universiti Putra Malaysia (Research) Rules 2012;
- there is no plagiarism or data falsification/fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the Universiti Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____ Date: 07th July 2014

Name and Matric No.: Pah Pin Shang and GS27886

© COPYRIGHT UPM

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) are adhered to.

Signature: _____	Signature: _____
Name of Chairman of Supervisory Committee: _____	Name of Member of Supervisory Committee: _____
Signature: _____	Signature: _____
Name of Member of Supervisory Committee: _____	Name of Member of Supervisory Committee: _____

© COPYRIGHT UPM

TABLE OF CONTENTS

		Page
ABSTRACT		iii
ABSTRAK		v
ACKNOWLEDEGEMENTS		vii
APPROVAL		viii
DECLARATION		x
LIST OF TABLES		xv
LIST OF FIGURES		xvii
LIST OF ABBREVIATIONS		xx
CHAPTER		
1.	**INTRODUCTION**	**1**
	1.1. Background of the study	1
	1.2. Problem statement	2
	1.3. Objective	4
	1.4. Scope	5
	1.5. Organisation of thesis	5
2.	**LITERATURE REVIEW**	**7**
	2.1. Introduction	7
	2.2. Healthcare	7
	2.3. Outpatient department	8
	2.4. Contemporary challenges confronting urban outpatient clinics	8
	2.5. Methods to solve outpatient clinic problem	9
	2.6. Advantages of simulation	10
	2.7. The application of computer simulation in outpatient clinics	11
	2.7.1. Outpatient scheduling with simulation	11
	2.7.2. Patient flow in outpatient clinic	15
	2.7.3. Outpatient clinic resource allocation	17
	2.7.4. Integrating outpatient scheduling and resources allocation	20
	2.8. Selection of simulation software for this project	20
	2.9. Sensitivity Analysis	22
	2.9.1. Used of sensitivity analyses in healthcare	22
	2.10. Summary	23
3.	**METHODOLOGY**	**25**
	3.1. Introduction	25

© COPYRIGHT UPM

3.2. Determining the process and data collection 27
3.3. Modelling the Current System with Simul8 30
3.3.1. Simulation objective function 31
3.4. Verification and validation of model 33
3.4.1. Verification of the current model 34
3.4.2. Validation of the current model 34
3.5. Identify the areas of improvement 35
3.6. Implementing the changes into the new model 35
3.7. Modelling result analysis 35
3.8. Sensitivity analyses 35
3.9. Summary 36

4. RESULT AND DISCUSSION 38
4.1. Outpatient clinic description 38
4.1.1. Overview 38
4.1.2. Staff and resources 38
4.1.3. Operations 39
4.1.4. Appointment scheduling process 42
4.1.5. Registration process 43
4.1.6. Doctor service process 44
4.1.6.1. Doctor consultation duration 45
4.2. Current System performance 47
4.2.1. Outpatient clinic capacity 47
4.2.2. Patient waiting time 47
4.2.3. Percentage of patients seen by doctors within 90 minutes after registration 49
4.2.4. Clinics end time 50
4.2.5. Patient no show 51
4.3. Simulation of the outpatient clinics 51
4.3.1. Simulation model description 53
4.3.2. Level and assumptions of simulation model 56
4.3.3. Simulation model verification and validation 57
4.4. Identification of area for improvement 58
4.4.1. Resources shortage of senior doctor 58
4.4.2. Late arrival of doctors 58
4.4.3. Appointment scheduling 58
4.4.4. Operating time for orthopaedic clinic two 60
4.5. Simulation modelling result 62
4.5.1. Patients' waiting time 62
4.5.2. KPI of PWT 67
4.5.3. The clinic end time and overtime 72
4.6. Sensitivity analyses 74
4.6.1. Patients' waiting time 74
4.6.2. KPI of PWT 80

© COPYRIGHT UPM

4.6.3. Clinic end time and overtime 86

5. CONCLUSION AND RECOMMENDATION 88
5.1. Conclusion 88
5.2. Thesis contribution 89
5.3. Recommendation 89

REFERENCES 91
APPENDICES 99
BIODATA OF STUDENT 114
PUBLICATIONS 115

© COPYRIGHT UPM