PUBLIC HEALTHCARE FACILITY PLANNING IN MALAYSIA: USING LOCATION ALLOCATION MODELS

S.SARIFAH RADIAH BINTI SHARIFF

INSTITUTE OF MATHEMATICAL SCIENCES
FACULTY OF SCIENCE
UNIVERSITY OF MALAYA
KUALA LUMPUR

2012

PUBLIC HEALTHCARE FACILITY PLANNING IN MALAYSIA: USING LOCATION ALLOCATION MODELS

S.SARIFAH RADIAH BINTI SHARIFF

THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

INSTITUTE OF MATHEMATICAL SCIENCES
FACULTY OF SCIENCE
UNIVERSITY OF MALAYA
KUALA LUMPUR

2012

UNIVERSITI MALAYA

ORIGINAL LITERARY WORK DECLARATION

Name of Candidate: **S.Sarifah Radiah Binti Shariff**
I.C./Passport No.: **670601-10-6584**
Registration / Matric No.: **SHB070003**
Name of Degrees: **Doctor of Philosophy (PhD)**
Title of Project Paper / Research Report / Dissertation / Thesis ("this Work"):
Public Healthcare Facility Planning In Malaysia: Using Location Allocation Models.

Field of Study: **Operational Research**

I do solemnly and sincerely declare that:

(1) I am the sole author/writer of this Work;
(2) This Work is original;
(3) Any use of any work in which copyright exists was done by way of fair dealing and for permitted purposes and any excerpt or extract from, or reference to or reproduction of any copyright work has been disclosed expressly and sufficiently and the title of the Work and its authorship have been acknowledged in this Work;
(4) I do not have any actual knowledge nor do I ought reasonably to know that the making of this work constitutes an infringement of any copyright work;
(5) I hereby assign all and every rights in the copyright to this Work to the University of Malaya ("UM"), who henceforth shall be owner of the copyright in this Work and that any reproduction or use in any form or by any means whatsoever is prohibited without the written consent of UM having been first had and obtained;
(6) I am fully aware that if in the course of making this Work I have infringed any copyright whether intentionally or otherwise, I may be subject to legal action or any other action as may be determined by UM.

Candidate's Signature Date:

Subscribed and solemnly declared before,

Witness's Signature Date:
Name:

Designation:

ABSTRACT

In many developing nations, the locations of public facilities are generally taken locally by government officers or by local elected leaders or by both. In Malaysia, the location of public health care are determined using some guidelines that were developed based on experience or some statistical information. There is still lack of formal analysis being carried out. As a result the decisions can very often be far from optimal. This study attempts to develop some mathematical location-allocation models for the locations of the public health care facilities in Malaysia. Two basic location allocation models with two different objectives are studied: The *p*-median problem and the Maximal Covering Location Problem (MCLP). We designed several solution methods by considering the un-capacitated, capacitated constraints and multiple objectives. The first part of the study focuses on the systems with un-capacitated facilities. The public healthcare facilities in Telok Panglima Garang(TPG), Selangor are taken as a case study to apply the models, and analyze the past and current location decisions. The models are extended to the capacitated case where a bigger district of Kuala Langat, Selangor is considered. These models which are in form of mixed integer programming models are solved using commercial optimization software CPLEX 10.2. The results from CPLEX are observed to violate some of facilities' constraint, thus making the solutions infeasible. A heuristic based on Genetic Algorithm (GA) is proposed and some computational analysis is carried out to gauge the performance of the existing facilities. In the third part of the study, a new model that simultaneously considers the *p*-median and the MCLP is proposed. The model is solved using a weighted sum multi objective approach that simultaneously minimizes

the average distance traveled (*p*-median) and maximizes the coverage percentage (MCLP). The data set are used to illustrate the effectiveness of the model. The fourth part concentrates on the development of a dynamic location model that incorporates a time factor. A sensitivity analysis which considers the future increase in demand and the need for new health care facilities is also carried out to assist the relevant authority to make proper planning of health care systems in Selangor and in Malaysia in general.

ABSTRAK

Di kebanyakan negara-negara membangun, lokasi kemudahan awam secara umumnya ditentukan oleh pegawai-pegawai kerajaan atau oleh pemimpin setempat yang dipilih atau kedua-duanya. Di Malaysia, lokasi penjagaan kesihatan awam ditentukan dengan menggunakan beberapa garis panduan yang telah dibangunkan berdasarkan pengalaman atau beberapa maklumat statistik. Terdapat masih kekurangan analisis formal yang dijalankan. Hasilnya keputusan selalunya boleh jauh dari optimum. Kajian ini cuba untuk membangunkan beberapa model matematik lokasi-peruntukan bagi lokasi penjagaan kemudahan kesihatan awam di Malaysia. Dua model asas peruntukan lokasi dengan dua objektif yang berbeza dikaji: Masalah *p*-median dan Masalah Lokasi Litupan Maksimal (MCLP). Kajian ini membentangkan beberapa kaedah penyelesaian model yang mempertimbangkan kekangan tidak had kapasiti bagi sesebuah kemudahan, berkapasiti dan berobjektif pelbagai. Bahagian pertama kajian ini memberi tumpuan kepada sistem dengan kemudahan tiada had kapasiti untuk kemudahan penjagaan kesihatan awam di Malaysia. Penjagaan kemudahan kesihatan awam di Telok Panglima Garang (TPG), Selangor telah diambil sebagai kajian kes untuk mengaplikasikan model bagi menganalisis keputusan lokasi di masa lalu dan semasa. Model-model itu diperluaskan kepada sekiranya kemudahan-kemudahan ini ada had kapasiti. Untuk tujuan ini, kawasan kajian yang lebih besar telah digunakan iaitu Daerah Kuala Langat, Selangor. Campuran model pengaturcaraan integer ini diselesaikan dengan menggunakan persisian komersial CPLEX 10,2. Hasil keputusan yang diperolehi dari CPLEX adalah didapati melanggar beberapa kekangan bagi kemudahan ini, sekali gus menjadikan penyelesaian infeasible. Heuristik yang

berdasarkan Algoritma Genetik (GA) adalah dicadangkan dan beberapa analisis pengiraan adalah dijalankan untuk mengukur prestasi kemudahan yang sedia ada. Dalam bahagian ke tiga kajian, satu model baru yang mempertimbangkan ke dua-dua objektif bagi model *p*-median dan MCLP pada masa yang sama adalah dicadangkan. Model ini diselesaikan dengan menggunakan sejumlah objektif wajaran pendekatan pelbagai yang pada masa yang sama mengurangkan purata jarak perjalanan (*p*-median) dan memaksimumkan peratusan liputan (MCLP). Set data adalah digunakan untuk menggambarkan keberkesanan model. Bahagian keempat akan memberi tumpuan kepada pembangunan model lokasi dinamik yang menggabungkan faktor masa. Analisis sensitiviti yang mengambil kira peningkatan permintaan dan keperluan untuk kemudahan penjagaan kesihatan yang baru juga akan dilaksanakan untuk membantu pihak berkuasa yang berkaitan untuk membuat perancangan yang sesuai bagi sistem penjagaan kesihatan di Selangor dan di Malaysia secara amnya.

ACKNOWLEDGEMENTS

I would like to express my sincere appreciation to my supervisors, Associate Professor Dr. Mohd Omar and Associate Professor Dr Noor Hasnah Moin, for their guidance, support and encouragement over the years. Their understanding and patience and valuable advice have been the keys to the success of this work. Thanks are extended to the committee members for their constructive comments in this research.. Also a special gratitude is acknowledged to Dr. David Smith for his helpful suggestions in doing this study.

I am grateful to the Ministry of Higher Education Malaysia and Universiti Teknologi MARA, for funding my study. I am also very much grateful to the Public Health Department of Ministry of Health Malaysia and Selangor Health Department, for approving the collection of real-world data on public health facilities in the study area. I would like to thank my special friends, Dr Sayang Mohd Deni, Ms Sanizah Ahmad and Ms Haliza Abd Hamid for their support and help throughout all these years. Not to forget to all of my good friends out there whom have always directly or indirectly motivate this journey.

Finally, with deep sense of gratitude, I especially want to thank my husband, Mr Nordin Alip, my mother, my sisters, my brother, my children and my in-laws who have always supported me in all my pursuits. Without their tremendous love, I would not have been able to concentrate on my study and endure some difficult times through all these years. And Alhamdulillah, Praise to Allah for His Blessings and without His Will, this study will never be completed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF ABBREVIATIONS

BA	Bionomic Algorithm
BHMM	Baldacci et al.
CC	Community Clinic
CCP	Capacitated Clustering Problem
CGA	Constructive Genetic Algorithm
CMCLP	Capacitated Maximal Covering Location Problem
CPkMP	Capacitated *p*-median with *k* existing facilities
CPMP	Capacitated *p*-median Problem
CPU	Computer Processing Unit
CS	Concentration Set
EMS	Emergency Medical Service
FNS	Fixed Neighbourhood Search
GA	Genetic Algorithm
GAP	Generalised Assignment Problem
GCSM	Guided Construction Search Meta-heuristic
GP	Government Policy
GRAMPS	Greedy Random Adaptive Memory Search Method
GRASP	Greedy Randomized Adaptive Search Procedure
GRIA	Global/Regional Interchange Algorithm
HC	Health Clinics
HCLP	Hierarchical Covering Location Problem
HFWC	Health and Family Welfare Centres

IDW	Inverse Distance Weighted
IMR	Infant Mortality Rate
ITH	Interchange Transfer Heuristic
J_GA	Jaramillo's Genetic Algorithm Representation
JKNS	Jabatan Kesihatan Negeri Selangor
KB	Kebun Bharu
KD	Klinik Desa
KK S	Klinik Kesihatan Sijangkang
KK TPG	Klinik Kesihatan Telok Panglima Garang
KK	Klinik Kesihatan
KLIA	Kuala Lumpur International Airport
KM	Kampung Medan
LAH	Location Allocation Heuristic
LP	Linear Programming
L-S	Lagrangean-Surrogate
LSCP	Location Set Covering Problem
LSLSH	Local Search Heuristic
MB	Mulvey & Beck
MCLP	Maximal Covering Location Problem
MCP	Maximal Covering Problem
mCPMP	Modified Capacitated *p*-median Problem
mGA	Modified Genetic Algorithm
MOE	Ministry of Education Malaysia
MOH	Ministry of Health Malaysia
MOLIP	Multi-Objective Linear Integer Programming
MTPG	Mukim Telok Panglima Garang

NHA	National Health Account
NHP	National Health Policy
NISE	Non Inferior Set Estimation
NP	Non Polynomial
OC	Osman & Christofides
OC-GA	Opportunity Cost Genetic Algorithm
OPL	Optimization Programming Language
OR	Operation Research
PCLS	Periodic Construction Local Search
PHC	Primary Healthcare
PP	Proposed Policy
RBK	Rumah Bidan Kerajaan
RC	Rural Clinics
SA	Simulated Annealing
SD	Sijangkang Dalam
SIC	Staff In Charge
SJC	San Jose Campus-city
SL	Sijangkang Luar
SP	Staff Perception
SQM	Stochastic Queue Median
SSCPLP	Single Source Capacitated Plant Location Problem
SS-PR	Scatter Search using Path Relinking
SS-V	Scatter Search by Voting
TPG	Telok Panglima Garang
TS	Tabu Search
UFLP	Un-capacitated Facility Location Problem

UK	United Kingdom
USA	United States of America
VNS	Variable Neighborhood Search
WHO	World Health Organization
WPRO	WHO Regional Office