PARAMETER ESTIMATION FOR OPTIMISED NUMBER OF BEDS IN HOSPITAL PLANNING DESIGN

YAHAYA BIN HASSAN

A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy (Health Science)

Department of Biomedical Engineering & Health Sciences
Faculty of Engineering
Universiti Teknologi Malaysia

SEPTEMBER 2022

DEDICATION

This thesis is dedicated to my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

ACKNOWLEDGEMENT

In preparing this thesis, I was in contact with many people, researchers, academicians, and practitioners. They have contributed towards my understanding and thoughts. In particular, I wish to express my sincere appreciation to my main thesis supervisor, Assoc. Professor Ir. Dr. Azli bin Yahya for encouragement, guidance, critics and friendship. I am also very thankful to my co-supervisor Associate Professor Dr. Norhalimah bt. Idris for their guidance, advices and motivation. Without their continued support and interest, this thesis would not have been the same as presented here. My gratitude to my research officer, Mr. Luqman Hafiz bin Elias and Siraj Munir bin Yahaya.

I am also indebted to Universiti Teknologi Malaysia (UTM) for my Ph.D study. Librarians at UTM, KPJ Berhad and Ministry of Health (MOH) Malaysia also deserve special thanks for their assistance in supplying the relevant literatures.

My fellow postgraduate student should also be recognised for their support. My sincere appreciation also extends to all my colleagues and others who have provided assistance at various occasions. Their views and tips are useful indeed. Unfortunately, it is not possible to list all of them in this limited space. I am grateful to all my family member.

ABSTRACT

Designing hospital buildings are a complex process which has to cater for different needs and requirements. The healthcare industry is expanding rapidly as the population increase in both public and private sector. Other than population, the other variables which can affect the number of hospital beds requirement are (1) admission rate, (2) average length of stay and (3) bed occupancy rate. Various models and methods for determining the number of hospital beds were developed to cater for regional and hospital level requirements. The factors for planning hospital capacity are based on the population of the region, the frequency of admission, occupancy of bed as well as length of stay. This thesis proposes a new predictive formula to determine the number of hospital beds by replacing the variable population of region and frequency of admission, with number of outpatients within the region and conversion rate of outpatient to inpatient respectively. Further discussion has been focused on the initial stage of hospital planning which incorporate nine design parameters in five design processes and the relationship between these parameters in each design processes as to determine the correct bed capacity. Data was analysed using Microsoft Excel – Data Analysis method of Regression Analysis during the research. This method was used to establish and predict the dependent variable (number of beds) using one or more independent variables. It was also predict the design bed capacity with a given suitable data's that have been extracted from management and operation inputs. Outputs from regression analysis successfully produced the trend in graphical form that predict the bed capacity. Using 8 private hospitals data from KPJ Hospitals and Health Facts from Ministry of Health Malaysia, results show a correlation between number of bed (dependent parameter) and other independent parameters which are, No. of Clinics, No. of Outpatients, No. of Inpatients, Bed Occupancy Rate and Length of Stay. Based on these 5 independent variables, the formula managed to predict the optimum number of beds required at hospital levels. Therefore, these parameters can be used to calculate the gap between formulated number of beds and the available bed to determine the present/future bed requirement.

ABSTRAK

Mereka bentuk bangunan hospital adalah proses kompleks yang perlu memenuhi pelbagai keperluan dan kehendak.. Industri Kesihatan di dalam sektor awam atau swasta akan mulai berkembang pesat apabila populasi penduduk dalam sesuatu kawasan meningkat. Selain daripada populasi penduduk, faktor lain yang mempengaruhi bilangan keperluan katil hospital ialah (1) kadar kemasukan pesakit, (2) purata hari penginapan pesakit dan (3) kadar penggunaan katil hospital. Pelbagai model dan kaedah untuk menentukan bilangan katil hospital telah dibangunkan untuk memenuhi keperluan peringkat wilayah dan hospital. Faktor perancangan kapasiti katil hospital adalah berdasarkan populasi kawasan, kekerapan kadar kemasukan pesakit, kadar penggunaan katil serta tempoh hari penginapan pesakit. Tesis ini mencadangkan formula ramalan baharu untuk menentukan bilangan katil hospital dengan menggantikan pembolehubah populasi kawasan dan frekuensi kemasukan pesakit, dengan bilangan pesakit luar dan kadar penukaran pesakit luar kepada pesakit dalam.. Perbincangan lanjut telah ditumpukan pada peringkat awal perancangan hospital yang menggabungkan dengan sembilan parameter reka bentuk bersama lima proses reka bentuk dan menerangkan hubungan parameter dengan setiap proses reka bentuk tersebut bagi menentukan kapasiti katil. Data dianalisis menggunakan Microsoft Excel – kaedah Data Analisis Regresi semasa penyelidikan. Kaedah ini digunakan untuk mewujudkan dan meramal pembolehubah bersandar (bilangan katil) dengan satu atau lebih pembolehubah tidak bersandar, Ia juga meramalkan kapasiti katil berdasarkan data yang diekstrak daripada perolehan Bahagian Pengurusan dan Operasi hospital. Hasil daripada Data Analisis Regresi ini berjaya menghasilkan trend di dalam bentuk graf bagi meramalkan kapasiti katil. Menggunakan data 8 hospital swasta daripada Hospital KPJ dan laporan *Health Facts* terbitan Kementerian Kesihatan Malaysia, keputusan menunjukkan korelasi antara bilangan katil (pembolehubah bersandar) dan pembolehubah tidak bersandar yang lain. Berdasarkan 5 pembolehubah tidak bersandar ini, formula berjaya meramalkan bilangan optimum katil yang diperlukan di peringkat hospital. Oleh itu, parameter ini boleh digunakan untuk mengira jurang antara bilangan katil yang dirumuskan dan katil yang tersedia untuk menentukan keperluan katil masa kini atau masa hadapan.

TABLE OF CONTENTS

TITLE		PAGE
DECLARATION		**iii**
DEDICATION		**iv**
ACKNOWLEDGEMENT		**v**
ABSTRACT		**vi**
ABSTRAK		**vii**
TABLE OF CONTENTS		**viii**
LIST OF TABLES		**xi**
LIST OF FIGURES		**xv**
LIST OF ABBREVIATIONS		**xxi**
LIST OF APPENDICES		**xxiii**
CHAPTER 1	**INTRODUCTION**	**1**
1.1	Background of the study	1
1.2	Problem Statement	6
1.3	Aim and Objectives	8
1.4	Scope of study	8
1.5	Significance of the study	9
1.6	Organizational of the thesis	10
1.7	Summary	11
CHAPTER 2	**LITERATURE REVIEW**	**13**
2.1	Introduction	13
2.2	Parameters used in hospital planning and design	16
	2.2.1 Bed Capacity and Occupancy	16
2.3	Relationship between parameters in hospital design and planning	20
2.4	Chapter Summary	23

CHAPTER 3 RESEARCH METHODOLOGY 25
3.1 Introduction 25
3.1.1 Source of Data 25
3.1.2 Case study 35
3.2 Methodology 35
3.3 Analysis 36
3.3.1 The Trend Analysis 36
3.4 Summary 36

CHAPTER 4 CASE STUDY 1: MATURE HOSPITAL 37
4.1 Introduction 37
4.2 Chapter Summary 83

CHAPTER 5 CASE STUDY 2: NEW HOSPITAL 85
5.1 Introduction 85
5.2 Chapter Summary 107

CHAPTER 6 CASE STUDY 3: RELOCATED HOSPITAL 109
6.1 Introduction 109
6.2 Chapter Summary 131

CHAPTER 7 FINDINGS 133
7.1 Introduction 133
7.2 Data Analysis 133
7.3 Main Results 134
7.3.1 KPJ Hospital – Mature Hospital 134
7.3.2 KPJ Hospital – New Hospital 144
7.3.3 KPJ Hospital – Relocated Hospital 148
7.4 Data Analysis 152
7.4.1 Mature Hospital 153
7.4.2 New Hospital 155
7.4.3 Relocated Hospital 156
7.5 Chapter Summary 157

CHAPTER 8 CONCLUSION AND RECOMMENDATIONS 161

8.1 Research Outcomes 161

8.2 Conclusion 163

8.3 Contribution to Knowledge 169

8.4 Limitation of the Study 169

8.5 Recommendations 169

8.5.1 Sustainability and Flexibility 170

8.5.2 Safety and Security 170

8.6 Summary 172

REFERENCES 173

LIST OF PUBLICATIONS 313

LIST OF TABLES

TABLE NO.	TITLE	PAGE
Table 1.1	Malaysia Healthcare System hospital providers	3
Table 1.2	Key Health Service Delivery Supply-Side Indicators, 2015–2020	5
Table 1.3	Secondary care health facilities, 2020	5
Table 2. 1	Key of factors in determine number of beds	14
Table 2. 2	Application in selected models for their advantages and challenges of use in determine the number of beds	20
Table 2. 3	Statistics of Bed Ration Based on Regions	21
Table 2. 4	Statistics of Malaysia Population and Hospitals in Year 2019	22
Table 2. 5	Statistics of Malaysia Population and Hospitals in Year 2020	22
Table 4. 1	KPJ Johor five (5) Variables Data	37
Table 4. 2	KPJ Johor - No. of Clinics (Variables 1)	39
Table 4. 3	KPJ Johor - No. of Outpatients (Variables 2)	41
Table 4. 4	KPJ Johor - No. of Inpatients (Variables 3)	43
Table 4. 5	KPJ Johor - 1/Bed Occupancy Rate (Variables 4)	45
Table 4. 6	KPJ Johor - Length of Stay (day) (Variables 5)	47
Table 4. 7	KPJ IPOH five (5) Variables Data	50
Table 4. 8	KPJ Ipoh - No. of Clinics (Variables 1)	50
Table 4. 9	KPJ Ipoh- No. of Outpatients (Variables 2)	52
Table 4. 10	KPJ Ipoh - No. of Inpatients (Variables 3)	54
Table 4. 11	KPJ Ipoh - 1/Bed Occupancy Rate (Variables 4)	56
Table 4. 12	KPJ Ipoh - Length of Stay (day) (Variables 5)	58
Table 4. 13	KPJ Damansara five (5) Variables Data	61
Table 4. 14	KPJ Damansara - No. of Clinics (Variables 1)	61
Table 4. 15	KPJ Damansara- No. of Outpatients (Variables 2)	63

Table 4. 16	KPJ Damansara - No. of Inpatients (Variables 3)	65
Table 4. 17	KPJ Damansara - 1/Bed Occupancy Rate (Variables 4)	67
Table 4. 18	KPJ Damansara - Length of Stay (day) (Variables 5)	69
Table 4. 19	KPJ Ampang five (5) Variables Data	72
Table 4. 20	KPJ Ampang - No. of Clinics (Variables 1)	72
Table 4. 21	KPJ Ampang- No. of Outpatients (Variables 2)	74
Table 4. 22	KPJ Ampang - No. of Inpatients (Variables 3)	76
Table 4. 23	KPJ Ampang - 1/Bed Occupancy Rate (Variables 4)	78
Table 4. 24	KPJ Ampang - Length of Stay (day) (Variables 5)	80
Table 4. 25	R^2 value for four (4) mature KPJ Hospital	83
Table 5. 1	KPJ Rawang five (5) Variables Data	85
Table 5. 2	KPJ Rawang - No. of Clinics (Variables 1)	86
Table 5. 3	KPJ Rawang- No. of Outpatients (Variables 2)	88
Table 5. 4	KPJ Rawang - No. of Inpatients (Variables 3)	90
Table 5. 5	KPJ Rawang - 1/Bed Occupancy Rate (Variables 4)	92
Table 5. 6	KPJ Rawang - Length of Stay (day) (Variables 5)	94
Table 5. 7	KPJ Pasir Gudang five (5) Variables Data	96
Table 5. 8	KPJ Pasir Gudang - No. of Clinics (Variables 1)	96
Table 5. 9	KPJ Pasir Gudang- No. of Outpatients (Variables 2)	98
Table 5. 10	KPJ Pasir Gudang - No. of Inpatients (Variables 3)	100
Table 5. 11	KPJ Pasir Gudang - 1/Bed Occupancy Rate (Variables 4)	102
Table 5. 12	KPJ Pasir Gudang - Length of Stay (day) (Variables 5)	105
Table 5. 13	R^2 value for two (2) new KPJ Hospital	107
Table 6. 1	KPJ Sabah five (5) Variables Data	109
Table 6. 2	KPJ Sabah - No. of Clinics (Variables 1)	110
Table 6. 3	KPJ Sabah- No. of Outpatients (Variables 2)	112
Table 6. 4	KPJ Sabah - No. of Inpatients (Variables 3)	114
Table 6. 5	KPJ Sabah – 1/Bed Occupancy Rate (Variables 4)	116
Table 6. 6	KPJ Sabah - Length of Stay (day) (Variables 5)	118

Table 6. 7	KPJ Tawakal five (5) Variables Data	120
Table 6. 8	KPJ Tawakal - No. of Clinics (Variables 1)	120
Table 6. 9	KPJ Tawakal- No. of Outpatients (Variables 2)	123
Table 6. 10	KPJ Tawakal - No. of Inpatients (Variables 3)	125
Table 6. 11	KPJ Tawakal - 1/Bed Occupancy Rate (Variables 4)	127
Table 6. 12	KPJ Tawakal - Length of Stay (day) (Variables 5)	129
Table 6. 13	R^2 value for two (2) KPJ Hospital	131
Table 7. 1	R2 value for eight (8) KPJ Hospital	133
Table 7. 2	KPJ Johor three (3) Multiple Parameters	135
Table 7. 3	KPJ Johor – Multiples Parameter (Variables 3.4.5)	136
Table 7. 4	Comparison of Actual No. of Bed and Calculated No. of Bed in KPJ Johor year 2014-2018	137
Table 7. 5	KPJ Ipoh three (3) Multiple Parameters	138
Table 7. 6	KPJ Ipoh– Multiples Parameter (Variables 3.4.5)	138
Table 7. 7	Comparison of Actual No. of Bed and Calculated No. of Bed in KPJ Ipoh year 2014-2018	139
Table 7. 8	KPJ Damansara three (3) Multiple Parameters	140
Table 7. 9	KPJ Damansara – Multiples Parameter (Variables 3.4.5)	140
Table 7. 10	Comparison of Actual No. of Bed and Calculated No. of Bed in KPJ Damansara year 2014-2018	140
Table 7. 11	KPJ Ampang three (3) Multiple Parameters	142
Table 7. 12	KPJ Ampang – Multiples Parameter (Variables 3.4.5)	142
Table 7. 13	Comparison of Actual No. of Bed and Calculated No. of Bed in KPJ Ampang year 2014-2018	142
Table 7. 14	KPJ Rawang three (3) Multiple Parameters	144
Table 7. 15	KPJ Rawang– Multiples Parameter (Variables 3.4.5)	144
Table 7. 16	Comparison of Actual No. of Bed and Calculated No. of Bed in KPJ Rawang year 2014-2018	145
Table 7. 17	KPJ Pasir Gudang three (3) Multiple Parameters	146
Table 7. 18	KPJ Pasir Gudang – Multiples Parameter (Variables 3.4.5)	146

Table 7. 19	Comparison of Actual No. of Bed and Calculated No. of Bed in KPJ Pasir Gudang year 2014-2018	146
Table 7. 20	KPJ Sabah three (3) Multiple Parameters	148
Table 7. 21	KPJ Sabah– Multiples Parameter (Variables 3.4.5)	148
Table 7. 22	Comparison of Actual No. of Bed and Calculated No. of Bed in KPJ Sabah year 2014-2018	149
Table 7. 23	KPJ Tawakal three (3) Multiple Parameters	150
Table 7. 24	KPJ Tawakal – Multiples Parameter (Variables 3.4.5)	150
Table 7. 25	Comparison of Actual No. of Bed and Calculated No. of Bed in KPJ Tawakal year 2014-2018	150
Table 7. 26	Category of KPJ Hospital	152
Table 7. 27	KPJ Ampang table of data year 2014	154
Table 7. 28	BOR cluster	155
Table 7. 29	Summary of Regression Line for KPJ Hospital Actual No. of Bed, Nbed and No. of Bed (Multiple Parameters) in 2014 to 2018	160
Table 8. 1	Average Los of Private Hospital during 2018-2019 by MOH	164
Table 8. 2	Average Los of government hospital during 2018-2019 by MOH	165
Table 8. 3	Cop-ip of Private Hospital during 2018-2019 by MOH	165
Table 8. 4	Cop-ip based on MOH Health Facts for year 2018-2019	166

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
Figure 1. 1	Per capita income in selected East Asian economies between year 2000-2018 (World Health Organization Global Health Expenditure, n.d.)	2
Figure 1. 2	Ratio of Bed to Population	6
Figure 3. 1	Elements & Variables in Hospital Planning & Design	28
Figure 3. 2	Overall hospital design process flowchart	29
Figure 4. 1	No. of Clinics (V1) vs No. of Bed for KPJ Johor Hospital	39
Figure 4. 2	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Johor Hospital – Variable 1	40
Figure 4. 3	No. of Outpatients (V2) vs No. of Bed for KPJ Johor Hospital	41
Figure 4. 4	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Johor Hospital – Variable 2	42
Figure 4. 5	No. of Inpatient (V3) vs No. of Bed for KPJ Johor Hospital	43
Figure 4. 6	Figure 4. 4 Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Johor Hospital – Variable 3	44
Figure 4. 7	1/Bed Occupancy Rate (V4) vs No. of Bed for KPJ Johor Hospital	46
Figure 4. 8	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Johor Hospital – Variable 4	46
Figure 4. 9	Length of Stay (V5) vs No. of Bed for KPJ Johor Hospital	48
Figure 4. 10	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Johor Hospital – Variable 5	48
Figure 4. 11	No. of Clinics (V1) vs No. of Bed for KPJ Ipoh Hospital	51

Figure 4. 12	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Ipoh Hospital – Variable 1	51
Figure 4. 13	No. of Outpatient (V2) vs No. of Bed for KPJ Ipoh Hospital	53
Figure 4. 14	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Ipoh Hospital – Variable 2	53
Figure 4. 15	No. of Inpatient (V3) vs No. of Bed for KPJ Ipoh Hospital	55
Figure 4. 16	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Ipoh Hospital – Variable 3	55
Figure 4. 17	1/Bed Occupancy Rate (V4) vs No. of Bed for KPJ Ipoh Hospital	57
Figure 4. 18	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Ipoh Hospital – Variable 4	57
Figure 4. 19	Length of Stay (V5) vs No. of Bed for KPJ Ipoh Hospital	59
Figure 4. 20	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Ipoh Hospital – Variable 5	59
Figure 4. 21	No. of Clinics (V1) vs No. of Bed for KPJ Damansara Hospital	62
Figure 4. 22	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Damansara Hospital – Variable 1	62
Figure 4. 23	No. of Outpatient (V2) vs No. of Bed for KPJ Damansara Hospital	64
Figure 4. 24	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Damansara Hospital – Variable 2	64
Figure 4. 25	No. of Inpatient (V3) vs No. of Bed for KPJ Damansara Hospital	66
Figure 4. 26	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Damansara Hospital – Variable 3	66
Figure 4. 27	1/Bed Occupancy Rate (V4) vs No. of Bed for KPJ Damansara Hospital	68

Figure 4. 28 Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Damansara Hospital – Variable 4 68

Figure 4. 29 Length of Stay (V5) vs No. of Bed for KPJ Damansara Hospital 70

Figure 4. 30 Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Damansara Hospital – Variable 5 70

Figure 4. 31 No. of Clinics (V1) vs No. of Bed for KPJ Ampang Hospital 73

Figure 4. 32 Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Ampang Hospital – Variable 1 73

Figure 4. 33 No. of Outpatient (V2) vs No. of Bed for KPJ Ampang Hospital 75

Figure 4. 34 Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Ampang Hospital – Variable 2 75

Figure 4. 35 No. of Inpatient (V3) vs No. of Bed for KPJ Ampang Hospital 77

Figure 4. 36 Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Ampang Hospital – Variable 3 77

Figure 4. 37 1/Bed Occupancy Rate (V4) vs No. of Bed for KPJ Ampang Hospital 79

Figure 4. 38 Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Ampang Hospital – Variable 4 79

Figure 4. 39 Length of Stay (V5) vs No. of Bed for KPJ Ampang Hospital 81

Figure 4. 40 Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Ampang Hospital – Variable 5 81

Figure 5. 1 No. of Clinics (V1) vs No. of Bed for KPJ Rawang Hospital 86

Figure 5. 2 Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Rawang Hospital – Variable 1 87

Figure 5. 3	No. of Outpatient (V2) vs No. of Bed for KPJ Rawang Hospital	88
Figure 5. 4	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Rawang Hospital – Variable 2	89
Figure 5. 5	No. of Inpatient (V3) vs No. of Bed for KPJ Rawang Hospital	90
Figure 5. 6	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Rawang Hospital – Variable 3	91
Figure 5. 7	1/Bed Occupancy Rate (V4) vs No. of Bed for KPJ Rawang Hospital	92
Figure 5. 8	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Rawang Hospital – Variable 4	93
Figure 5. 9	Length of Stay (V5) vs No. of Bed for KPJ Rawang Hospital	94
Figure 5. 10	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Rawang Hospital – Variable 5	95
Figure 5. 11	No. of Clinics (V1) vs No. of Bed for KPJ Pasir Gudang Hospital	97
Figure 5. 12	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Pasir Gudang Hospital – Variable 1	97
Figure 5. 13	No. of Outpatient (V2) vs No. of Bed for KPJ Pasir Gudang Hospital	99
Figure 5. 14	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Pasir Gudang Hospital – Variable 2	99
Figure 5. 15	No. of Inpatient (V3) vs No. of Bed for KPJ Pasir Gudang Hospital	101
Figure 5. 16	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Pasir Gudang Hospital – Variable 3	101
Figure 5. 17	1/Bed Occupancy Rate (V4) vs No. of Bed for KPJ Pasir Gudang Hospital	103

Figure 5. 18	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Pasir Gudang Hospital – Variable 4	104
Figure 5. 19	Length of Stay (V5) vs No. of Bed for KPJ Pasir Gudang Hospital	105
Figure 5. 20	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Pasir Gudang Hospital – Variable 5	106
Figure 6. 1	No. of Clinics (V1) vs No. of Bed for KPJ Sabah Hospital	110
Figure 6. 2	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Sabah Hospital – Variable 1	111
Figure 6. 3	No. of Outpatient (V2) vs No. of Bed for KPJ Sabah Hospital	112
Figure 6. 4	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Sabah Hospital – Variable 2	113
Figure 6. 5	No. of Inpatient (V3) vs No. of Bed for KPJ Sabah Hospital	114
Figure 6. 6	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Sabah Hospital – Variable 3	115
Figure 6. 7	1/Bed Occupancy Rate (V4) vs No. of Bed for KPJ Sabah Hospital	116
Figure 6. 8	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Sabah Hospital – Variable 4	117
Figure 6. 9	Length of Stay (V5) vs No. of Bed for KPJ Sabah Hospital	118
Figure 6. 10	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Sabah Hospital – Variable 5	119
Figure 6. 11	No. of Clinics (V1) vs No. of Bed for KPJ Tawakal Hospital	121
Figure 6. 12	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Tawakal Hospital – Variable 1	121

Figure 6. 13	No. of Outpatient (V2) vs No. of Bed for KPJ Tawakal Hospital	123
Figure 6. 14	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Tawakal Hospital – Variable 2	124
Figure 6. 15	No. of Inpatient (V3) vs No. of Bed for KPJ Tawakal Hospital	125
Figure 6. 16	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Tawakal Hospital – Variable 3	126
Figure 6. 17	1/Bed Occupancy Rate (V4) vs No. of Bed for KPJ Tawakal Hospital	127
Figure 6. 18	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Tawakal Hospital – Variable 4	128
Figure 6. 19	Length of Stay (V5) vs No. of Bed for KPJ Tawakal Hospital	129
Figure 6. 20	Comparison Actual No. of Bed vs Expected No. of Bed using Linear Regression Analysis for KPJ Tawakal Hospital – Variable 5	130
Figure 7. 1	Regression analysis in KPJ Johor year 2014-2018	137
Figure 7. 2	Regression analysis in KPJ Ipoh year 2014-2018	139
Figure 7. 3	Regression analysis in KPJ Damansara year 2014-2018	141
Figure 7. 4	Regression analysis in KPJ Ampang 2014-2018	143
Figure 7. 5	Regression analysis in KPJ Rawang year 2014-2018	145
Figure 7. 6	Regression analysis in KPJ Pasir Gudang year 2014-2018	147
Figure 7. 7	Regression analysis in KPJ Sabah year 2014-2018	149
Figure 7. 8	Regression analysis in KPJ Tawakal year 2014-2018	151
Figure 8. 1	Overall hospital design process flowchart	162
Figure 8. 2	The Fundamentals of Elements and Variable in Hospital Planning	163

LIST OF ABBREVIATIONS

ABM	-	Activity Based Management
ALOS	-	Average Length of Stay
AR	-	Admission Rate
BMSH	-	Bukit Mertajam Specialist Hospital
BSC	-	Balanced Scorecard
BOMPS	-	Bed Occupancy Modelling and Planning Systems
CBN	-	Current Bed Numbers
CEO	-	Chief Executive Officer
CICU	-	Cardiac Intensive Care Unit
CMCO	-	Conditional Movement Control Order
CMI	-	Case Mix Indexed
CON	-	Certificate of Need
CPRC	-	Crisis Preparedness and Response Centre
CSSD	-	Central Sterile Services Department
DES	-	Discrete Event Simulation
DID	-	Diagnostics and Imaging Department
DP	-	Disease Prevalence
DOW	-	Day of Warded
EBD	-	Evidence Based Hospital Design
ED	-	Emergency Department
F	-	Frequency of use
FL	-	Funding Level
GDP	-	Gross Development Profit
HR	-	Hospitalization Rates
HUKM	-	Hospital Universiti Kebangsaan Malayisa
HUSM	-	Hospital Universiti Sains Malaysia
HVAC	-	Heating, Ventilation & Air Conditioning
IDPMS	-	Integrated Dynamic Performance Measurement System
ICU	-	Intensive Care Unit
JSH	-	Johor Specialist Hospital

KPJ	-	Kumpulan Perubatan Johor
LEED	-	Leadership in Energy and Environmental Design
LOS	-	Length of Stay
MCO	-	Movement Control Order
MOH	-	Ministry of Health
NICU	-	Neonatal Intensive Care Unit
ORU	-	Out-of-region use (inter-regional flows)
OT	-	Operating Theatre
P	-	Population
PPE	-	Personal Protective Equipment
PT	-	Patient Transfer to other providers
QFD	-	Quality Function Deployment
RPR	-	Region of patient residence (sub-regional flows)
SMI	-	Special Medical Institution
TA	-	Technology Advances
UTM	-	Universiti Teknologi Malaysia
WT		Waiting time

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
Appendix A	Universiti Teknologi Malaysia Hospital Data Application Letter	189
Appendix B	Official letter to the President and Managing Director of KPJ Healthcare Bhd	190
Appendix C	List of Hospital Data KPJ Hospital Data and Summary of Health Facts 2011-2020 Data Collection from KKM	192
Appendix D	Example of Hospital Project Questionnaires from KPJ Hospital	194
Appendix E	Malaysia Ministry of Health (MOH) Hospital Bed Occupancy Rate (BOR) Data in 2020 from COVID-19 Pandemic	217
Appendix F	International Conferences Participation Awards and Certification	218
Appendix G	Author Journal 1 – Principles in Designing the Hospital Building	219
Appendix H	Author Journal 2 – The Relationship Between Five Elements and Nine Variables in Hospital Planning	220
Appendix I	Author Journal 3 – Design Considerations for COVID-19 Patients Hospital	221
Appendix J	KPJ JOHOR Data from 2014 to 2018 Analysis	222
Appendix K	KPJ IPOH Data from 2014 to 2018 Analysis	230
Appendix L	KPJ DAMANSARA Data from 2014 to 2018 Analysis	240
Appendix M	KPJ AMPANG Data from 2014 to 2018 Analysis	250
Appendix N	KPJ RAWANG Data from 2014 to 2018 Analysis	260
Appendix O	KPJ PASIR GUDANG Data from 2014 to 2018 Analysis	270
Appendix P	KPJ SABAH Data from 2014 to 2018 Analysis	280
Appendix Q	KPJ TAWAKAL Data from 2014 to 2018 Analysis	290
Appendix R	Multiple Variable Regression Method Analysis - KPJ IPOH	300

Appendix S	Multiple Variable Regression Method Analysis - KPJ DAMANSARA	302
Appendix T	Multiple Variable Regression Method Analysis - KPJ AMPANG	304
Appendix U	Multiple Variable Regression Method Analysis - KPJ RAWANG	306
Appendix V	Multiple Variable Regression Method Analysis - KPJ PASIR GUDANG	308
Appendix W	Multiple Variable Regression Method Analysis - KPJ SABAH	310
Appendix X	Multiple Variable Regression Method Analysis - KPJ TAWAKAL	311

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Designing hospital buildings is a complex process as to cater for different needs and requirements in clinical circulation, safety, environment and technological aspects which are numerous and time consuming. Many literatures related to hospital design covers the requirement of floor area, movement of patient and staff, logistics, departmental connectivity such as outpatient department, emergency department, diagnostic department, operation theatre, radiology division, pathology department and servicing/logistic departments such as central sterile and supply departments (CSSD), laundry, housekeeping, food and dietary department, clinical waste management and administrative department.

The studies will also analyze the issues pertaining to strategies for growth and expansion program which is in dire need of hospital beds in Malaysia healthcare facilities.

In general Malaysia government spent 3.76% of its GDP on health in 2018, which is about lower compared to other East Asia countries (World Health Organization Global Health Expenditure, n.d.). Malaysia expenditure in healthcare has risen steadily over the past decade with mean annual growth above 4%. Malaysia is in the mid-range among East Asia countries which in line with the predicted level given its per capita income as in Figure 1.1. The following Figure 1.1 below shows per capita income in selected East Asian economies between year 2000-2018

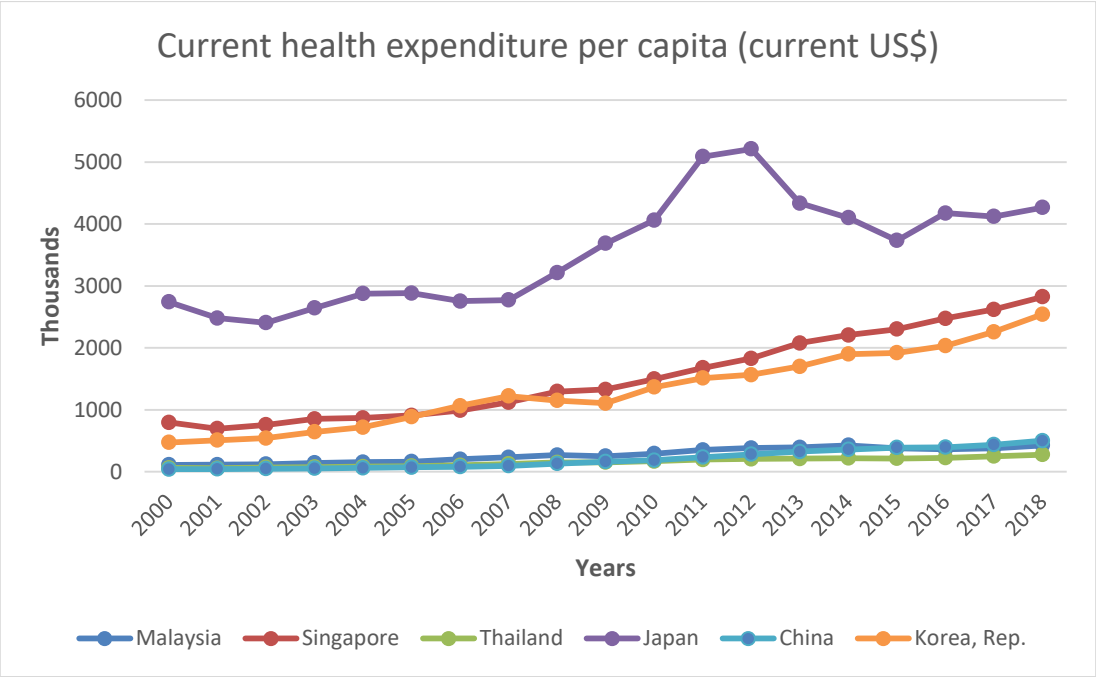

Figure 1.1 Per capita income in selected East Asian economies between year 2000-2018 (World Health Organization Global Health Expenditure, n.d.)

Malaysian healthcare system has been structured by the present of a public-sector hospital. All Malaysian are entitled for almost free treatment from all government hospitals. Since 2000, Malaysia general economic has gone through much success and prosperity, the number of private hospital has increased substantially. One of the reasons for this could be due to Malaysians overall scepticisms on government hospital which are publicly funded hospitals are not providing quality healthcare services that contributed to their preferences to private hospitals. Healthcare and education have been the largest components of Malaysia's budgetary expenditure. Consequently, the government has attempted to shift the burden of healthcare to private sector, thereby decreasing its expenditure.

With the improvement of Malaysia economy, the publics' expectation of health and medical services has changed for the better (Bemmel, 1999). Consequently, the government's has been modernizing all government hospitals and clinics to ensure that they offer quality services. The government has also attempted to attract foreigners to seek treatment through the provision of quality services through Health Tourism. For this purpose, the Health Ministry and local providers of medical care have jointly organized an accreditation program by an independent

body, The Malaysian Society for Quality in Health (MSQH). The accreditation program emphasizes evaluation of the quality of services, education, and training against internationally accepted professional standards.

By March 2022, 47% of Ministry of Health hospitals were being accredited (63 out of 135) and 30% of private hospitals (60 out of 202) were accredited. Among 26 KPJ group of hospitals, 18 number of the hospital has been accredited by MSQH. A benchmarking study conducted by Arthur Andersen and Associated reported that local private hospitals needed to be more efficient to service the highly competitive industry (Ferri, C A; Klein, S R;, 2000). This study suggested the use of best practices as a short-term solution. As a long-term remedy, the study proposed the development and implication of an information system that can support efficient management decisions on a continuous basis.

About 70% of healthcare services are still being provided by the public sector, which focus on primary, secondary and tertiary levels (Blyth, A.; Worthington, J, 2001). The rapidly growth of private hospital in Malaysia, has offers an alternative healthcare service which is financed strictly on a non-subsidized, fee-for-services basis. As of year 2005 data, in the public sector, Malaysia Healthcare System consists of the following categories. They are as listed in table below.

Table 1.1 Malaysia Healthcare System hospital providers

Provider	**Type of Hospital**
Ministry of Health	Government Hospital
Ministry of Education	Teaching Hospitals
Ministry of Internal Affairs	Hospital for the Aborigines
Ministry of Defence	Military Hospital
Ministry of Unity and Social Welfare	Nursing Homes
Local Authorities	Big Cities

Besides the above list, in general, there are three types of public hospitals, namely;

i. General Hospitals
ii. District Hospitals
iii. Special Medical Institutions (SMIs)

Malaysia has sixteen state capitals and each of them are being serve by a general hospital with an average number of beds of 600 to 700 beds. Each of this general hospital provide full range of healthcare services. In each of this state, at their district level they are being serve by a smaller hospital with the bed capacity of between 250 to 400 beds each, providing basic diagnostic and curative services. As for Special Medical Institutions (SMIs), this are hospital that provide treatment to specific diseases such as Institut Jantung Negara (IJN) which provide cardiac treatment, National Cancer Centre which provide cancer treatment and other SMIs.

There also network of health clinic which provide primary healthcare to the population and a comprehensive referral system to the district hospital and Special Medical Institution which are in place at district level and state capital centre. The private hospital account for almost 22% of Malaysia hospital bed and employed more than 50% of nation's doctor. Table below indicates the spread and demographics of public and private hospitals in Malaysia and it expected growth. As can be observed the pattern here is towards increasing hospital infrastructure and bed space.

Table 1.2 Key Health Service Delivery Supply-Side Indicators, 2015–2020

Year	Public		Private		Total		Hospital per 100,000 population	Hospital Beds per 1,000 population	Population
	Hospitals	Beds	Hospitals	Beds	Hospitals	Beds			
2015	134	36,447	183	12,963	317	49,410	1.02	1.58	31,186,100
2016	135	41,995	187	13,957	322	55,952	1.02	1.77	31,660,700
2017	135	37,470	200	14,799	335	52,269	1.05	1.63	32,022,600
2018	135	37,609	210	15,957	345	53,566	1.07	1.65	32,382,300
2019	135	38,131	208	16,469	343	54,600	1.05	1.68	32,581,400
2020	135	38,543	202	17,155	337	55,698	1.03	1.71	32,657,300

(Atun, Berman, Hsiao, Myers, & Wei, March 2016)
Source: Health Facts, MOH; Malaysia Health System Review 2016-2021, WHO; NHEWS.

Table 1.3 Secondary care health facilities, 2020

Secondary care health facilities	No.	Beds	% total beds
MOH Hospitals	135	38,543	57.99
MOH special medical institutions	11	5,574	8.39
Non-MOH government hospitals	10	4,288	6.45
Private hospitals	202	17,155	25.81
Private maternity homes	17	48	0.07
Private nursing homes	21	821	1.24
Private hospice	3	39	0.06
Total	**399**	**66,468**	**100**

(Jaafar, et al., 2013)
Source: Ministry of Health Malaysia, 2021c

Based on Health Facts 2020, out of 32 million of population there were 16.6 million of outpatient and 2.3 million inpatient being treated by for government hospital. By using the ratio of 2.5:1000 population, the bed required at that time are 81,643 of hospitals beds. This show that Malaysia government hospitals are shortage of beds by 43,100 with ratio of 2.5:1000 population.

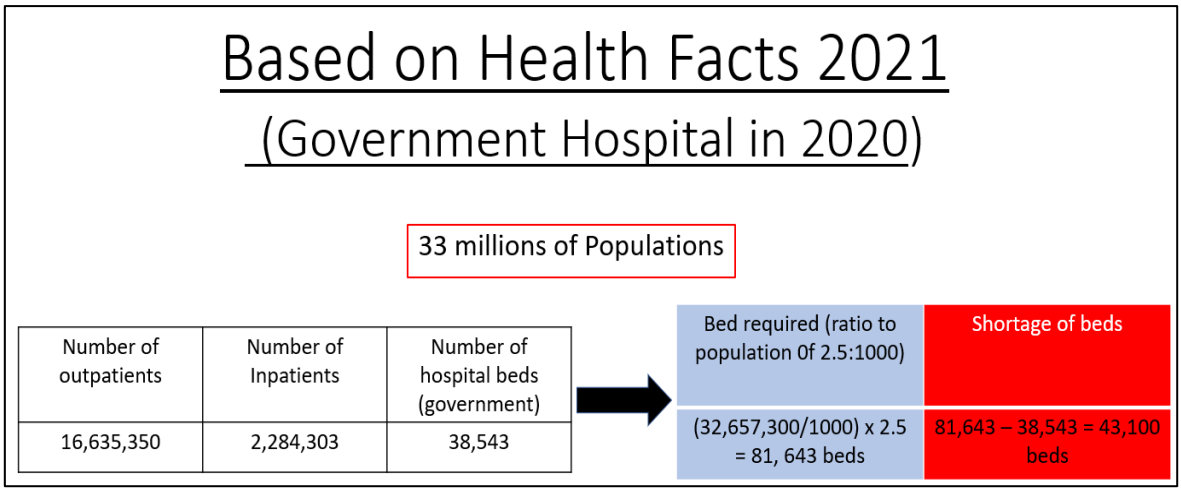

Figure 1.2 Ratio of Bed to Population

1.2 Problem Statement

Number of hospital beds are important part and most crucial issue due to increasing of population and the growing demand for expansion for Malaysia's government and private hospitals. In 2020 with population of 32 million, Malaysia treated 3,200,597 inpatients using 55,698 beds (Health Facts 2021, November 2021). Out of 71% were being treated by government hospital and only 29% of treated by private hospital. With a targeted bed to population ratio of 2.5:1000, Malaysia shows shortage of 25,945 hospital beds as indicated in Figure 1.2.

Most of hospitals in Malaysia were built since 1960s and to date the hospital buildings in all region of Malaysia need to be upgraded. Based on Health Facts 2021 Ministry of Health there were 135 numbers for government hospitals contribute 38,543 beds (285 beds per hospitals) while 202 numbers of private hospitals produced 17,155 beds (85 beds per hospitals). Hence, the exercise to increase the number of beds to reduce the shortage of beds need to be undertaken both by the public and private sector is of enormous important. Respectively, the ability to decide on the number of beds to be constructed by building new hospitals or to upgrade the capacity of current hospitals is equally important.

Unlike normal office building or commercial building, requirements for hospital buildings are very strict in term of the mechanical and electrical requirement so does clinical work flows (Griffin, 2005). Issues in upgrading of wards and other departments required the same approach before a master plan of upgrading work can be formalized and approved.

Determining the number of beds can be a complex exercise due too many factors and parameters that can be associated with it such as length of stay, number of outpatients and inpatients, population and etc. Healthcare industry usually deals with emergency and urgent situation by operating 24 hours per day for 365 days per year. The rate of change in spending per enrollee for both public and private health continues to raise, private health spending per enrollee increased more than public health. In Malaysia, numbers of hospital beds are often decided by business and financial decision, rather than meeting the need of patients. Decisions are made by hospital board of director and management at different level in healthcare systems.

From Chapter 2 Literature review (Kuntz, Scholtes, & Vera, 2007) stated that the parameters in planning hospital bed capacity were based on the population, frequency of admission, occupancy of bed as well as length of stay. There were several models and methods mentioned in several literatures on determining bed capacity such as formula method. Yet, there are not a single models and methods that can carry this task exceptionally well. (Mackay & Lee, 2005) in his journal mentioned that, a complex model can result in an over-fitting bed capacity, whereas simple predictive methods or model can give a better in determine the number of beds for present or future hospitals in Malaysia.

1.3 Aim and Objectives

The aim of this research was to study the best approach of predictive formula method as decision making tools for capital investment in hospital Building Expansion Program by considering the various parameters which affect the design requirement to produce the required number of hospital beds. The following are the objective of this thesis:

(a) To identify an optimum design system which will be able to project the present and future needs of the hospital capacity.

(b) To develop a measuring tool to project the future capacity needs of the existing/new hospital.

(c) To provide a decision-making tool for any upgrading, refurbishment and rebuilding of hospital facilities using gap analysis method on the deficiency in the hospital bed capacity.

Objective of this research work is to develop a systematically approach in upgrading the existing hospitals bed capacity while still meet the clinical and technical hospital facilities requirement. It is not the goal of this research to resolve the current massive convoluted problem faced by existing hospital building but would suffice to create and develop a systematically approach in solving this problem.

1.4 Scope of study

Scope of this study include the following items:

i. The study will be conducted on three (3) categories of hospital namely, Mature Hospitals, New Hospitals and Relocated Hospitals from eight (8) KPJ Healthcare Berhad hospitals.

ii. The parameters captured on the hospitals include;

a. Type of services.
b. Treatment time.
c. Conversion rate for Outpatient to Inpatient.
d. Length of Stay (LOS)
e. Bed Occupancy Rate (BOR)
f. No. of Hospital Beds

Extracted from 5 years of data (2014-2018). However, data from 2019 to 2021 where not be considered because of the pandemic situation which not reflect the true operational scenario.

iii. Using regression analysis to predict the formula and relationship of the 6 parameters from the data of eight (8) hospitals that collected. The parameters for government hospitals are being collected from (Health Facts 2015-2020, Ministry of Health) to show the relationship between the number of beds (dependent variables) and the independent variables.

1.5 Significance of the study

The purpose of this study was to measure the bed requirement for the 3 categories hospital which are Mature Hospitals, New Hospitals and Relocated Hospitals. A comparative analysis from the retrieved sample data of the (8) eight KPJ Hospital were done using linear regression analysis as benchmarking exercise. It is anticipated that findings of this study will provide better understanding between the types and categories of hospitals that operates with the same parameters but different bed design requirement. It is expected that findings from this research will help hospital operators to further plan an early hospital development planning initiatives and mitigation plans to improve the hospital operation and services.

The 5 parameters identified from the sample of data of the eight (8) KPJ hospital will be analyze and the relationship will be formulated to show the relationship between a hospital bed capacity and the (5) five variables.

Findings from the parameters or variables through their categories are essential for the operators to take into consideration in planning and designing the right mitigation tools or activities to help to improve and project the optimum bed capacity to the stakeholder (patients and staff). Since there are lack of literatures and findings in determining the right sizing of a hospital, it could contribute to further knowledge enhancement in hospital design. Findings from this research will contributed to further knowledge in the area of hospital which are somehow lacking in the literatures.

1.6 Organizational of the thesis

This thesis consisted of eight chapters and the overall thesis structure is as follows:

Chapter 1 introduce the Malaysia healthcare delivery system which is provided by public and private hospitals. Through this chapter the identification and background of this research study the healthcare data were included and to identify the three (3) objectives and the proposed scope of the study.

Chapter 3 described the research methodology that the detailed parameters of data collection from KPJ Berhad's hospitals were discussed and a statistical method to be used was proposed to test the correlation between parameters between the three (3) categories of hospital which are: (a) Mature hospitals, (b) New hospitals, and (c) Relocated hospitals.

The highlight of the findings was discussed in Chapter 4 which the case study of the Mature Hospitals from KPJ Berhad's hospital carried out. This chapter calculated and summarized the regression analysis and trend line for hospital that has

been newly established and operates between 30-40 years range. The analysis was done based on data collected from the year of 2014-2018.

Chapter 5 the highlight of the finding of New Hospital from KPJ Berhad's Hospitals categories. This chapter calculated and summarized the regression analysis and trend line for these newly hospital that age range between 10-20 years old. The analysis was done on data collected from the year 2014-2018.

Case study on Relocated Hospital from KPJ Berhad's Hospitals categories were discussed in Chapter 6. The findings on calculation and summary of regression analysis and trend line for hospital that have histories of operation. These hospitals were relocated into certain or targeted location due to improvising or increasing of the bed occupancy rate (BOR). The analysis was done data collected from the year 2014-2018.

In the Chapter 7 of the thesis covers two different parts. The first part shows the results obtained from the statistical analysis while the second part present the correlation analysis between the parameters or variables of the study.

Lastly, the Chapter 8 will provide summation and conclusion with recommendations to the whole research to meet the aim and objective of this thesis.

1.7 Summary

This chapter has presented the background of study, problem statements, research objectives and scope of study. The next Chapter 2 follows several review of the literature related to this study.

REFERENCES

Private Healthcare Facilities and Services Act 1998 (Act 586) (May 2006).

Adan, I. B., & Vissers, J. M. (2002). Patient mix optimisation in hospital admission planning: a case study. *International Journal of Operations & Production Management, 22*(4), 445-461.

Aiken, L. H., Clarke, S. P., & Sloane, D. M. (2002b). Hospital staffing, organization, and quality of care: cross-national findings. *International Journal for Quality in Health Care, 14*(1), 5-13.

Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Siber, J. H. (2002a). Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *Journal of the American Medical Association, 288*(16), 1987-1993.

Aiken, L. H., Sermeus, W., Koen Van den Heede, Sloane, D. M., Busse, R., McKee, M., . . . Kutney-Lee, A. (2012). Patient safety, satisfaction, and quality of hospital care: cross sectional surveys of nurses and patients in 12 countries in Europe and in the United States. *BMJ*, 1-14.

Akroyd, D. (1995, December). The Logical Framework Approach and the post-evaluation of health sector projects by the African Development Bank. *Project Appraisal, 10*(4), 210-222.

Akroyd, D. (1999). Logical framework approach to project planning, socio-economic analysis and to monitoring and evaluation services: a smallholder rice project. *Impact Assessment and Project Appraisal, 17*(1), 54-66.

Albert, H. T. (2006, Jun 1). A strategic approach to managing maintenance performance. *Journal of Quality in Maintenance Engineering, 4*(2), 87-94.

Al-Shammari, M. (1999). "A multi-criteria data envelopment analysis model for measuring the productive efficiency of hospitals. *International Journal of Operations & Production Management, 19*(9), 879-890.

Amy, H. K., & Roger, J. L. (2008). Hospital Disaster Preparedness in Los Angeles County. *Academic Emergency Medicine, 13*(11), 1198-1203.

Anderson, J. C., Cleveland, G., & R., G. S. (1989, April 8). "Operations Strategy: A Literature Review". *J. Operations Management*, 133-158.

Anderson, J., Jansz, A., Steele, K., Thistlewhaite, P., Bishop, G., & Black, A. (2004). *Green Guide to Composites: an environmental profiling system for composite materials and products.* Watford: BRE Press.

Appleby, C. (1995). Fit to be cared for. *Hospitals & Health Networks, 69*(16), 34-36.

Applegate, L. M., R., M. O., & D., T. (February 1986). Design of a Management Support System for Hospital Strategic Planning. *Journal of Medical Systems 10*, 79-95.

Ashby, J., Guterman, S., & Greene, T. (2000). An analysis of hospital productivity and product change. *Health Affairs, 19*(5), 197-205.

Atun, R., Berman, P., Hsiao, W., Myers, E., & Wei, Y. A. (March 2016). *MALAYSIA HEALTH SYSTEMS RESEARCH VOLUME 1*. Government of Malaysia.

Australian Government. (2004, February). *The Logical Framework Approach 3*. Retrieved from AusGUIDElines: www.ausaid.gov.au

Bagust, A., Place, M., & Posnett, J. W. (1999). Dynamics of bed use in accommodating emergency admissions: stochastic simulation model. *BMJ, 319*(7203), 155-158.

Banerjea, K. (2004). Process reenigneering of accident and emergency services in the Queen Elizabeth Hospital. Barbados: University of the West Indies, Barbados.

Bayou, M. E. (2001). Developing an instrumental capacity model for industry. *Managerial Finance, 5*(2), 55-78.

Bemmel, J. (1999). Toward a Visrtual Electronic Patient Recors. *MD Computing, 16*(6).

Bern, M. W. (1998). Computational geometry for mesh generation. *IMR*, (p. 227).

Berwick, D. (1998). Developing and testing changes in the delivery of care. *Annals of Internal Medicine, 128*, 651-6.

Berwick, D. M. (2009). What 'patient-centered' should mean: Confession of an Extrimist. *Health Affairs, 28*(3/4), 555-565.

Beukeboom, C. J., Langeveld, D., & Dijkstra, T. K. (2012). Stress-reducing effects of real and artificial nature in a hospital waiting room. *The journal of alternative and complementary medicine, 18*(4), 329-333.

Bjornberg, U. (2000). Equality and backlash: family, gender, and social policy in Sweden. *in Haas, L.L., Hwang, P. and Russell, G. (Eds), Organizational*

Change and Gender Equity: International Perspectives on Fathers and Mothers at the Workplace, 57-75.

Black, A. (2015). Designing a very different hospita. *Future Hospital Journal, 2*(1), 19-21.

Blyth, A.; Worthington, J. (2001). *Managing the Brief for Better Design.* London: Spon.

Bourne, M., Kennerly, M., & Franco-Santos, M. (2005). Managing through measures: a study of impact on performance. *Journal of Manufacturing Technology Management, 16*(4), 373-395.

Boyer, K. K. (1998). Longitudinal linkages between intended and realized operations strategies. *International Journal of Operations & Production Management, 18*(4), 356-366.

Bozarth, C. (1993). A conceptual model of manufacturing focus. *International Journal of Operations & Production Management, 13*(1), 81-92.

Brambilla, A., Rebecchi, A., & Capolongo, S. (2019). Evidence Based Hospital Design. A literature review of the recent publications about the EBD impact of built environment on hospital occupants' and organizational outcomes. *ANNALS OF HYGIENE PREVENTIVE AND COMMUNITY MEDICINE, 31*(2), 165-180. doi:10.7416/ai.2019.2269

Brand, S. (1994). *How Buildings Learn: What Happen After They're Built.* New York: Viking.

Bromley, E. (2012). Building patient-centeredness: Hospital design as an interpretive act. *Social Sciences & Medicine, 75*, 1057-1066.

Brown, M. P., Sturman, M. C., & Simmering, M. J. (2003). Compensation policy and organizational performance: the efficiency, operational, and financial implications of pay levels and pay structure. *Academy of Management Journal, 46*(6), 752-762.

Bucheit, S. (2001). Outcome effects and capacity cost reporting. *Managerial Finance,, 27*(5), 3-16.

Buffa, E. (1984). *Meeting the Competitive Challenge.* Homewood, IL: Dow Jones-Irwin.

Building Systems Development and Stone, M. (1977). *Development Study - VA Hospital Building System.* Washington D.C: U.S Government Printing Office.

Burns, L. R., Chilingerian, J. A., & Wholey, D. R. (1994). The effect of physician practice organization on efficient utilization of hospital resources. *Health Services Research, 29*(5), 583-603.

Butler, T. W., & Leong, G. K. (2000). The impact of operations competitive priorities on hospital performance. *Health Care Management Science, 3*, 227-235.

Butler, T. W., Leong, G. K., & Everett, L. N. (1996). The operations management role in hospital strategic planning. *Journal of Operations Management, 14*(2), 137-157.

Caron, A., Jones, P., Neuhauser, D., & Aron, D. C. (2004). Measuring performance improvement: total organizational commitment or clinical specialization. *Quality Management in Health Care, 13*(4), 210-215.

Chesteen, S., Helgheim, B., Randall, T., & Wardell, D. (2005). Comparing quality of care in non-profit and for-profit nursing homes: a process perspective. *Journal of Operations Management, 23*(2), 229-242.

Cifter, A. S. (2017, September 06). A Review on Future Directions in Hospital Spatial Designs with a Focus on Patient Experience. *The Design Journal*, S1998-S2009. doi:10.1080/14606925.2017.1352719

Cleverly, W. O. (1990). Improving financial performance: a study of 50 hospitals. *Hospital & Health Services Administration, 35*(2), 173-187.

Curtain, L. L. (2003). An integrated analysis of nurse staffing and related variables: effects on patient outcomes. *Online Journal of Issues in Nursing, 8*(3).

D., M. D. (2000). Health policy and case management. *Care management journals : Journal of case management ; The journal of long term home health care, 2*(3), 160-168.

Davidson, J. E., Powers, K., Hedayat, K., Tieszen , M., Kon, A., Shepard, E., . . . Armstrong, D. (2007). Clinical practice guidelines for support of the family in the patient-centered intensive care unit. *American College if Critical Care Medicine Task Force 2004-2005, 35*(2), 605-622.

Director-General, W. (2020, March 11). WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020. (Media, Interviewer)

Dixon, R. J., Nanni, A. J., & Vollmann, T. E. (1990). *The New Performance Challenge: Measuring Operations for World-Class Competition.* New York, NY: Business One Irwin.

Douglas, C. H., & Douglas, M. R. (2005). Patient-centered improvements in health-caer built environments: perspectives and design indicators. *Health Expectations, 8*, 264-276.

Edmonson, A. C. (2003). Speaking up in the operating room: how team leaders promote learning In interdisciplinary action teams". *Journal of Management Studies, 40*(6), 1419-1452.

El-Darzi, E., V., C., C., T., & Millard, P. H. (1998). A simulation modelling approach to evaluating length of stay, occupancy, emptiness and bed blocking in a hospital geriatric department. *Health Care Management Science, 1*(2), 143-149.

F. Gorunescu, McClean, S. I., & Millard, P. H. (January 2002). A Queueing Model for Bed-Occupancy Management and Planning of Hospitals. *The Journal of the Operational Research Society, 53*(1), 19-24.

Ferri, C A; Klein, S R;. (2000). Telemedicine: New Modalities Complicate the Legal Balance. *MD Computing, 17*(4).

Fine, D. (1995). The Importance of the Arts in Hospital Development. *Health Estate Journal, 49*(7), 20-21.

Flood, S. D., & Diers, D. (1988). Nurse staffing, patient outcome and cost. *Nursing Management, 19*(5), 34-43.

Floyd, B. D., Rasche, C., & Margaria, T. (2016). Service Model Innovation in Hospitals: Beyond Expert Organizations. In M. A. Pfannistiel, & C. Rasche, *Service Business Model Innovation in Healthcare and Hospital Management* (pp. 1-20). Springer International Publishing AG 2017.

Flyn, B. B., Schroeder, R. G., & Flynn, E. J. (1999). World class manufacturing: an investigation of Hayes and Wheelwright's foundation. *Journal of Operations Management, 17*(3), 249-269.

Franc-Law, J. M., Bullard, M., & Corte, F. D. (2008). Simulation of a Hospital Disaster Plan: A virtual, Live Exercise. *Prehospital and Disaster Medicine*(23), 346-353.

Ganasegeran, K., Ch'ng, A. S., & Looi, I. (2020). COVID-19 in Malaysia: Crucial measures in critical times. *Journal of Global Health, 10*(2), 1-4.

Gemmel, P., & Van Dierdonck, R. (1999). "Admission scheduling in acute care hospitals: does the practice fit with the theory? *International Journal of Operations & Production, 19*(9), 863-878.

Gezer, H. (2014). The accessibility of the health buildings and hospitals. *Istanbul Ticaret Universitesi Fen Bilimleri Dergisi, 13*(25), 29-49.

Ghalayini, A., Noble, J. S., & Crowe, T. J. (1997). An integrated performance measurement system for improving manufacturing competitiveness. *International Journal of Production Economics, 48*, 207-225.

Glick, H. A., Orzol, S. M., Tooley, J. F., & Mauskopf, J. O. (2003). Design and analysis of unit cost estimation studies: how many hospital diagnoses? How many countries? *Health Economics, 12*(7), 517-527.

Goldstein, S. M., & Ward, P. T. (2004). Performance effects of physicians' involvement in hospital strategic decisions. *Journal of Service Research, 6*(4), 361-371.

Goldstein, S. M., Ward, P. T., Leong, G. K., & Butler, T. W. (2002). The effect of location, strategy, and operations technology on hospital performance. *Journal of Operations Management, 20*(1), 63-75.

Green, L. V. (November 1, 2002). How Many Hospital Beds? *The Journal of Health Care Organization, Provision and Financing*, 400-412.

Griffin, D. (2005). A new look at constructed choice processes. *Marketting Letters, 16*(3), 321-333.

Gro¨nroos, C., & Ojasalo, K. (2004). Service productivity: towards a conceptualization of the transformation of inputs into economic results in services. *Journal of Business Research, 57*(4), 414-423.

Gross, P. A., Braun, B. I., Kritchevsky, S. B., & Simmons, B. P. (2000). Comparison of clinical indicators for performance measurement of health care quality: a cautionary note. *British Journal of Clinical Governance, 5*(4), 202-211.

Gurd, B., & Gao, T. (2008). Lives in the balance: an analysis of the balanced scorecard (BSC) in healthcare organization. *International Journal of Productivity and Performance Management, 57*(1), 6-21.

Habraken, N. (1998). *The Structure of the Ordinary: Form and Control in the Built Environment.* Cambridge, MA: The MIT Press.

Hagland, M. (1996). Building Blocks. *Hospital & Healthcare Networks, 5*(5), 27-29.

Hareide, p. J., Bjorberg, S., Store-Valen, M., Haddadi, A., & Lohne, J. (2016). Strategies for optimization of value in hospital buildings. *Procedia - Social and Behavioral Sciences, 226*, 423-430.

Harman, J. S., Cuffel, B. J., & Kelleher, K. J. (2004). Profiling hospitals for length of stay for treatment of psychiatric disorders. , *Journal of Behavioral Health Services & Research, 31*(1), 66-74.

Harper, P. R. (2002). A Framework for Operational Modelling of Hospital Resources. *Health Care Management Science 5, 5*(3), 165-173.

Harper, P. R., & Shahni, A. K. (2002). Modelling for the planning and management of bed capacities in hospitals. *Journal of the Operational Research Society, 53*, 11-18.

Harper, P., & Shahani A. (2000). A decision support simulation model for planning and managing hospital bed capacities. *Proc Int Conf Health Scis Simul*.

Harris, P. B., McBride, G., Ross, C., & Curtis, L. (2002). A place to heal: Environmental sources of satisfaction among hospital patients. *Journal of Applied Social Psychology, 32*(6), 1276-1299.

Harrison, G. W., Shafer, A., & Mackay, M. (2005). Modelling Variability in Hospital Bed Occupancy. *Health Care Management Science, 8*(4), 325-334.

Hattis, P. D. (1971). *DR. RICHARD BATTIN: INVENTING AND APPLYING MODERN SPACE GUIDANCE WHILE ALSO BEING A MORAL COMPASS.*

Haughton, J. (2000). en Puzzles and Surprises Economic and Social Change in Vietnam, 1993-1998. *Comp Econ Stud 42*, 67-92. doi:10.1057/ces.2000.24

Hayes, R. H., & Wheelwright, S. C. (1984). *Restoring Our Competitive Edge.* New York: John Wiley and Sons.

Health Informatics Centre - Planning Division. (November 2021). *Health Facts 2021*. Malaysia: Ministry of Health Malaysia.

Heineke, J. (1995). Strategic operations management decisions and professional performance in U.S. HMOs. *Journal of Operations Management, 13*(4), 255-272.

Hensher, M., Price, M., & Adomakoh, S. (2006). *Disease Control Protiotites in Developing Countries: Chapter 66 Referral Hospitals.* (D. T. Jamison, J. G. Breman, A. R. Measham, G. Alleyne, M. Claeson, D. B. Evans, . . . P. Musgrove, Eds.) Washington, DC: The World Bank and Oxford University Press.

Hill, T. (1994). *Manufacturing Strategy: Text and Cases.* Homewood, IL: Irwin.

Hurst, J., & Siciliani, L. (2003). *Tackling Excessive Waiting Times for Elective Surgery: A Comparison of Policies in Twelve OECD.* Paris, France: OECD 2.

Investorwords.com. (2009). Retrieved from Investorwords.com: www.investorwords.com/3665/performance.html.

J. Bailey, N. T. (1956). Statistics in Hospital Planning and Design. *Journal of the Royal Statistical Society. Series C (Applied Statistics), 5*(3), 146-157.

Jaafar, S., Mohd Noh, K., Abdul Muttalib, K., Othman, N. H., Healy, J., Maskon, K., . . . Mohd Said, Z. (2013). *Malaysia Health System Review* (Vol. 3). Malaysia: World Health Organization 2012.

Jelinek, M., & Burstein, M. C. (1982). The production administration structure: a paradigm for strategic fit. *Academy of Management Review, 7*(2), 242-252.

Johnston, R., & Jones, P. (2004). Service productivity: towards understanding the relationship between operational and customer productivity. *International Journal of Productivity and Performance Management, 53*(3), 201-213.

Jones, R. P. (2020). Would the United States Have Had Too Few Beds for Universal Emergency Care in the Event of a More Widespread Covid-19 Epidemic. *International Journal of Environmental Research and Public Health*, 1-14.

Kaplan, R. S., & Norton, P. D. (1992, January/February). Balanced Scorecard: measures that drive performance. *Harvard Business Review*.

Kathura, R., & Davis, E. B. (2001). Quality and work force management practices: the managerial performance implication. *Production and Operations Management, 10*(4), 460-477.

Kendall, G. (2004). *Viable Vision: Transforming Total Sales into Net Profits.* Ft. Lauderdale, FL: J. Ross Publishing.

Kennerly, M., & Neely, A. (2002). *Performance measurement frameworks: a review.* Cambridge: Cambridge University Press.

Kilbridge, K. L., & Klein, E. A. (2000). Intravesical Therapy for Superficial Bladder Cancer. *In: Markman M. (eds) Regional Chemotherapy.*, 291-303. doi:https://doi.org/10.1007/978-1-59259-219-7_18

Kim, Y. K., Glover, S. H., Stoskopf, C. H., & Boyd, S. D. (2002). The relationship between bed size and profitability in South Carolina hospitals. *Journal of Health Care Finance, 29*(2), 53-63.

Klassen, K., & Rohleder, T. (2004). Outpatient appointment scheduling with urgent clients in a dynamic, multi-period environmenT. *International Journal of Service Industry, 15*(2), 167-186.

Kumar, A., & Motwani, J. G. (1999). Management of health care technology literature (1979-1997): a multidimensional introspection. *IEEE Transactions on Engineering Management, 46*(3), 247-264.

Kuntz, L., Scholtes, S., & Vera, A. (2007). Incorporating efficiency in hospital-capacity planning in Germany. *Eur J Health Econ*, 213-223.

Lagoe, R. J., Westert, G. P., Kendrick, K., Morreale, G., & Mnich, S. (2005). Managing hospital length of stay reduction: a multihospital approach. *Health Care Management Review, 30*(2), 82-92.

Landon, B., Iezzoni, L. I., Ash, A. S., & Schwartz, M. (1996). Judging hospitals by severity-adjusted morality rates: the case of CABG surgery. *Inquiry, 33*(2), 155-166.

Langland-Orban, B., Gapenski, L. C., & Vogel, W. B. (1996). Differences in characteristics of hospitals with sustained high and sustained low profitability. *Hospital & Health Services Administration, 41*(3), 385-399.

Leong, G. K., Snyder, D. L., & Ward, P. T. (1990). Research in the process and content of manufacturing strategy. *Omega International Journal of Management Science, 18*(2), 109-122.

Lewis, M. W., & Boyer, K. K. (2002). Factors impacting AMT implementation: an integrative and controlled study. *Journal of Engineering & Technology Management, 18*(2), 111-130.

Li, L. X., & Benton, W. C. (2003). Hospital capacity management decisions: emphasis on cost control and quality enhancement. *European Journal of Operational Research, 146*(3), 596-614.

Li, L. X., & Collier, D. A. (2000). The role of technology and quality on hospital financial performance: an exploratory analysis. *International Journal of Service Industry Management, 11*(3), 202-224.

Li, L. X., Benton, W. C., & Leong, G. K. (2002). The impact of strategic operations management decisions on community hospital performance. *Journal of Operations Management, 20*(4), 389-408.

Li, Q., Guan, X., Wu, P., Wang, X., Zhou, L., Tong , Y., . . . Feng, Z. (2020). Early Transmission Dynamics in Wuha, China, of Novel Coronavirus - Infected Pneumonia. *The New England Journal of Medicine, 382*(13), 1199-1207.

Loo, K.-Y., & Letchumanan, V. (2021). COVID-19: Malaysia's fight against this deadly virus. *Progress in Microbes and Molecular Biology*, 1-11.

Lynch, R., & Cross, K. (1991). *Measure Up! Yardsticks for Continuous Improvement.* Oxford: Blackwell.

Mackay, M. (2001). Practical experience with bed occupancy management and planning systems: an Australian view. *Health Care Management Science, 4*, 47-56.

Mackay, M., & Lee, M. (2005). Choice of Models for the Analysis and Forecasting of Hospital Beds. *Health Care Management Science 8*, 221-230.

MacStravic, S. (1999). Quality indicators and specious inferences. *Health Care Strategic Management, 17*(6), 15-18.

Madison, K. (2004). Multihospital system membership and patient treatments, expenditures, and outcomes. *Health Services Research, 39*(4), 749-769.

Malone, E. B., & Dellinger, B. A. (2011). Furniture design features and healthcare outcomes. *The Center for Health Design*.

McAdam, R., Hazlett, S. A., & Casey, C. (2005). Performance management in the UK public sector: addressing multiple stakeholder complexity. *International Journal of Public Sector, 18*(3), 256-273.

McDermott, C., & Stock, G. N. (2007). Hospital operations and length of stay performance. *International Journal of Operations & Production Management, 27*(9), 1020-1042.

McFadden, K. L., Towell, E. R., & Stock, G. N. (2004). Critical success factors for controlling and managing hospital errors. *Quality Management JournaL, 11*, 61-74.

McLaughlin, C. P., Pannesi, R. T., & Kathuria, N. (1991). The different operations strategy planning process for service operations. *International Journal of Operations & Production Management*, 63-76.

Millard, P. (1989). *Geriatric medicine: a new method of measuring bed usage and a theory for planning.* University of London: MD thesis.

Miller, J. G., & Roth, A. V. (1994). A Taxonomy of Manufacturing Strategies. *Management Science, 40*(3), 285-304.

Miller, R. L., & Swensson, E. S. (1995). Hospital and healthcare facility design. *New York: McGraw-Hill, Inc.*

Millsap, J. E. (2007). *Understanding the Hospital Planning, Design and Construction Process*. Retrieved from Millsap J.E [Electronic resource]: http://www.chcf.org/resources/download.aspx?id...B094–4558.

MOH, M. o. (November 2019). *Health Facts 2019.* Malaysia: Planning Division, Health Informatics Centre.

MOH, M. o. (October 2020). *Health Facts 2020.* Malaysia: Planning Division, Health Informatics Centre.

Moore, J. H. (2003). The ubiquitous nature of epistasis in determining susceptibility to common human diseases. *Human heredity, 56*(1-3), 73-82.

Nagasawa, Y. (2019, January). Global Hospitals in 2050 - A review of the historical development of hospital building studies from a global perspective. *Japan Architectural Review, 3*(1), 5-24. doi:10.1002/2475-8876.12131

National Guideline Centre (UK). (March 2018). *Emergency and acute medical care in over 16s: service delivery and organisation.* National Institute for Health and Care Excellence (NICE).

Neely, A., & Bourne, M. (2000). Why measurement initiatives fail? *Measuring Business Excellence, 4*(4), 3-6.

New York State Department of Health. (1993). *Acute Care Bed Need Methodology Background for the Derivation of 1996 Adult and Pediatric Bed Need.* Albany: Bureau of Health Facility Planning.

Pesch, M. J., & Schroeder, R. G. (1996). Measuring factory focus: an empirical study. *Production and Operations Management, 5*(3), 234-254.

PK, T., S, S., PP, G., A, F., & An, H. (August 2012). *National Healthcare Establishments & Workforce Statistics.* Malaysia: The National Healthcare Statistics Initiative (NHSI).

Polverejan, E., Gardiner, J. C., Bradley, C. J., & Holmes-Rovner, M. (2003). Estimating mean hospital cost as a function of length of stay and patient characteristics. *Health Economics, 12*(11), 935-947.

Porter, M. E. (1996). What is strategy? *Harvard Business Review, 74*(6), 61-78.

Price, A. F., & Lu, J. (2013). Impact of hospital space standardization on patient health and safety. *Architectural Engineering and Design Management, 9*, 49-61.

Price, J. L. (2001). Reflections on the determinants of voluntary turnover. *International Journal of Manpower, 22*(7), 600-624.

Pronovost, P. J., Angus, D. C., Dorman, T., Robinson, K. A., Dremsizov, T. T., & Young, T. L. (2002). Physician staffing patterns and clinical outcomes in

critically ill patients: a systematic review. *JAMA: Journal of the American Medical Association, 288*(17), 2151-2162.

Pullman, M. E., & Moore, W. L. (1999). Optimal service design: integrating marketing and operations perspectives. *International Journal of Service Industry Management, 10*(2), 239-261.

Radnor, Z., & McGuire, M. (2004). Performance management in the public sector: fact or fiction? *International Journal of Productivity and Performance Management, 53*(3), 245-260.

Raffiee, K., & Wendal, J. (1991). Interactions between hospital admissions, cost per day and average length of stay. *Applied Economics, 23*(1B), 237-246.

Rampal, L., & Seng, L. B. (2020). Coronavirus disease (COVID-19) pandemic. *Medical Journal Malaysia, 75*(2), 95-97.

Ravaghi, H., Alidoost, S., Mannion, R., & Belorgeot, V. D. (2020). Models and methods for determining the optimal number of beds in hospitals and regions: a systematic scoping review. *BMC Health Services Research, 20*(186), 1-13. doi:https://doi/10.1186/s12913-020-5023-z

Rechel, B., & Wright, S. (2010). Hospital capacity planning: From measuring stocks to modelling flows. *Bulletin of the World Health Organisation*, 632-636.

Render, B., & Heizer, J. (2004). *Principles of operations management.* Pearson Education.

Renner, C., & Palme, E. (1999). Outsourcing to increase service capacity in a New Zealand hospital. *Journal of Management in Medicine, 13*(5), 325-338.

Ross, J. P. (1957). Building A Hospital Disaster Plan. *The American Journal of Nursing, 57*(11), 1461-1462.

Safizadeh, M. H., Ritzman, L. P., Sharma, D., & Wood, C. (1996). An empirical analysis of the product-process matrix. *Management Science, 42*(11), 1576-1591.

Santerre, R. E., & Adams, A. S. (2002). The Effect of Competition on Reserve Capacity: The Case of California Hospitals in the Late 1990s. *International Journal of Health Care Finance and Economics 2*, 205-218.

Schmidt, R., Geisler, S., & Spreckelsen, C. (2013). Decision support for hospital bed management using adaptable individual length of stay estimations and shared resources. *BMC Medical Informatics Decision Making, 13*(3).

Schroeder, R. G., Anderson , J. C., & Cleveland, G. (1986, August). The Concept of Manufacturing Strategy: An Empirical Study. *J. Operations Management*, 405-415.

Sear, A. M. (1992). Operating characteristics and comparative performance of investor-owned multihospital systems. *Hospital & Health Services Administration, 37*(3), 401-415.

Shi, L. (1996). Patient and hospital characteristics associated with average length of stay. *Health Care Management Review, 21*(2), 46-61.

Simona, D. C. (2002, December). Well-being in Hospitals : Design aids for Functionally Environmentally sound Therapeutic Buildings. *USO-Built Report Series 1*, 75-80.

Skinner, W. (1974). The focused factory. *Harvard Business Review, 52*(3), 113-122.

Slack, N., Chambers, S., Johnston, R., & Betts, A. (2008). *Operations and Process Management: Principles and Practice for Strategic Impact* (Second Edition ed.). Harlow: PFinancial Times/Prentice Hall, Harlow.

Smith-Daniels, V. L., Schweikhart, S. B., & Smith-Daniels, D. E. (1988). Capacity management in health care services: review and future research directions. *Decision Sciences, 19*(4), 889-919.

Srivastava, R., & Homer, C. J. (2003). Length of stay for common pediatric conditions: teaching versus nonteaching hospitals. *Pediatrics, 112*(2), 278-281.

Stidsen, L., Kirkegaard, P. H., & Fisker, A. M. (2010). Design proposal for pleasurable light atmosphere in hospital wards. *In: Proceedings of Colour and Light in Architecture Conference, Knemesi, Italy,*, 366-371.

Suess, C., & Mody, M. (2017). Hospitality healthscapes: A conjoint analysis approach to understanding patient responses to hotel-like hospital rooms. *International Journal of Hospitality Management, 61*, 59-72.

Swamidass, P. (1986). Manufacturing strategy: its assessment and practice. *Journal of Operations Management, 6*(4), 471-484.

Swamidass, P. M., & Newell, W. T. (1987). Manufacturing Strategy, Environmental Uncertainty and Performance: A Path Analytic Model. *Management Science, 33*(4), 509-525.

Swink, M., & Way, M. (1995). Manufacturing strategy: propositions, current research, renewed directions. *International Journal of Operations & Production Management, 15*(7), 4-26.

Teich, J. M., & Wrinn, M. M. (2000, January 1). Clinical decision support systems come of age. *MD computing, 17*(1), 43-46.

Thomas, J. W., Guire, K. E., & Horvat, G. (1997). Is patient length of stay related to quality of care? *Hospital & Health Services Administration, 42*(4), 489-507.

Trzin, T. (1995). Healthy Office Buildings- Guidelines for Architects. *Proceedings of the Conference Healthy Buildings '95, Milan (I),*, 1451-1456.

Tucker, A. L., & Edmonson, A. C. (2003). Why hospitals don't learn from failures: organizational and psychological dynamics that inhibit system change. *California Management Review, 45*(2), 55-72.

Ulrich, R. S. (1991). Effects of interior design on wellness: Theory and recent scientific research. *Journal of Health Care Interior Design, 3*(1), 97-109.

Ulrich, R., Zimring, C., & Zhu, X. (2008). A review of the research literature on evidence-based healthcare design. *Health Environ Res. Design J., 1*, 61-125.

Valiris, G., Chytas, P., & Glykas, M. (2005). Making decisions using the balanced scorecard and the simple multi-attribute rating technique. *Performance Measurement and Metrics*, 159-171.

Van Looy, B., Gemmel, P., Sesmet, S., Van Dierdonck, R., & Serneels, S. (1998). Dealing with productivity and quality indicators in a service environment: some field experiences. *International Journal of Service Industry Management, 9*(4), 369-376.

Vermeulen, M. J., Ray, J. G., Bell, C., Cayen, B., Stukel, T. A., & Schull, M. J. (2009). Disequilibrium Between Admitted and Discharged Hospitalized Patients Affects Emergency Department Length of Stay. *Health Policy and Clinical Practice/Original Research, 54*(6), 794-804.

Vos, L., Groothuis, S., & van Merode GG. (2007). Evaluating hospital design from an operation management perspective. *Health Care Manag Sci, 10*, 357-64.

Vuorinen, I., Jarvinen, R., & Lehtinen, U. (1998). Content and measurement of productivity in the service sector: a conceptual analysis with an illustrative case from the insurance business. *International Journal of Service Industry Management, 9*(4), 377-396.

Wagstaff, A. (December 2005). Health Systems in East Asia: What Can Developing Countries Learn from Japan and the Asian Tigers? *The World Bank, Washington DC, USA*, 2.

Wang, B. B., Wan, T. H., Clement, J., & Begun, J. (2001). Managed care, vertical integration strategies and hospital performance. *Health Care Management Science, 4*(3), 181-191.

Watcharasriroj, B., & Tang, J. (2004). The effects of size and information technology on hospital efficiency. *Journal of High Technology Management Research, 15*(1), 1-16.

World Health Organization. (2020). *Novel Coronavirus (2019-nCov); Situation Report -22.*

World Health Organization Global Health Expenditure. (n.d.). *Current health expenditure (% of GDP) - Malaysia, China, Japan, Korea, Rep., Singapore, Thailand, Hong Kong SAR, China*. Retrieved from The World Bank Group: https://data.worldbank.org/indicator/SH.XPD.CHEX.GD.ZS?end=2018&locations=MY-CN-JP-KR-SG-TH-HK&name_desc=false&start=2000&view=chart

Xanthopoulos, C. (1994). The Needs and Preferences of Hospital Staff and the Scope of Design. *World Hospitals, 29*(3), 20-27.

Yi, P., George, S. K., Paul, J. A., & Li Lin. (2010). Hospital capacity planning for disaster emergency management. *Socio-Economic Planning Sciences, 44*(3), 151-160.

Yon, D. D. (2020, November 3rd). KESIAPSIAGAAN UNIT RAWATAN RAPI (ICU) DAN ALAT BANTUAN PERNAFASAN (VENTILATOR) DI HOSPITAL KKM.

Younis, M. (2004). Length of hospital stay of medicare patients in the post-prospective-payment-system era. *Journal of Health Care Finance, 31*(1), 23-30.

Younis, M. Z., & Forgine, D. (2005). Using return on equity and total profit margin to evaluate hospital performance in the US: a piecewise regression analysis. *Journal of Health Care Finance, 3*, 82-88.

Zhao, Y., Mourshed, M., & Jonathan, W. (2009). FACTORS INFLUENCING THE DESIGN OF SPATIAL LAYOUTS IN HEALTHCARE BUILDINGS. *Online Research @ Cardiff (ORCA)*, 1041-1049. Retrieved from

http://www.arcom.ac.uk/-docs/proceedings/ar2009-1041-1049_Zhao_Mourshed_and_Wright.pdf

Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., . . . Tan, W. (2020). A Novel Coronavirus from Patients with Pneumonia in China, 2019. *The New England Journal of Medicine*, 727-733.

LIST OF PUBLICATIONS

Indexed Conference Proceedings

1. Hassan, Y., Yahya, A., Yunus, J., Fikri, S., Idris, N., & Hamzah, H. (2020). THE RELATIONSHIP BETWEEN FIVE ELEMENTS AND NINE VARIABLES IN HOSPITAL PLANNING. *Conference on "Emerging Trends in Applied Science, Engineering and Technology"* (pp. 267-274). Malaysia: Journal of Mechanics of Continua and Mathematical Sciences. doi:https://doi.org/10.26782/jmcms.spl.9/2020.05.00027

2. Hassan, Y., Yahya, A., Yunus, J., Fikri, S., Idris, N., & Hamzah, H. (May, 2020). PRINCIPLES IN DESIGNING THE HOSPITAL BUILDING. *Conference on "Emerging Trends in Applied Science, Engineering and Technology"* (pp. 259-266). Malaysia: Journal of Mechanics of Continua and Mathematical Sciences. doi:https://doi.org/10.26782/jmcms.spl.9/2020.05.00026

Non-Indexed Conference Proceedings

1. **Hassan, Y.,** Yahya, A., Yunus, J., Fikri, S., Idris, N., & Elias, L. H. (November, 2021). DESIGN CONSIDERATIONS FOR COVID-19 PATIENTS HOSPITAL. *International Teleconference on Technology and Policy for Supporting Implementation of COVID-19 Response and Recovery Plan in Southeast Asia (ITTP-COVID19). 1*, pp. 1-1. Malaysia: ITTP-COVID19.