THALASSAEMIA MANAGEMENT OUTCOME AND EFFICIENCY IN MALAYSIA

SITI RAHMAH @ NOOR SYAHIREEN BINTI MOHAMMED

UNIVERSITI SAINS MALAYSIA

2022

THALASSAEMIA MANAGEMENT OUTCOME AND EFFICIENCY IN MALAYSIA

by

SITI RAHMAH @ NOOR SYAHIREEN BINTI MOHAMMED

Thesis submitted in fulfilment of the requirements
for the degree of
Master of Science

July 2022

ACKNOWLEDGEMENT

In the name of Allah the Most Merciful the Most Gracious.

First and foremost, praises and thanks to the God, the Almighty, for His showers of blessings throughout my research work to complete the research. I would like to express my deep and sincere gratitude to my supervisor, Prof. Dr Asrul Akmal Shafie for giving me the opportunity work under him and providing invaluable guidance throughout this study. It was such a great privilege and honor to also work under the guidance of my second supervisor Dr See Kok Fong. I am extremely grateful for all their patience and guidance. In my years in USM, not only I gained so much invaluable experience and knowledge, unexpectedly I have the honor of meeting some of the best people who are now proudly my friends. Thank you Kak Ujie, Jacqueline, Irwinder and finally, my dear friend Annu. Last but never the least, I am truly grateful to be blessed with such an amazing family, each everyone who have been a constant support during all my endeavors and in every stage of my life.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ASA	autonomous supply agency
CI	confidence intervals
CMI	co-Managed Inventory
CMS	central medical stores
CRS	constant return to scale
DEA	data envelopment analysis
DFD	data flow diagram
DFO	Desferoxamine
DFP	Deferiprone
DFX	Deferasirox
DMU	decision-making units
FTE	full-time equivalent
ICT	iron chelating therapy
JIT	Just-In-Time
MOH	Ministry of Health
MYR	Malaysian Ringgit
NTDT	non- transfusion dependent
PSC	pharmaceutical supply chain
PSP	Pharmaceutical Services Programme
PTJ	Pusat Tanggungjawab, Autonomy Centre
SD	standard deviation
SE	scale efficiency
SFA	stochastic frontier analysis
TCC	thalassaemia care centres
TDT	transfusion dependant thalassaemia
TE	technical efficiency
VMI	Vendor-Managed Inventory
VRS	variable return to scale
WHO	World Health Organization

KEBERHASILAN DAN KECEKAPAN PENGURUSAN RAWATAN TALASEMIA DI MALAYSIA

ABSTRAK

Talasemia ialah penyakit keturunan yang kompleks dan memerlukan penjagaan kesihatan yang berpanjangan. Pesakit talasemia kronik memerlukan transfusi darah secara rutin yang turut melibatkan keperluan lawatan ke fasiliti kesihatan dengan kerap. Selain itu, pesakityang mendapat transfusi darah secara kerap akan memerlukan ubat 'iron chelation' bagi mengelakkan komplikasi kesihatan yang serius dan juga kematian. Perkara ini melibatkan kos yang tinggi . Kebanyakan pesakit talasemia di Malaysia bergantung kepada fasiliti kesihatan awam bagi mendapatkan penjagaan kesihatan. Fasiliti kesihatan ini dinamakan Pusat Pengurusan Rawatan Talasemia (PPRT). Bilangan pesakit memerlukan transfusi darah secara rutin yang tinggi, memberi bebanan dan tekanan tinggi kepada sumber kesihatan negara. Oleh itu, pihak yang bertanggungjawab perlu mencari jalan bagi meningkatkan kecekapan sistem bagi menyediakan penjagaan kesihatan kepada pesakit tanpa perlu berkompromi dalam aspek keselamatan, keberkesanan dan kualiti. Oleh demikian, objektif utama tesis ini ialah meneroka keberhasilan dan kecekapan pengurusan program rawatan talasemia di Malaysia. Sesi temubual pakar berkaitan dan dan analisa penerbitan-penerbitan dan laporan organisasi telah dijalankan bagi mengenalpasti struktur dan susun atur pusat pengurusan rawatan talasemia. Bagi menilai kecekapan teknikal sesuatu PPRT, analisis data envelopment (DEA) telah digunapakai. Regresi 'bootstrap truncated' pula digunakan bagi mengenalpasti faktor-faktor yang mempengaruhi kecekapan operasi sesuatu PPRT. Tesis ini turut meneroka dengan lebih lanjut apakah halangan semasa pengurusan rawatan talasemia dari kacamata kedua-dua belah pihak iaitu anggota kesihatan dan pesakit. Dapatan kajian menunjukkan terdapat dua amalan di PPRT iaitu pertama, pengurusan pesakit dibahagikan kepada dewasa dan kanak- kanak. Kedua,

pesakit dewasa dan kanak-kanak diberikan rawatan di pusat penjagaan harian yang digabungkan dan diuruskan oleh pasukan kesihatan yang sama. Di samping itu, pembelianubat 'iron chelation' bagi pesakit dijalankan secara berpusat oleh kerajaan. Di samping itu, analisa yang telah dijalankan menunjukkan skor purata kecekapan teknikal ialah 0.73 dan majoriti iaitu 51% PPRT berfungsi pada kecekapan yang baik. Analisa lanjut pula menunjukkan pemisahan pengurusan pesakit talasemia dewasa dan kanak-kanak memberi impak yang positif kepada skor kecekapan teknikal manakala kepanjangan tempoh operasi sesuatu pusat jagaan adalah memberi impak berbalik kepada skor kecekapan teknikal. Temubual lanjut bersama anggota kesihatan menunjukkan antara faktor halangan pengurusan rawatan talasemia adalah termasuk kekurangan sumber kewangan dan juga tenaga kerja. Tahap kepatuhan pesakit dalam mengikuti rawatan dan ubat-ubatan bagi talasemia juga didapati masih lemah. Namun begitu, pesakit talasemia yang menerima rawatan didapati secara amnya berpuas hati dengan akses mudah kepada rawatan di fasiliti kesihatan awam. Menariknya, anggota kesihatan dan pesakit, kedua-duanya bersetuju bahawa tahap kesedaran mengenai talasemia di kalangan masyarakat awam di Malaysia masih amat rendah.

THALASSAEMIA MANAGEMENT OUTCOME AND EFFICIENCY IN MALAYSIA

ABSTRACT

Thalassaemia is a complex inherited blood disorder requiring life-long medical care. Severe thalassaemia patients require regular blood transfusion and frequent visits to healthcare facilities. Routinely transfused thalassaemia patients necessitate costly iron chelating therapy to prevent iron overload complications that if left untreated, will cause serious morbidity and mortality. Majority of thalassaemia patients in Malaysia rely on public health facilities to receive medical care. Public hospitals providing comprehensive care to thalassaemia patients including routine blood transfusions are termed as thalassaemia care centres (TCC). The high number of transfusion-dependent thalassaemia patients put substantial strain on the healthcare system. Hence, with finite healthcare resources and growing number of patients, policymakers are urgently finding more efficient ways to deliver health services without compromising on quality of care and safety. Thus, the main objective of this thesis is to explore the management and outcome of thalassaemia treatment program in Malaysia. The structure and management of each thalassaemia care centres were characterized by means of qualitative interviews with key opinion leaders as well as by analysing the existing literatures and organizational reports. Next, data envelopment analysis (DEA) was utilized to evaluate the technical efficiency of thalassaemia care centres. Bootstrap truncated regression was then applied to determine the factors affecting the efficiency of thalassaemia care centres. This thesis further investigates the barriers during thalassaemia care management from both healthcare providers' and patients' viewpoint. Findings showed that in TCCs, there are generally two practices, where

adult and paediatric are either managed separately or, in a combined day- care by a common team. The essential iron chelators in Malaysia are supplied and procured through centralized purchasing. The mean technical efficiency scores for TCC were 0.73 where 51% showed good technical efficiency. Further analysis showed separate management of thalassaemia patients exhibited positive relationship whereas longer operations inversely impact the efficiency. Qualitative interviews found that barriers to optimal thalassaemia management include insufficient fund allocation and manpower as well as poor patient adherence. Ultimately, patients in general were satisfied with treatment accessibility. Both healthcare providers and patients were in agreement that there is still poor public awareness on thalassaemia.

CHAPTER 1
INTRODUCTION

1.1 Background

Thalassaemia broadly refers to blood diseases in which there is reduced or absent synthesis of normal globin chains of the haemoglobin molecule. Each normal haemoglobin molecule is constructed by four globin chains; usually two from α- and another two from β- family of the globin chains (Barnett, 2019). Thalassaemia is classified based on which of the globin is defective. Depending to the chain whose synthesis is impaired, they are called α-, β-, γ-, δ-, $\delta\beta$-, or $\varepsilon\gamma\delta\beta$ thalassaemias. However, from a clinical point of view, the most relevant types are α- and β-, which are caused by a reduction in one of the two types of polypeptide chains (or) that make up the typical adult human haemoglobin molecule (Cappellini et al., 2014). As one of the most commonly inherited haemolytic anaemia, thalassaemia can be mostly found in Asian regions (Farmakis et al., 2020).

Globally, it is estimated that more than 300 million people are thalassaemia carriers. It is also reported that more than 350,000 babies are born each year with hemoglobinopathies including thalassaemia. From the clinical perspective, the thalassaemias can be classified according to the severity of the anaemia and the need for regular red blood cell transfusions. Thalassaemia minor, resulting from the heterozygous inheritance of one thalassaemic mutation, is clinically asymptomatic with minimal, microcytic, and hypochromic anaemia. Patients with thalassemia major require routine red blood cell transfusions for the rest of their lives, beginning in early childhood. Thalassaemia intermedia patients' anaemia is less severe, and they only occasionally or never need blood transfusions. In practice simplification, the two main thalassaemia groups are the transfusion dependant thalassaemia (TDT) and non- transfusion dependant (NTDT) (Cappellini et al., 2014, Kattamis et al., 2022) .

Hemopoietic stem cell transplantation is still the curative treatment for thalassaemia particularly for TDT. This treatment option is nonetheless, limited. The mainstay of therapy for majority of TDT patients is lifelong regular blood transfusions that are necessary for survival (Shafie et al., 2021). Nevertheless, regularly transfused patients are at risk of multiple complications as they are unable to eliminate the excess iron that was released from the breakdown of transfused red blood cells. The excess iron will deposit in different organs as hemosiderin and ferritin, especially in the heart and liver. This accumulation of toxic quantities of iron leads to complications like heart failure, diabetes, hypothyroidism and liver disease. Iron overload (IOL) in chronically transfused patients contributes to high morbidity and mortality rate (Barnett, 2019).

This once ominous diagnosis has now had better prognosis with the advanced progress. The introduction of prenatal or preimplantation screening programmes led to early diagnosis and early intervention. The use of sophisticated therapeutic and monitoring technologies such as reliable genotyping, and accurate iron overload monitoring contributed to early initiation of iron chelation therapy and diagnosis of evolving organ damage. These factors transformed thalassaemia from a paediatric disease with a guarded prognosis to a chronic disease with a survival of at least up to the fifth decade of life (Taher et al., 2018).

As aforementioned, the therapeutic management of patients with thalassaemia focuses on treating chronic anaemia and on close monitoring and treating iron overload with iron chelating therapy (ICT) drugs and treatment-induced or disease-related complications. ICT drugs acts to prevent the toxic effects of iron accumulation. The discovery and availability of ICT has dramatically increase patient's survival and quality of life (Farmakis et al., 2020, Cappellini et al., 2018).The average life expectancy for beta thalassaemia patients increased from 17

years in 1970 to 27 years in 1980 and 37 years in 1990. In 1967, only 37% of patients lived to the age of 16. On the other hand, in 2011, 89 percent of patients survived to the age of 40. According to more recent evidence, 63 percent of patients are expected to live to the age of 50, and 33 percent of these patients are expected to be free of disease-related complications at this age, implying a much longer life expectancy (Chapin et al., 2022, Longo et al., 2021, Farmakis et al., 2020).

1.2 Thalassaemia in Malaysia

It is estimated that about five percent of Malaysian populations are carriers of thalassaemia genes. Data from Malaysian Thalassaemia Registry showed that there are 8681 registered thalassemia patients in Malaysia in 2018. Sabah recorded the highest number with 1,814 patients that mostly are of Kadazan-Dusun ethnicity and more than 72% of them are categorized as TDT patients (Mohd Ibrahim, 2019). Cost burden for thalassaemia treatment in Malaysia is very significant. A lifetime cost of treatment for a TDT patient is estimated to be USD 606,665 or RM 2,699,052.58. High out of pocket expenditure by patient and family especially spent on transportation (Shafie, Wong, Ibrahim, Mohammed, & Chhabra, 2021). This evidently showed the major public health issue with high cost burden to the healthcare system.

Universally, all Malaysian citizens are eligible for comprehensive medical care with minimal fees. Studies have shown that Malaysia has one of the most well-established quality medical care from screening program, counselling, curative care up to palliative care for thalassaemia patients (Azman et al., 2016). This comes as one of the outcomes from the launching of National Thalassaemia Prevention and Control

Programme in late 2004. This initiative is an effort to ensure better management of thalassaemia in Malaysia as well as address the increasing trend in number of cases each year.

The nationwide effort comprises of four major initiatives involving provisioning of comprehensive clinical management of thalassaemia patients, launching and monitoring of population screening and counselling within community, establishing a national-level registry as well as coordinating collaborative action with various stakeholders to promote public health education for public to take active action to control and prevent thalassaemia (Mohd Ibrahim et al., 2020). A special budget was also approved by Cabinet to acquire infusion pumps and provide ICT nationwide under this programme. In Malaysia, there are three available types of ICT for treatment of IOL complications which are desferrioxamine (DFO), deferiprone (DFP) and deferasirox (DFX).

1.3 Healthcare System in Malaysia

Malaysia's healthcare is divided into public and private sector. Public healthcare provides comprehensive healthcare services like disease prevention, diagnostic, curative care and health promotion. Malaysia, having a heavily subsidized public healthcare system by federal taxation and other government revenues. Consequently, it provides universal healthcare to all citizens at nominal cost. Non-citizens are similarly eligible for public healthcare, but with additional cost as only citizens will receive subsidy.

Ministry of Health (MOH) Malaysia is the central organization coordinating healthcare provision to the public. The organization structure consists of three main levels: federal, state and district. The level of authority differs at the separate

hierarchical level. This system is established to provide greater network of healthcare facilities to ensure accessibility and equity to public. Public can seek medical care in hospitals and health clinics in numerous locations all around the country, in both urban and rural areas. District health offices and health clinics principally serve the community providing primary care to surrounding community. On the other hand, hospitals serve as the secondary and tertiary tier in the healthcare system. In this situation, patients from the community are referred to hospitals for further and more specialized medical care and treatment (Thomas, Beh, & Nordin, 2011).

1.4 Concept of efficiency, distribution and resource allocation health system

There has been steady shift of the practice of healthcare system, globally, inclining towards value-based medicine on top of the existing evidence-based medicine. This is as field of medicine advances particularly in treating diseases, in parallel, more demand is placed to discover approaches for a better resources allocation by means of improving efficiency and productivity. In any field including healthcare, efficiency and good governance are key to cost optimization and increase in productivity whilst at the same time ensuring equity in access to healthcare (Baghdadi-Sabeti & Serhan, 2010).

Healthcare expenditure represents an integral part in resource utilization of a country. Ageing population and advancement in medical technologies paves the way for more advanced diagnostics and treatment options are among the factors that contribute to increased demand in healthcare. Rising demand on finite healthcare resources puts pressure on policy makers for a further efficient way to deliver healthcare services. Efficiency improvements in the health sector, even in small

amounts, can yield considerable savings of resources or expansion of services for the community (Peacock, Chan, Mangolini, & D., 2001).

Assessment of efficiency is one of the ways to evaluate the performance of any healthcare facility. The assessment of efficiency concerns with the relation between resource inputs and either intermediate outputs or final health outcome. Efficiency in healthcare sector is an attribute of performance that is measured by examining the relationship between specific products of the health care system and the resources used to create those products (Bill, 1997).

A provider is said to be efficient if the input can be minimized to produce a given output or able to maximize the output for a given set of inputs. Efficiency in publicly funded healthcare services is best measured from the perspective of technical efficiency. This is because the public health service providers are limited by a relatively fixed patient base for which they produce a fixed number of outputs. Thus, the challenge is to produce these outputs with minimal inputs (Amirteimoori & Khoshandam, 2011).

Malaysian public procurement tantamount to about 24-33% of the country's gross domestic product (GDP) (Adham & Siwar, 2012). Malaysian healthcare consists of public and private sector where public healthcare provides comprehensive services like disease prevention, diagnostic, curative care and health promotion whereby private practices focuses mainly on diagnostic and curative care. Public sector caters to almost 82% of inpatient care and 35% of ambulatory care while the inpatient care in private sector amounted to only 18% and 62% of ambulatory care (Hussein, 2010).

1.5 Problem statement

As aforementioned, the curative therapy for thalassaemia is hemopoietic stem cell transplant. However, this option is often limited in Malaysia forcing most thalassaemia patients to depend on blood transfusion. For this reason, many thalassaemia patients rely on public healthcare for a lifelong care and health monitoring.

The special budget allocated under the National Thalassaemia Prevention and Control Program was made available to acquire infusion pumps and provide ICT nationwide. The budget allocation is then decentralized to each hospital. However, increasing number of patients despite numerous preventive campaigns and initiatives and increasing cost of treatments leads to strain on the finite resources. It is reported that less than 20% of thalassaemia patients receive adequate iron chelation therapy where majority are destined to die in the 2nd or 3rd decade of life from complications of multiple organ failure secondary to iron overload (George, 2001). Therefore, understanding the level of efficiency as well as external factors that could potentially contribute to the performance will shed insight to circumvent this matter for service improvement.

Additionally, to date, there has not been any study exploring on efficiency and management outcomes with focus on thalassemia care centres (TCC) in Malaysia. With this information on relative efficiency, policy makers and thalassemia TCC managers will be able to make informed, strategic decision that has the potential to not

only better optimize the existing resources allocations but also lead to improvement in overall output.

1.6 Research question

In any healthcare system in the world, patient is the most integral component. As most study of efficiency only considers vertical viewpoint from one stakeholder to another, it is imperative that the system is also explored horizontally to identify the weaknesses in the current practice (Pan et al., 2019, Hamzah and See, 2019, Hunt and Link, 2020, Yildiz et al., 2018, Lacko et al., 2018). The findings would allow improvement of the service provided to patient as well as look at any inefficiency that might arise with the current practice.

This study intent to enrich the dimension to encompass on the entire spectrum of thalassaemia care management by exploring on the pharmaceutical supply chain, patient management system in healthcare facility, and understanding the viewpoint of healthcare provider as well as patients involved. This study aims to identify the potential areas where better resource allocation can be optimized and at the same time improves patient outcome. Hence, this study intent to address the following research questions:

1) How are thalassaemia patients managed in the hospitals?
2) What are the facilities and resources involved in managing thalassaemia patients requiring frequent blood transfusion?
3) How are the iron chelating therapy supplied in Malaysian healthcare?
4) How efficient are the thalassaemia care centres in Malaysia?
5) What affects the efficiency?
6) What are the barriers healthcare provider faced to provide care for thalassaemia patients?

7) What are the obstacles and issues patient experience when seeking treatment?

1.7 Research objectives

The main objective of this thesis is to explore the management and outcome of thalassaemia treatment program in Malaysia. The specific objectives are as follows:

1) To characterize the thalassaemia care center's structure and iron chelation therapy supply chain in Malaysia healthcare
2) To evaluate the technical efficiency of thalassaemia care centres and the determinants of the efficiency
3) To identify the barriers to thalassaemia treatment from the healthcare provider's perspective
4) To delve into patient's experience and journey during episode of care in public healthcare facilities

CHAPTER 2

LITERATURE REVIEW

2.1 Efficiency studies in healthcare systems

The analysis and measurement of efficiency of organization in health care settings is complicated and a challenging task. These organizations oftentimes pursue multiple goals while at the same time subjected to operational limitations over which they have no choice or control and that the procedures used to produce healthcare are intricate and uniquely. Furthermore, the processes involved in producing healthcare are complex and individually tailored. This also makes it difficult to define the technologically feasible model of production consequently, to assess the degree to which organisations are deviating from this viable production modality (Coelli et al., 1998).

Several comparative analysis techniques are commonly employed for performance evaluation in health care are stochastic frontier analysis (SFA) and data envelopment analysis (DEA). SFA is a parametric technique in which a functional form is used to estimate efficiency. DEA on the other hand is a non-parametric technique where efficiency is expressed as the ratio of sums of the weighted outputs to the sums of the weighted inputs. Both DEA and SFA are often applied to data on a sample of firms or 'decision making unit (DMU) such as a hospital, clinic or a country and provides comparison on the relative efficiency among the DMUs. The selected DMUs technically should operate in similar production processes to allow for a fair comparison (Organization, 2016, Yildiz et al., 2018).

While both approaches provide comprehensive quantification of performance, there are still some limitations. One of the main disadvantages of SFA is that it requires predetermination of functional form of the production frontier as well as the

need for a large sample size. On the other hand, DEA with its deterministic property, does not account for measurement of error in computing the efficiency measures (Coelli et al., 2005, Jacobs, 2001, Katharakis et al., 2013).

DEA allows simultaneous evaluation of multiple inputs, outputs and other explanatory variables for efficiency in any production unit. There have been various studies using DEA in measuring efficiency in healthcare (Aminuddin & Ismail, 2016; Foo, Lim, Sivasampu, Dahian, & Goh, 2015; Shreay et al., 2014).

Numerous studies on healthcare efficiency and hospitals have been conducted over the years using data envelopment analysis (DEA). Some selected studies measure hospital efficiency in Saudi Arabia (Helal & Elimam, 2017), South Korea (Lee, Chun, & Lee, 2008), Turkey (Ersoy, Kavuncubasi, Ozcan, & Harris II, 1997), Greek (Aletras, Kontodimopoulos, Zagouldoudis, & Niakas, 2007) and Gambia (Jarjue, Nor, Ghani, & JALIL, 2015). Several other studies adopted DEA to compute efficiency in regards to disease condition such as stroke (Ozcan, Watts, Harris, & Wogen, 1998) diabetes (Amado & Dyson, 2009), malaria (Atake, 2017), and HIV/AIDS (Zeng, 2012).

Apart from that, application of DEA also extends to measure efficiency of healthcare services for example oral health service (Linna, Nordblad, & Koivu, 2003), nursing unit (Mark, Jones, Lindley, & Ozcan, 2009), primary care (Giuffrida & Gravelle, 2001), maternal health (Amiri & Gerdtham, 2013), pharmacy service (Barnum, Shields, Walton, & Schumock, 2011; Hamzah & See, 2019) and general practitioner (Staat, 2003). Additionally, there are several comprehensive reviews on efficiency studies conducted mainly in hospitals, such as by Kohl et al (Kohl,Schoenfelder, Fügener, & Brunner, 2019), Hollingsworth et al (Hollingsworth, 2008),and O'Neill (O'Neill, Rauner, Heidenberger, & Kraus, 2008). Similar point of issue raised by all the review papers, were how translational are the findings into real practice and bridging the gap of theoretical postulation into real value for policymakers

and managers.

While all of the stated studies adapt the traditional two-stage DEA, we also found several other studies that utilizes Simar and Wilson double bootstrap DEA to assess efficiency in healthcare such as by Cavalieri et al (Cavalieri, Guccio, Lisi, & Pignataro, 2018), Hamzah et al. (Hamzah & See, 2019), See et al. (See & Yen, 2018), Chowdhury et al (Chowdhury & Zelenyuk, 2016) and Staat et al. (Staat, 2006). Simar and Wilson (Simar & Wilson, 1998) introduced the double bootstrap DEA to address the issues on data generating process during efficiency score calculation as well as the second stage regression to investigate the environmental factors affecting efficiency scores.

Although DEA is considered the more preferred method, it is still worth mentioning some hospital-associated efficiency studies in which stochastic frontier analysis (SFA) were applied. Some examples of studies include by Goudarzi et al. (Goudarzi et al., 2014) looking at efficiency of teaching hospitals in Iran, Yildiz et al. (Yildiz, Heboyan, & Khan, 2018) assessing the technical efficiency of Turkish hospitals, Canadian hospital efficiency study by Abeney et al. (Abeney & Yu, 2015) and Rosko et al. (Rosko & Mutter, 2011) a review paper discussing on SFA applied efficiency studies on 27 hospitals in United States. As discussed, there has not been any study looking at the technical efficiency thalassaemia care centre. However, we based the process and functionality of similar practice or service, the most relatable would be of a dialysis centre. The rationale behind this, is because dialysis centre runs as outpatient or ambulatory care where patient comes to be dialyzed. The cluster patients attending the facilities are mostly registered patients which are similar in the case of thalassaemia.

On that note, several efficiency evaluations studies have been conducted in dialysis centres. A paper by Gerard and Roderick (Gerard & Roderick, 2003) evaluated

the efficiency of 82 haemodialysis satellite units in England and Wales using output-oriented variable returns to scale (VRS) DEA model. Inputs selected were number of nurses and number of dialysis machine whilst selected output was patients treated per week. Result from thestudy showed that the mean overall efficiency score is 0.94. 24 units are identified as best practicing units in which 10% more output were to be augmented if all units were to be efficient. Additionally, Kontodimopuolos et al. (Kontodimopoulos & Niakas, 2005) applied DEA to assess efficiency on 118 haemodialysis units in Greece. Selected inputs were number of nurses and number dialysis machine. Input-oriented VRS DEA model were selected in the study. Study found that units should reduce input utilization by 30% to achieve efficiency. The study also found that being in private or public sector affects the efficiency scores.

Subsequently, following the study by Ozgen (2002), Shreay et al. (Shreay et al., 2014) expanded and evaluated 43 freestanding haemodialysis units. Findings showeda quarter of units operates at full efficiency with mean score of 0.78 which is almost similar with previous study. Shreay et al. also found that input reduction by 30% would aid inefficiency units to reach the efficient frontier. Findings from the study showed that region, organization size and urban location influenced the efficiency scores. Consistent with findings of Ozgen et al., the ownership form was found to affect the score. Apart from that, geographic region and urbanicity also influence the efficiencyscores of the studies units.

Findings from these studies demonstrated the usefulness of DEA in addressing issues of resource allocation and output optimization by assessing efficiency levels whilst capturing the complexity and managerial trade-offs that characterize healthcare services.

2.2 Efficiency study in Malaysia healthcare

There are limited number of studies conducted in Malaysia specifically assessing the efficiency in healthcare system or facilities. Hamzah et al. (2021) conducted evaluation on the efficiency level of government healthcare response to the outbreak of Covid-19 in Malaysia. Using network DEA, it is found that Malaysia healthcare system responded well to the global health crisis. The input variable included in this study are number of quarantine centres and cumulative number ofpeople quarantined as well resources used such as personal protective equipment. Number of positive cases was used as intermediate output to assess the overall efficiency (Hamzah, Yu, & See, 2021).

Another notable efficiency study conducted in local healthcare setting is by Foo et al in 2015 where the performance of ophthalmology clinics in public hospitals throughout Malaysia were evaluated. It is found that one-third of the centres performed sub-optimally. Further analysis showed that centres could increase output level by 10% should they improve in the service delivery process. Interestingly also Foo et al. found that state hospitals has the best efficiency in ophthalmology services compared to other types of hospitals (Foo et al., 2015).

Several other studies evaluating efficiency in Malaysia healthcare system comparing performance among public hospitals are published by Samsudin et al (2016), Appalanaidu et al (2014), Norzahira et al. (2013) and Che Razak et al. (2003). All studies found that most public hospitals are operating at good efficiency level with percentage of 74% up to 93%. However, Samsudin et al. (2016) found that efficiency is influenced by admission rate, the ratio of outpatient and doctor as well as type of hospital. It is also found that there is underutilization of specialist hospital in which output could have been improved with better utilization of input measures (Samsudin, 2016). Concurring to this, in 2014, Applanaidu et al. has noted that one of the hospitals

performing at poorer efficiency was caused by the excess of labour input such as number of doctors (Applanaidu, Samsudin, Ali, Dash, & Chik, 2014; Che Razak, 2003; Samsudin, 2016).

Apart from that, other studies investigated the performance among departments in public hospital settings. Aminuddin et al (2016) conducted efficiency assessment in Emergency Department comparing the zones in the department. Relocation of resources between zones was found to be able to improve performance in Emergency Department. For example, reshuffling and implementation of new doctor's shift and mobilizing nurses between zones (Aminuddin & Ismail, 2016).

2.3 Summary of gap and strength

The pursuit of efficiency has been a key concern for all policymakers in any healthcare system. It is apparent from the literature searches that thalassaemia has a significant bearing on economic burden particularly on healthcare resources. With the substantial size of thalassaemia patients in Malaysia, it is imperative that a strategy be formulated to optimize resources efficiently while at the same time provide the most comprehensive and optimal care to the patients. From the literature review, it can be concluded that there has never been any study looking at the efficiency evaluation of a disease management that requires lifelong medical care and health monitoring such as thalassaemia.

Until this point of writing, there has not been any efficiency evaluation on thalassemia treatment centres in Malaysia. Therefore, exploring the efficiency using DEA that considers multiple inputs such as cost (labour and non-labour) and output such as quantity of procedure and quality for thalassemia treatment is justified. Knowledge in the level of efficiency (or inefficiency) as well as external factors that potentially contribute to their efficiency (or inefficiency) will shed insight into

developing intervention for service improvement. Optimization in resource allocation, service output and quality can be achieved.

With this knowledge on relative efficiency, policy makers and thalassemia treatment centre managers will be able to make informed, strategic decision that has the potential to lead to improvement in overall output.

2.4 Conceptual framework

CONCEPTUAL FRAMEWORK		
Research Questions	**Method**	**Source**
▪ How are thalassaemia patients getting treatment? ▪ How is iron chelating drugs supplied to patients?	Literature Review	Databases
▪ What do patient encounter when they seek treatment for thalassaemia? ▪ What are the obstacles and issues during this experience? ▪ What are the challenges faced by healthcare professionals while providing care to thalassaemia patients?	Qualitative Interview	Healthcare professionals Patients
▪ How efficient are thalassaemia treatment centres? ▪ What affects its efficiency?	Data Envelopment Analysis	Databases / record at site

CHAPTER 3

METHODOLOGY

3.1 General study design

This study was organized into four phases to address all the research questions and objectives. Phase One adapted case study approach involving triangulation of information from multiple sources and methods of data collection. Phase Two was designed to quantify the technical efficiency scores of thalassaemia care centres and investigate the determining factors affecting the technical efficiency scores. Phase Three and Phase Four were devised to explore the human component of care; both provider and patient and understand the barriers and challenges they experience in thalassaemia care.

3.2 Ethical consideration

This study was registered with the Malaysian National Medical Research Registry (NMRR-17-2614-38966 (ISR)) and approved by the Malaysia Medical Research and Ethics Review Committee (MREC). Informed consent was obtained from all participants in qualitative interviews.

3.3 Phase One: Characterizing the thalassaemia care centre's structure and iron chelation therapy supply chain in Malaysia healthcare.

Case study approach was employed in this phase to explore the framework of how thalassaemia care is delivered to patient. This process-oriented case study focuses on the chain of events on how patient is managed in hospitals or thalassaemia care

centres during an episode of care as well as describing the supply chain of essential iron chelating drugs to patients.

Case study is a methodology to systematically investigate in-depth a case or an event order to generalize the cases or events. This method allows for understanding of complex phenomena or events in its natural setting to increase understanding of them (Yin, 2017). This approach may obtain data from multiple sources to capture the case under study in its entirety (Yazan, 2015). As mentioned, this phase of this study aims to characterize the thalassaemia treatment care centre's structure and how ICT is supplied.

Accordingly, it neither intend to impose any changes nor introduce any intervention to the existing process. Due to that, case study is arguably the suitable method to use to address the 'how' of the research question and understand the processes and events involved in its natural environment or context. Several sites were selected for study conduct in Phase One and in each site, to compare and contrast the similarities and differences.

3.3.1(a) Data collection

Data was collected through three main techniques in this phase as detailed below.

1. Interviews
2. Process mapping through observation
3. Literatures and organization's document review

In each site, several participants were interviewed to ensure saturation is reached. Process mapping and observations on the process flow were conducted in both paediatric and adult thalassaemia day-care.

3.3.1(b) Interviews

Semi-structured face-to-face interviews were carried out in selected hospitals providing care to thalassaemia patients. Interviewees are generally from two groups, healthcare providers, that include key personnel working in providing care and treatment to patients either directly or indirectly (Group A). The other interviewee group were thalassaemia patients or in case of paediatric thalassaemia patients, their proxy or caregivers were interviewed instead (Group B). Based on a systematic review by Hennink et al., 9 to 12 subjects are required to achieve saturation (Hennink and Kaiser, 2022).

Participants from Group A were selected using maximum variation sampling with focus on the expertise of participants. Maximum variation sampling was used for the select participants to allow for the phenomenon to be representative of different perspectives (Palinkas et al., 2015). The name list of potential participants was retrieved from each State Health Department's Human Resource database. Once participants were identified, they were then contacted via e-mail and phone. A summary of the study was then explained to participant and those agreeable were set for appointment. The participants of in-depth interviews for this Group A were as follows:

1. Head of Paediatrics Department
2. Head of Medical or Haematology Department
3. Nurse (Paediatric / Medical / Haematology Department)
4. Pharmacist (Medical store / Ward (clinical) /Outpatient department)

Interviews were conducted with agreeable participants using a prepared semi-structured interview guideline. Face to face interviews lasting about 15-30 minutes were carried out in English at sites based on the interview guide (Appendix A).

Interviews were all audio recorded.

As for Group B, participants were selected using purposive sampling where, investigator travelled to sites and visited thalassaemia day-care. Agreeable participants who were present in during thalassaemia clinic day or came for blood transfusion were asked for consent to be interviewed. Participants were asked to recall their experience during their journey of getting treatment during an episode of care. Investigator would then populate the journey map template as detailed in Appendix B. Group B participants were interviewed for both Phase One and Phase Three. The interview guide for Group B is detailed in Appendix C.

3.3.1(c) Process mapping through observation

Investigator conducted observations on the working flow of the thalassaemia care centres to map out the activities and processes involved in delivering health service to thalassaemia patients in selected sites. This process-based approach was selected to answer the research question and objective of this phase.

Process mapping is commonly used to model the actual process flow in graphical form. The diagram allows one to see how a process works within its functional boundaries. Process mapping permits for a better understanding on a functioning process and allows for exploration on how to improve efficiency and effectiveness of a process (Rodger & Pendharkar, 2001).

Data Flow Diagram (DFD) technique is used to illustrate or model the management process starting from the initial phase up until how it reaches the end user. Using DFD allows for visualization of the structure of the entire system. DFD process map uses four different symbols to signify the main components as shown in Figure 1

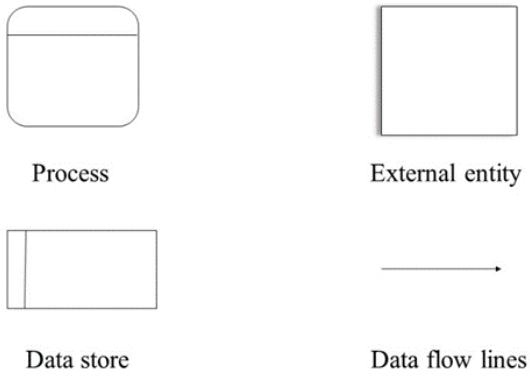

Figure 1 Four main Data Flow Diagram components

3.3.1(d) Literatures and organization's document reviews

In order to first understand the entire framework of thalassaemia care delivery in public healthcare, literatures search was conducted. This initial stage of literature search was performed in a broader sense to gain general insights of the healthcare system framework and pharmaceutical supply chain. Background reading were carried out to better understand the fundamental context of pharmaceutical supply chain. To further verify findings, documentations at sites were reviewed such as organization policy, job description report, standard operating procedures, and other relevant documents.

3.3.1(e) Study sites

Sites selection are primarily based on suggestion by subject matter expert discussed at study inception. The general rule of site selection is that it covers sites at different regions. All the data collected from interviews were constantly compared and data saturation were achieved after five sites. However, three additional sites were included with similar participant's demographic to confirm the data saturation. Each interviewee was contacted and appointment was made before the day of the interview. Only agreeable and willing participants are interviewed. Finally, the sites in which qualitative interviews and process mapping were conducted are as follows:

Table 1 List of study sites for Phase One

No.	Hospital	State
1.	Hospital Sultanah Bahiyah	Kedah
2.	Hospital Pulau Pinang	Pulau Pinang
3.	Hospital Sultanah Aminah	Johor
4.	Hospital Sultan Ismail	Johor
5.	Hospital Umum Sarawak	Sarawak
6.	Hospital Queen Elizabeth I	Sabah
7.	Hospital Wanita dan Kanak-kanak Sabah	Sabah
8.	Hospital Sultanah Nur Zahirah	Terengganu
9.	Hospital Raja Perempuan Zainab	Kelantan

3.3.1(f) Data analysis

All of interview sessions were recorded and transcribed verbatim for analysis. Interview files were coded by the investigator using both pre- determined and inductive categories. Process mapping of the patient management flow and the supply chain yielded process flow diagram illustrating the key stages involved in the events. Data collected from all techniques were later triangulated and analysed. Triangulation from multiple data source help to validate and strengthen the results. All data were analyzed and triangulated using Atlas.ti version 9 (ATLAS.ti Scientific Software Development GmbH).

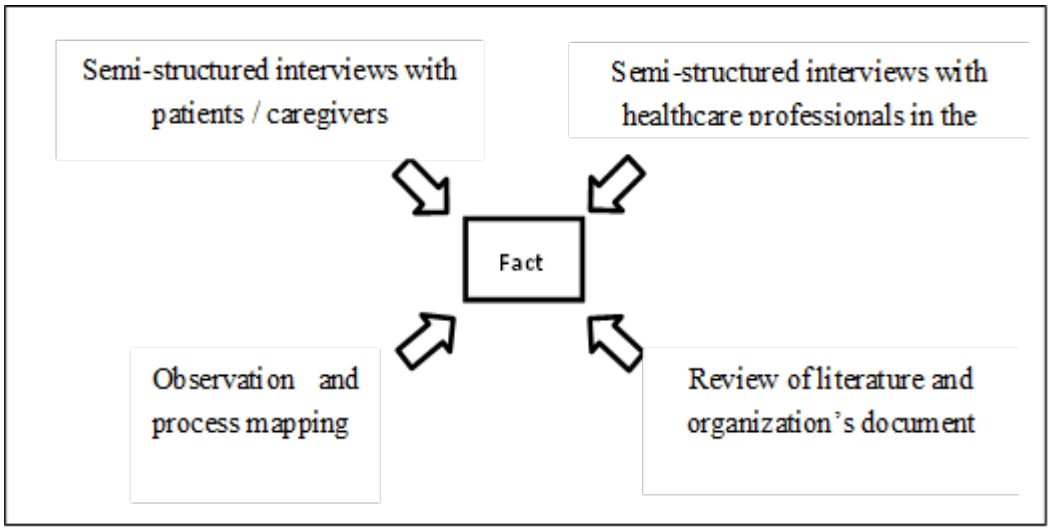

Figure 2 Triangulation of data in this study

3.4 Phase Two: Efficiency of thalassaemia treatment centres

As aforementioned, DEA measures technical efficiency by first identifying a 'best practice' production possibility frontier based on the selected firms or decision-making units (DMU) achieving the highest output mix for their input (Charnes, Cooper, & Rhodes, 1978). These DMUs lying on the frontier would be considered efficient compared to others in the sample and would be assigned a score of 1.0. Other DMUs would then be benchmarked against these frontier centres most similar to themselves (the 'peers') and then be given scores of more than 1.0 by comparing their output / input ratio.

Efficiency in publicly funded healthcare services is best measured from the perspective of technical efficiency. This is due to the fact that public health service providersare constricted by having a relatively fixed number of patients' for which they must produce a fixed number of output. Thus, the challenge is to produce these outputs with minimal inputs (Amirteimoori& Khoshandam, 2011).

DEA is selected for this study as it allows for multiple inputs and outputs to be used to compute a single score of efficiency for each DMU. DEA also identifies the best of performance by DMU rather the averages. This allows derivation of

various performance indicators and identification of peers most relevant to each DMU for mutual learning. DEA is able to handle non-commensurate input and outputs without having to put unit prices for each. Apart from to exploit all the advantages of DEA, this study also adopts DEA due to the relatively small number of samples (Katharakis et al., 2013, Coelli et al., 2005)

3.4.1(a) DEA model and approach

3.4.1(a)(i) Standard DEA model

DEA model analysis can adopt either input or output oriented approach. Input-oriented model allows for exploration to which extend resources can be minimized whilst maintaining similar level of output. On the other hand, output oriented model DEA maximizes output for a given level of input; in other words, it indicates how much a firm can increase its output for a given level of input. In this study, input-oriented VRS DEA model is applied to measure technical efficiency (TE) scores.

As to describe standard DEA model, the notation X represents the K × N matrix of inputs, consisting of K inputs from N hospital thalassaemia care centres (TCC), while Y represents the M × N matrix of outputs, consisting of M outputs from N hospital TCC. The input-oriented constant return to scale (CRS) DEA model can be summarized as follows:

$$Min_{\emptyset,\lambda}\, \emptyset \qquad (1)$$

Subject to:

$$-y_i + Y\lambda \geq 0,$$

$$\emptyset x_i - X\lambda \geq 0$$

$$\lambda \geq 0$$

$\emptyset$ signify a scalar while λ denotes an N × 1 vector of constants. The resulting