ASSESSING THE PREVALENCE OF HAND, FOOT AND MOUTH DISEASE (HFMD) USING GEOSPATIAL DENSITY AND DISTRIBUTION TECHNIQUES

NUR NAJIHAH BINTI HASAN

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DEDICATION

Alhamdulillah..

Every challenging work needs patience as well as support from my loved ones. Due to that, I dedicate this thesis to my beloved father and mother,
Mr Hasan bin Bajuri and Mrs Ramlah binti A Rahman.
Their affection, encouragement and prayers enable me to keep going on and succeed.

To my friends,
Mohamed Hassan Haji,
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ABSTRACT

The prevalence of hand, foot and mouth disease (HFMD) cases in Malaysia is now rising as reported by several sources such as the mass media and Internet. In this study, the prevalence of HFMD in Johor is comprehensively studied using geospatial density and distribution techniques to assess the prevalence of HFMD in Johor. Three objectives were designed for this study. The first objective was to conduct a needs assessment for identifying the requirement of a geospatial database of HFMD prevalence at Johor. The second objective aimed to develop a geospatial database for Johor HFMD cases. The last, which is the third objective, was to analyze the prevalence of HFMD in Johor via geospatial density and distribution techniques using open source software. This study is significant in order to provide the information of HFMD prevalence to the Department of Health Johor. The result indicates that the disease can occur throughout the year, however it reaches peak in February and March, of which is during the dry season. Concurrently, the distribution of HFMD cases in Johor exhibited a clustered pattern., which most mean centres and standard deviation ellipses occurred at similar areas. The direction of the standard deviation ellipses also oriented towards the northwest of Johor. Furthermore, this study identified the most common areas for the prevalence of HFMD cases in Johor, which is Johor Bahru. As a conclusion, this study achieves the entire objectives. Therefore, this study is expected to assist the Department of Health Johor in order to fulfill their needs.

ABSTRAK

Kes-kes penyakit kaki, tangan dan mulut (HFMD) di Malaysia kini semakin meningkat seperti dilaporkan oleh beberapa sumber seperti media massa dan internet. Dalam kajian ini, kes HFMD di Johor telah dikaji secara komprehensif dengan menggunakan analisis ketumpatan geospatial (*geospatial density*) dan teknik taburan (*distribution techniques*) untuk mengkaji secara mendalam kes-kes HFMD di Johor. Bagi mencapai tujuan tersebut, tiga objektif yang telah dikenalpasti. Objektif yang pertama adalah untuk menjalankan penilaian keperluan (*needs assessment*) bagi mengenalpasti keperluan pangkalan data geospatial HFMD di Johor. Objektif kedua bertujuan untuk membangunkan pangkalan data geospatial bagi kes-kes HFMD di Johor. Objektif yang terakhir iaitu objektif ketiga adalah untuk menganalisis kes-kes HFMD di Johor melalui ketumpatan geospatial dan teknik taburan dengan menggunakan perisian sumber terbuka (*open source software*). Kajian ini dijangka akan membawa kepentingan kepada Jabatan Kesihatan Johor dalam memberikan maklumat berdasarkan keperluan mereka. Hasil kajian ini menunjukkan bahawa HFMD boleh berlaku pada bila-bila masa sepanjang tahun namun HFMD ditemui mencapai kemuncak pada bulan Februari dan Mac iaitu semasa musim panas. Pada masa yang sama, taburan kes-kes HFMD di Johor juga mempamerkan corak berkelompok di mana, titik min (*mean centers*) dan bujuran sisihan piawai (*Standard deviation ellipses*) berlaku di kawasan yang sama. Bujuran sisihan piawai juga menunjukkan orientasi ke arah barat laut Johor. Di samping itu, kajian ini juga mendapati kawasan yang mempunyai kekerapan kes HFMD yang tinggi di Johor adalah bandaraya Johor. Kesimpulannya, kajian ini telah mencapai keseluruhan objektif. Oleh itu kajian ini diharap dapat membantu Jabatan Kesihatan Johor bagi memenuhi keperluan mereka.

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LIST OF ABBREVIATIONS

HFMD	Hand, Foot and Mouth Disease
CA16	Coxsackievirus A16
EV-71	Enterovirus 71
EV-A71	Enterovirus A71
WHO	World Health Organization
MoH	Ministry of Health
DoHT	Department of Health Terengganu
YPKT	Yayasan Pembangunan Keluarga Terengganu
GIS	Geographic Information System
DoHJ	Department of Health Johor
DoHS	Department of Health Sarawak
CDCIS	Communicable Disease Control Information System
CDCIS	Communicable Disease Control Information System
LIS	Labotory Information System
NNDSS	National Notifiable Disease Surveillance System
CNS	Central nervous system
DIC	Deviance Information Criterion
NN	Nearest Neighbour
MC	Mean Centre
LISA	Local Indicators of Spatial Association
CDC	Communicable Disease Centre
GPS	Global Positioning System
MREC	Medical Research & Ethics Committee
NMRR	National Medical Research Register
CRC	Clinical Research Centre
JPP-NIH	NIH Research Review Committee

QGIS	Quantum GIS
LTS	Long Term Support
DWG	AutoCAD Drawing Database (file extension)
WMS	Web Map Services
WFS	Web Feature Services
NA	Need Assessment
UML	Unified Modeling Language
ER	Entity Relationship
MDL	Master Data List
NGO	Non-governmental Organization
KPWKM	Ministry of Women, Family and Community Development
RSO	Rectified Skew Orthomorphic
MyGOSC	Malaysia Geospatial Online Service
MaCGDI	Malaysian Centre for Geospatial Data Infrastructure
JUPEM	Department of Survey and Mapping Malaysia

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Hand, foot and mouth disease (HFMD) epidemic was first reported in 1957 in New Zealand. HFMD is caused by infection of various types of viruses such as polioviruses, coxsackieviruses and echoviruses (WHO, 2012). Nevertheless, Coxsackie A16 (CA16) virus and Enterovirus 71 (EV-71) are the main viruses that cause infection in HFMD patients (Sarma, 2013). These closely-related viruses belong to Picornaviridae family. HFMD was named after its general clinical characteristics. This disease has led to millions of attacks and several outbreaks across the world (Zhuang *et al.*, 2015). In the past decades, HFMD outnumbered any other epidemic in Asia Pacific region and became a serious issue for global public health (Chan *et al.*, 2000).

HFMD, a visible illness that mainly infects infants and children, is a common infectious disease mostly for kids under five years of age (Xie *et al*., 2014). Its symptoms include fever, painful sores in mouth and rash with blisters on hands, feet and buttocks. When patients are infected with HFMD, the usual period from infection to onset of symptoms – fever is the first symptom of HFMD followed by blisters or rashes – is between three to seven days; it is known as incubation period (Golden Horses Health Sanctuary, 2012). Most patients with fatal complications are infected with virus Enterovirus 71 (EV- 71) (Zhu et al., 2011).

Until now, effective vaccination approaches for dealing with HFMD are not available although the development of HFMD vaccines has rapidly expanded and already undergone pre-clinical studies (Sun *et al.*, 2014). The transmission of HFMD usually occurs when a person have direct contact with the nasal discharge, saliva or fluid from the blisters of existing patients. Furthermore, food or water contaminated with faecal droplets, nasal discharge, fluid or saliva from an infectious person can also cause HFMD infection. On top of that, weather variable may also affect the transmission of HFMD either directly or indirectly (Leong *et al.*, 2011).

Globally, HFMD outbreaks have been documented for more than four decades (Ratchaphon *et al*, 2013). The western pacific region – that includes countries such as Japan, Malaysia, Singapore, Thailand and China – is reported to be the most severely affected area by HFMD in the last decade. Furthermore, other countries such as Taiwan, Hong Kong, Vietnam, Cambodia, Brunei, Mongolia and the Republic of Korea are also affected (Ratchaphon *et al.*, 2013).

In Malaysia, HFMD cases were first reported in Sarawak. It caused 28 deaths of children in 1997 and the infections were found due to Enterovirus A71 (EV-A71) virus. Ever since, the recurrent cyclical epidemics of HFMD occurs every two to three years. This recurring scenario highlighted two of the factors that increase the epidemic of HFMD; they are the deterioration of immunity level particularly among infants and the shifting of population from one state to another. In addition, another factor that increases the epidemic of HFMD is travel to neighbouring countries with high HFMD infection cases; however, the root causes of the recurring disease still remain mystery (Nadia *et al*., 2016).

In October 2000, new fatal cases were reported in Johor after an outbreak of HFMD occurred in Singapore in a month before. Since then, Johor has stepped up its vigilance for HFMD disease. Since Singapore is a neighbouring country located near Johor, there are massive daily movements of population between these two places that can be considered as an increasing factor for HFMD disease. Thus, the cases of

HFMD increased drastically from 36 cases in the first week of 2000 to 274 cases in the last week of October 2000 (Lam, 2000).

This study intends to assess the prevalence of HFMD cases in Johor by using geospatial density and distribution techniques. The case study of this research covers Johor which are located in the southern part of Peninsular Malaysia and is surrounded by Negeri Sembilan, Malacca and Pahang to the north, and situated at the north of Singapore and separated by the Straits of Johor. Figure 1.1 shows a map of Johor with its districts namely Johor Bahru, Pontian, Kota Tinggi, Kluang, Segamat, Muar, Batu Pahat, Tangkak, Kulai and Mersing. (Johore State Investment Center, 2015).

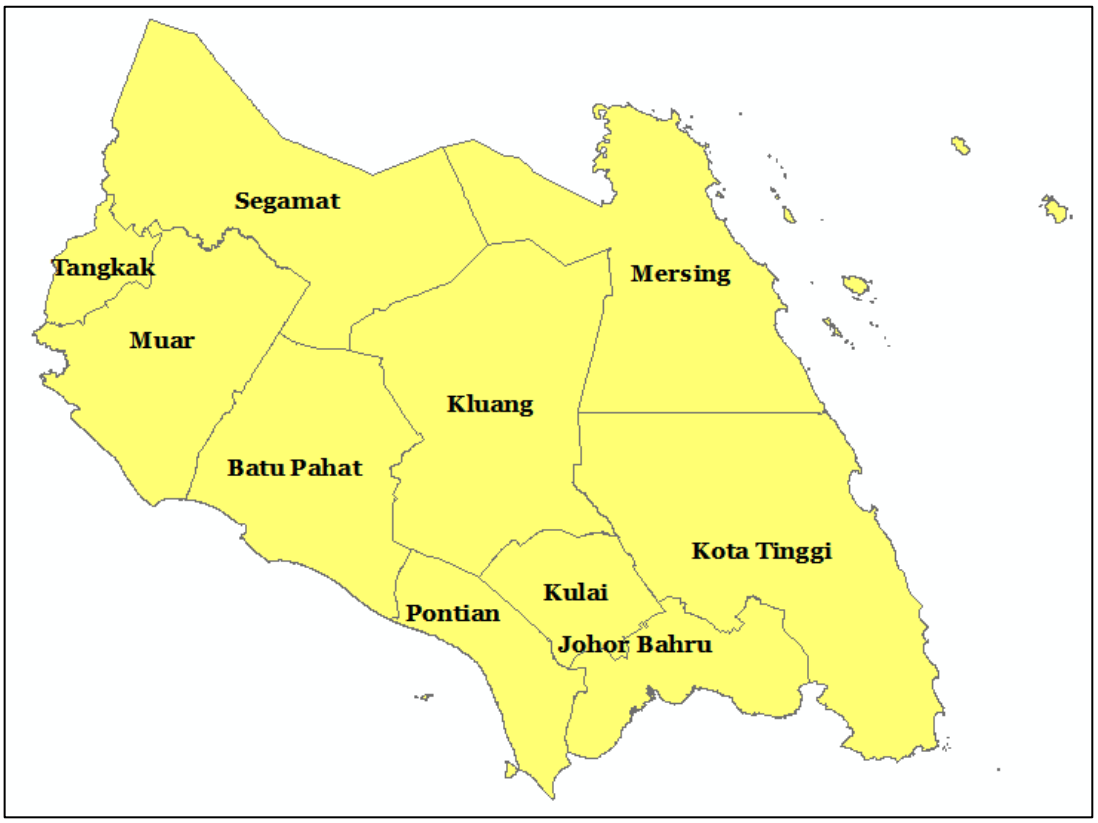

Figure 1.1 Districts of Johor

1.2 Problem Background

In 1997, the first case of HFMD in Malaysia happened which had caused 28 deaths of children in several cities in Sarawak (WHO, 1997). Autopsies performed on the deceased confirmed the deaths were caused by several symptoms linked to HFMD such as poor peripheral perfusion, tachycardia and cardiac failures. The mean age of victims ranged from seven months to six years (WHO, 1997).

After the first case in 1997, many children had been infected by HFMD in Sarawak and had developed several symptoms such as shock, pallor, cold extremities, delayed capillary refill and weak peripheral pulses (WHO, 1997). Therefore, in 1998, the Ministry of Health (MoH) acknowledged that HFMD was endemic in Malaysia, with periodic outbreaks among young children. Since the first outbreak in Malaysia in 1997, the MoH has periodically ordered the closure of playschools, primary schools, nurseries and kindergartens where likely to be the source of the disease (Baby Center Malaysia Medical Advisory Board, 2014).

Then, there were 1178 cases reported in Johor, mostly occurred in kindergarten and nursery. Similarly, the HFMD cases increased 15% in 2014 as compared to 1027 cases in 2013. For the purpose of disinfection and the disease control, two nurseries and one kindergarten were ordered to close (Sinar Harian, 2014).

Subsequently, in August 2016, The Department of Health Terengganu (DoHT) documented new cases of HFMD among infants at Gems Nurseries, Kuala Terengganu (Astro Awani, 2016). In addition, DoHT also announced that nine nurseries under *Yayasan Pembangunan Keluarga Terengganu* (YPKT) were instructed to close due to the outbreak of HFMD within the vicinity.

As shown in Table 1.1, in year 2015, Ministry of Health Malaysia reported that Sarawak contributed the largest proportion of HFMD cases as compared to other states, which was 7040 cases (46.4%) and followed by Selangor with 3044 cases (20.1%) and then Johor with 1130 cases (7.4%). These states were in the top three with a high number of HFMD cases (Ministry of Health Malaysia, 2015).

Table 1.1 HFMD cases in Malaysia on 2015
(Ministry of Health Malaysia, 2015)

STATE	CASES	PERCENTAGE (%)
Sarawak	7040	47.4
Selangor	3044	21.1
Johor	1130	8.4
Kuala Lumpur	739	5.9
Perak	718	4.9
Sabah	714	4.7
Penang	402	3.9
Others	400	3.7
TOTAL	**14187**	**100**

Although having high number of cases, HFMD prevalence is not extensively studied in Johor. Several researchers investigated HFMD in Sarawak since it is the first reported cases in Malaysia. For example, a study conducted by (Zohardinn *et al*., 2013), discussed the application of Geographic Information System (GIS) for mapping the polar transmission of HFMD cases and Leptospirosis in Sarawak. In this study, the results are the thematic maps of combination dataset, of which include prevalence of the disease and the total rainfall and flood datasets, and also the prevalence of the disease and river pollution data. This study was conducted in order to observe the relationship between the prevalence of the disease and the natural factor like land parcel, flood and river pollution.

The thematic maps for rainfall in this study are divided into several temporal types like global, time and cell but this study only explained generally about the entire thematic maps. In that thematic maps, there have shown the color tone from

light yellow to dark red and this color tone represent the relative risk between cases and the natural factor. This study did not perform any vector data manipulation analysis and the geospatial distribution techniques such as buffer, mean centre and standard deviation ellipse even though the ArcGIS software that this study used have all this features capabilities. These vector data manipulation and the geospatial distribution analyses should be used in order to produce variety of infectious disease map not even just thematic map. Instead, this study was inconclusive due to focus on the Leptospirosis disease only rather than HFMD disease.

On other development, the specific study on accessing HFMD cases in Johor was done in 2003 by Badrul *et al.* (2003). This study used the datasets in 2000 which is not applicable currently to be referred by the stakeholder such as the DoHJ due to several limitations such as the datasets are outdated due to time changing and there might have the development of the new facilities and residential area. Even though this research was done in Johor, the result of this study is in the form of tables and graph – they were not involved any spatial analysis for prevalence of HFMD cases in Johor. Therefore, until now, there is less specific study that has conducted spatial analysis in geospatial density and distribution techniques for the prevalence HFMD in Johor.

Furthermore, there is a lack of study done in studying the socio-economic variable related to HFMD. Bo *et al*. (2014) suggested that the socio-economic variables including size, population density and the proportion of the student population contributes to HFMD transmission. However, the findings of the study only concentrated on other factors such as the meteorological factors making it inconclusive. Therefore, even Bo *et al.* (2014) recommended the socio-economic variable, they were not able to address and came out with the result on socio-economic factor in their study.

Yien *et al.*, (2011) had found that the outbreaks of HFMD peaks in the hot season of the year contradicting to report by Ratchaphon *et al.*, (2014) which had discovered that the peak of HFMD cases appeared in rainy and cold season. Therefore, the gaps can be observed from these two studies, which mean that HFMD

cases peaks is not static in certain season; however, it may change due to the climate or metrological factor for each places.

Similarly, Jiaojiao *et al.* (2014), Chunxiang *et al*. (2013) and Qian *et al.* (2016) attempted to come up with spatial analysis methods that can be applied on HFMD by using the commercially available software. However, only Bo *et al*., (2014) used open source software in conducting the analysis in their study. Therefore, there is lack of study that uses open source software in their investigation.

Thus, there is a general paucity of study investigating the prevalence of HFMD cases in Johor. It can be seen here, most issues regarding HFMD studies looking from geospatial point of view are on the spatial and statistic analysis. Many previous studies preferred to use same techniques of analysis like spatial temporal analysis and thematic map in order to produce the prevalence of HFMD map. In addition, there is lack of study that used spatial and statistic analysis such as heat map, buffer and overlay, standard distance, standard deviation ellipse, basic statistic and nearest neighbour to find the prevalence area of HFMD. In Johor, the study that used these techniques is insufficient.

1.3 Aim

The aim of this study is to assess the prevalence of HFMD in Johor via geospatial density and distribution techniques using open source software.

1.4 Study Objectives

In order to achieve the aim of this study, three objectives are designed. The objectives are:

a) To conduct a needs assessment for identifying the requirement of a geospatial of HFMD prevalence in Johor.
b) To develop a geospatial database for Johor HFMD cases.
c) To analyze the prevalence of HFMD in Johor via geospatial density and distribution technique using open source software.

1.5 Research Questions

In order to achieve the objective of this study, two research questions for each objective are designed. These research questions are showed in Table 1.2 below.

Table 1.2 Research Questions

OBJECTIVE	RESEARCH QUESTIONS
a. To conduct a needs assessment for identifying the requirement of a geospatial database of HFMD prevalence in Johor.	How to determine the influencing factor for the prevalence of HFMD in Johor?
	What is the influencing factor for assessing the prevalence of HFMD in Johor and how to transform these factors into geospatial datasets?
b. To develop a geospatial database for Johor HFMD cases.	What is the geospatial datasets other than the influencing factors that is required in order to establish the database for the prevalence of HFMD in Johor?
	How can the geospatial database of HFMD cases be developed in Johor?
c. To analyze the prevalence of HFMD in Johor using geospatial density and distribution technique with open source software.	How to analyze HFMD cases in Johor using distribution and density techniques by using Quantum GIS?
	How to visualize the map of HFMD prevalence in Johor?

1.6 Significant of Study

This study is significant in a way that it provides the information on mapping the occurrence of HFMD cases in Johor in 2016; so that, it can be used for identifying the prevalence and incidence of HFMD in the state. Furthermore, this study also used several analyses such as heat map, standard distance, standard deviation ellipse and nearest neighbour analysis to find the prevalence area of HFMD. Hence, this study provides information on the current trend of HFMD cases in Johor.

Ministry of Health Malaysia stated that HFMD cases are on the rise in 2016as compared to other contagious diseases like leptospirosis and varicella. HFMD is considered as high-risk disease, and awareness on this contagious diseases and emergency measures may be necessary to avert a calamity since the health status can be easily deteriorated if the disease become an epidemic in populous areas. Therefore, this contagious disease can also have negative impact on social and economic sectors like the schools should be closed for several weeks.

Therefore, this study may assist the public and health agencies such as the DoHJ in highlighting the hot spots which is useful for directing health agencies in order to raise the public awareness, taking action and controlling the outbreak of the disease. Moreover, mapping the occurrence of HFMD can provide further clues for identifying the source of the disease. This can assist in raising the alarm on the disease among public.

In addition, this study is also beneficial among the open source software communities and health agencies who are interested in applying GIS for health sectors since this study carries out several analyses by using an open source software.

1.7 Thesis Outline

This section describes the structure of the thesis by outlining each chapter. The thesis outline is important; it gives general overview for every chapter. This study consists of five chapters as depicted in Figure 1.2 below.

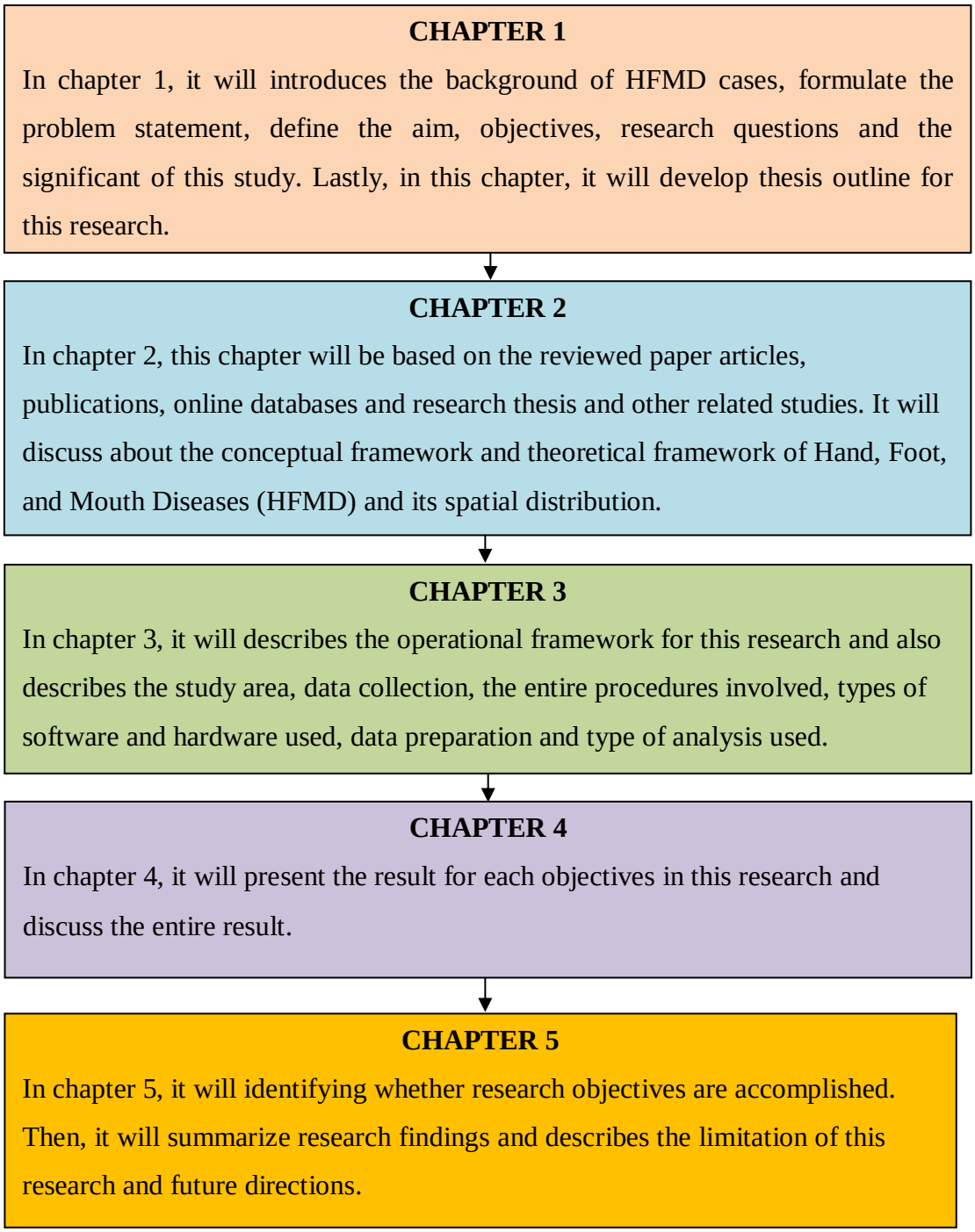

Figure 1.2 Thesis Outline

1.8 Chapter Conclusion

This chapter introduces the present study by reviewing on HFMD cases around the globe. Later, it is further detailed to formulate the problem. Throughout the study, three objectives and six research questions were established to achieve the aim. This chapter also provides the significant of the current study. Finally, an outline of this study is given to provide a brief introduction on how this study was carried out.

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