A Dynamic SEIPR Model for The Spread of Hand, Foot and Mouth Disease in Sarawak

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***Abstract*—In Sarawak, a series of hand, foot and mouth disease (HFMD) outbreaks since 1997 started to catch the public attention. Feared and worried among society in the region had arisen followed by the unusual fatalities cases. Some clinical researches and mathematical models regarding HFMD were produced. Clinical researches revealed that there exist the incubation period and post-infection virus shedding period which are not captured together in any mathematical models so far. In this study, the SIR (Susceptible-Infected-Recovered) model is being improved by building a simple deterministic SEIPR (Susceptible-Incubation (Exposed)-Infected-Post infection virus shedding-Recovered) model. By adding the incubation and post-infection virus shedding as parts of the compartments into SEIPR model, the number of infected cases is predicted. The simulation result shows rapid spreading of HFMD viruses through cohort and the ability of the model to predict the outbreak behavior pattern in the first ten weeks. Comparison between the SEIPR model and SIR model verified SEIPR model. Validation of the model is done by comparing the simulation with the actual data in 2006. Basic reproduction number, R_0 computed was 2.15 which suggesting the highly contagious HFMD is likely to spread fast. The threshold value analysed can allow the possible interventions based on the minimum proportion of the population which create the liability of disease spreading. We hope that this model can help the public health personnel to reduce the burden of the disease by planning an effective manner of intervention during the outbreaks.**

***Index Terms*—Hand foot and mouth disease; Dynamic model; Incubation period; Post-infection virus shedding period**

I. INTRODUCTION

Hand, foot and mouth disease (HFMD) is an acute viral illness that primarily affects infants and children under the age of 10, but can also affect older children, teenagers and adults. HFMD is caused by several different viruses that belong to the enterovirus group, it is mostly caused by coxsackie virus (CV-A16), human enterovirus (EV71) or other enteroviruses including Coxsackie A viruses, CV-A2, CV-A4, CV-A5, CV-A6, CV-A7, CV-A10 and CV-A12 or Coxsackie B viruses, CV-B1, CV-B2, CV-B3 and CV-B5 [1].

HFMD is a worldwide concern disease as the outbreaks in the countries such as Taiwan, China, Singapore, Vietnam, Mongolia, Brunei and Australia brought the tense among the public due to the high number of infected cases and complicated death cases [2-4].

During the outbreaks, the patients are advised to be quarantined at home or hospitalised. This is to avoid the direct contact with the patients as the viruses can be easily transmitted through aerosol or ingestion and fomites [4]. Besides that, HFMD also caused the chaos of social welfare and economic problems. Due to the fear of the spreading disease, the closure of some schools had been implemented [4, 5]. The closure may bring the problems to the working parents as they need to find the alternative ways of taking care of their children. Parents were requested to keep their children away from crowded places during the outbreaks. Also, there are some other social and economic problems are taking place during the disease outbreaks which are not easily quantifiable [5].

In Sarawak, a state of Malaysia on the island of Borneo, encountered outbreaks of the HFMD since 1997. There were death cases reported. A cluster of unusual paediatric deaths due to encephalitis and cardiac failure were observed [6]. A seven years sentinel surveillance for EV71 in Sarawak was carried out to elucidate the epidemiology regarding the patterns of transmission of the viruses [1]. Also, some mathematical modellers have developed models for analysing the dynamic behaviour of the HFMD. SEIR model was analysed theoretically by using numerical simulation which showed that the number of actively infective people at initial time and the disease transmission coefficient play more role on the transmission [2]. In [7], the study showed that the disease transmission rate is affected by number of infected individuals and at which quarantined may help control the disease. Another study, in which a spatial-temporal ARMA model is presented where monthly average temperature, relative humidity and total sunshine are factors contributed to the incidence. In this study, the incidence peak season in Wenzhou, China was between May and July [8]. In another study, the effect of short-term changes in weather on the incidence of HFMD had been analysed in Singapore. The study showed that a maximum daily temperature above 32°C and rainfall up to 75 mm is expected to increase the HFMD incidence [9]. SEIQRS model was analysed theoretically by using numerical simulation, had suggested transmission rate and recovery-rate of non-hospitalised individuals are the most sensitive parameters. Thus, to curb HFMD, quarantine is the best method to be implemented [10]. Another model which was also analysed theoretically by using numerical simulation in Matlab is a delayed hand-foot-mouth disease epidemic model with pulse vaccination, the result showed that pulse vaccination is an effective strategy to eliminate HFMD [11]. Meanwhile, in Sarawak, SIR model had been studied to predict impending outbreaks in Sarawak and suggested that number of susceptible is the parameter that may be able to control the disease [5]. However, to date, no mathematical