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Economic cost and burden of dengue during epidemics and non-epidemic years in Taiwan

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ABSTRACT

Background: Determining the disease and economic burden of dengue is critical for the allocation of public health resources. Several studies have used disability-adjusted life-years (DALYs) to estimate the disease burden of dengue in different regions. However, there are no published studies discussing the estimates of dengue-related economic and disease burden specifically in Taiwan.
Objectives: We assessed the economic cost and disease burden of dengue infections in Taiwan for the period 1998–2014, and compared these during epidemic and non-epidemic years.
Methods: We estimated the annual DALYs per million population using the disability weights for dengue fever (DF), dengue hemorrhagic fever (DHF), dengue shock syndrome (DSS), and death cases. Economic costs were estimated and divided into direct (medical costs) and indirect costs (lost work days and caregiver fees).
Results: For the period 1998–2014, a mean of 115.3 (range: 6.3–934.3) DALYs per million population annually were lost to dengue. In epidemic years, direct costs associated with dengue resulted mostly from hospitalization (86.09%), emergency (7.77%), outpatient (6.10%), and drug costs (0.03%). For indirect costs, lost productivity due to death (70.76%) was the dominant contributor. Overall, the costs were 12.3 times higher in epidemic years than in non-epidemic years (Wilcoxon rank sum test, $p < 0.05$).
Conclusions: This study is the first to evaluate the economic costs and disease burden of dengue infections for this period in Taiwan, and reveals significant differences in economic impact between epidemic and non-epidemic years.

Introduction

Dengue fever (DF) is the most frequent arthropod-borne viral disease in humans [1]. Over 50 million people living in tropical and subtropical urban and semi-urban areas are infected with dengue annually, and up to 500,000 people develop the potentially lethal complications dengue hemorrhagic fever or dengue shock syndrome [1]. Recently, Stanaway et al. [2] estimated dengue mortality, incidence, and burden for the Global Burden of Disease Study in 2013. The results showed that there are almost 60 million symptomatic dengue infections per year, resulting in about 10,000 deaths and suggested that, within the past two decades, there was a large increase in the incidence of dengue. In addition, the number of symptomatic dengue infections more than doubled every ten years between 1990 and 2013. The global incidence of dengue was 148.1 (95% confidence interval (CI): 59.4–310.6) and 810.1 (327.4–1,690.8) per 100,000 in 1990 and 2013, respectively [2].

Determining the disease and economic burden of dengue is critical for the allocation of public health resources. It can inform policy makers to set health policy priorities, and to implement disease-control technologies [3]. The disability-adjusted-life-years (DALYs) parameter estimates the amount of time, ability, or activity that is lost by an individual as a result of disease-induced disability or death [4]. One DALY represents the loss of the equivalent of one year of full health [4]. These composite measures incorporate estimates of the incidence, prevalence, and duration of a particular condition as well as the outcome, whether it be disability or premature death [4]. Several studies have used DALYs to estimate the disease burden of dengue in various regions, including Mexico [5], the USA [6], Nicaragua [7], Southeast Asia [3], and globally [2]. However, there are no published studies discussing the estimates of dengue-related economic and disease burden specifically in Taiwan.

Taiwan is geographically located in both subtropical and tropical climates (22–25°N and 120–122°E) with relatively high tempera-

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tures and humidity year-round, creating the ideal conditions for the growth of both the vectors *Aedes aegypti* and *Ae. albopictus*. Dengue is a notifiable disease in Taiwan. The Centres for Disease Control of Taiwan have established the Taiwan National Infectious Disease Statistics System (TNIDSS) to effectively monitor the occurrence of HAIs (Healthcare-Associated Infections) and to evaluate epidemiological trends. Dengue outbreaks have occurred almost every year in Taiwan since 1987, first appearing in the southern part of the island. Human population density, which usually increases during rapid urbanization, has been associated with dengue transmission [8,9]. However, in the past two years (2014–2015) there have been two outbreaks with over 15,000 cases of DF, dengue hemorrhagic fever (DHF), and dengue shock syndrome (DSS) in Taiwan [10]. From an economic point of view, it is important to assess the long-term burden of dengue.

Dengue begins after an incubation period of 3–8 days (range, 3–14 days), and has a wide spectrum of clinical presentation, often with unpredictable clinical evolution and outcome. While most patients recover following a self-limiting non-severe clinical course, a small proportion progress to severe disease, mostly characterized by plasma leakage with or without hemorrhage. Intravenous rehydration is the therapy of choice. Appropriate interventions can reduce the case fatality rate to less than 1% of severe cases. The group progressing from non-severe to severe disease is difficult to define. Early diagnosis and prompt supportive treatment can substantially lower the risk of medical complications and death [10]. The main strategies to control dengue fever in Taiwan are eliminating vector-breeding sources and effectively lowering vector (mosquito) density. Taiwan CDC has devised a three-stage prevention strategy for controlling the dengue fever epidemic. Primary prevention measures include source reduction and control of the vector population. Secondary measures cover disease surveillance and emergency/contingency mechanisms, such as public reporting and promptly investigate suspected transmission sources. Finally, the tertiary prevention involves controlling the mortality rate. The practices measure includes establishing guidelines for dengue fever diagnosis and treatment [10].

The current healthcare system in Taiwan, the National Health Insurance (NHI) programme, is a compulsory single-payer social insurance program that provides medical insurance coverage to all citizens [11]. Healthcare providers are reimbursed by the NHI for services based on a points system according to "fee-for-service" schedules and case-payment schedules. They operate within the constraints of five separate global budget systems for dental services, traditional outpatient Chinese medicine services, Western-based medicine clinics, and hospitals providing Western-based medical care, including both inpatient and outpatient services [12]. Aside from care delivered under case payment or diagnosis-related group (DRG) plans, standard reimbursements for medical services and treatment are based on a resource-based relative value scale (RBRVS) system first developed in July 2004 and then completely revised in 2011. This system assigns relative values to medical services based on the medical resources used to provide the service. Using RBRVS instead of monetary value to determine costs provides a more reliable estimate of disease burden.

Hence, the objective of this study was to measure the economic costs and disease burden of dengue infections in Taiwan. We estimated both the annual DALYs per million population and the total costs during epidemic and non-epidemic years. We hypothesize that these peak years, rather than the average per year, reflect the impact of dengue on Taiwan's health system and economy. We arrived at this conclusion by: (i) estimating the disease burden using DALYs methods for the period 1998–2014; and (ii) evaluating the direct and indirect costs during epidemic and non-epidemic years.

Methodology

Dengue data collection

Official data on the annual number of cases in Taiwan were obtained from the Centres for Disease Control, ROC [10]. The time period was chosen because of data availability and because it encompasses two epidemics, which occurred in 2002 and 2014. There were 5323 and 15,464 DF cases reported and confirmed during the 2002 and 2014 epidemics, respectively. All DF, DSS, and DHF cases that were reported and confirmed between 1998 and 2014 in Taiwan are presented in Fig. 1. Detailed epidemiological data are shown in Table A1.

Estimating DALYs

DALYs lost in each confirmed case of dengue in Taiwan for the period 1998–2014 were estimated by using the following formula [4]:

$$-\left[\frac{DCe^{-(\beta a)}}{(\beta+r)^2}\left[e^{-(\beta+r)(L)}\left(1+(\beta+r)(L+a)\right)-\left(1+(\beta+r)a\right)\right]\right]$$

where D is the disability weight ($D=1$ for premature death, 0 for perfect health). Disabilities are then classified into six categories or grades, with each grade allocated a scalar value weighting between 0 and 1. The lower the value, the less impact the disability has on a person's life [4]. C and β are parameters from an age weighting function and a is age at the onset of disease. The age categories used were 0, 1, 2, 3, 4, 5–9, 10–14, 15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59, 60–64, 65–69 and >70 years, according to data collection protocols at the Centres for Disease Control of Taiwan. L is the duration of the disability or years of life lost due to premature death, and r is the social discount rate.

The choice of D and L appropriately into the disease burden estimation are key questions in this research. We set the values for D and L based on values used in other published papers (Table A2). D represents the severity of an illness and the ability to perform activities encountered in daily life [4]. In Table A2, numerous studies set D as 0.81 for DF and DHF/DSS cases. At this level of severity, the afflicted individual needs assistance with the essential activities of daily life [13]. However, the diagnosis and medicine care of DF and DHF/DSS are different in each country. We considered that the appropriate values for D were different for DF and DHF/DSS cases. Hence, the average (range) of D that we used was 0.197 (0.172–0.211) and 0.545 (0.475–0.583) for DF and DHF/DSS cases, respectively [14]. The duration of disability (L) varies with the time of diagnosis, medical condition, infected serotype, and age of the subject (adult or child). Specific durations for each type of dengue were not available for our study. We therefore used a triangular distribution for duration, to assess the variation in annual DALYs per million population.

The input parameters for the DALYs estimates are presented in Table 1. The values used for C, β, and r are the same as those used in the World Bank study [13,15]. We set D as 0.197 and 0.542 for DF and DHF/DSS cases respectively [14]. Disability duration due to DF and DHF/DSS cases was adopted from Murray and Lopez [13]. The DALYs for each age-specific category and degree of severity were multiplied by the number of cases in each year, and then summed to give annual totals. These totals were then divided by the year-specific population to give DALYs per million population per year, which were the units used in the World Bank report [4,15].

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