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Distribution and Spatial Pattern Analysis of Dengue Cases Reported to The District General Hospital Matale, Sri Lanka: Before and During the COVID-19 Pandemic

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Abstract

Background: Dengue is a vector-borne disease that occurs predominantly in tropical and subtropical regions. Public and social measures during the COVID-19 pandemic may have impacted the health-seeking behavior, the transmission of disease, and the spatial and temporal distribution of dengue patients in Sri Lanka and the district of Matale This study aimed to ascertain dengue patient pathways to the District General Hospital (DGH) Matale and identify the spatial and temporal distribution of patients reported to the hospital before and during the COVID-19 pandemic.

Objective: Data were obtained from the Notification Register of the DGH Matale and National Dengue Control Unit from January 2017 to December 2021. The patient locations were converted into a UTM coordinate system, and a Geographical Information System (GIS)-based map was developed using QGIS.

Methods: The number of dengue cases treated within Matale district increased from 29.6% to 72.0%, with a depletion (55.4%) reported in 2020. The majority were from the southwestern part of the district, where population density and urbanization were higher. The number of dengue patients from other districts admitted to the hospital increased from 8.7% in 2017 to 20.6% in 2019 and decreased to 14.7% in 2020 and 9.1% in 2021. The highest incidence rates were reported in the Southwest and Northeast monsoon seasons. Further, middle adulthood (29.5 %) male patients (57%) were predominantly affected

Conclusion: The distribution and spatial pattern of dengue cases reported in this study provide strategic information for managing future dengue outbreaks.

Keywords: Dengue Patients; COVID-19; Spatial Pattern

Background

Dengue, a vector-borne disease primarily found in tropical and subtropical regions, has experienced rapid growth, affecting 70% of the global disease burden in Asia [1]. The COVID-19 pandemic has disrupted dengue transmission globally because of restrictions on internal movements, closing workplaces and educational institutes, and international travel bans, but cases have surged in Brazil, Peru, Bolivia, Singapore, and India due to primary household dengue transitions rather than occupational settings [2-4].

Sri Lanka, a tropical island, has a high prevalence of dengue fever across its territory [5]. Precipitation is a significant factor in nationwide dengue outbreaks, along with factors such as land management, urbanization, population density, wind, and sociodemographic traits [6-8]. Dengue incidence in Sri Lanka peaks during two monsoon seasons from May to September and December to February [6,9].

Island-wide lockdown and travel restrictions during the COVID-19 pandemic have significantly reduced the number of dengue cases in Sri Lanka [8-10]. In addition, patient health-seeking behaviors for dengue treatment may have been affected by COVID-19 and the lockdown. COVID-19 prevention and control have received increased attention from Sri Lanka's public health sector, which is crucial for dengue surveillance and prevention. However, the impact of the COVID-19 pandemic on the spread of dengue fever and health-seeking behavior of dengue patients has not been thoroughly examined in Sri Lanka. Although studies have used geographical information systems (GIS) to identify risk hotspots and changing trends in patient reporting across the country, the spatial and temporal distribution of dengue patients has not been thoroughly investigated in the Matale district [6,11,12]. Additionally, comprehensive research on the mapping of catchment areas for dengue patients and the patterns of patients seeking treatment for dengue has not been conducted in major hospitals in Sri Lanka.

Objective

To ascertain dengue patient pathways to the District General Hospital (DGH) Matale and identify the spatial and temporal distribution of dengue patients reported to the hospital to identify the dengue hotspots in the Matale district before and during the COVID-19 pandemic.

Methods

Matale is the largest district in Central Province, and it is located in the Intermediate Zone of Sri Lanka between 5° and 7° north latitude and 79° and 81° east longitude. It covers a total area of 1993 Km2, and its elevation ranges from 100 m to more than 1500 m, resulting in various human settlements [13]. The area receives rainfall throughout the year; annual rainfall varies from 700 mm to 1000 mm, and the mean annual temperature varies between 25.6 0C and 27.5 0C [14]. The average wind speed ranges from 5 to 25 km/h and over 80% humidity throughout the year [14]. The administrative district comprises 540 Grama Niladhari (GN) divisions and has 484531 population [13].

DGH Matale (70.46', 800.62') is the only tertiary healthcare institution in Matale district. In addition to residents of the Matale district, the hospital caters to residents from other districts. The hospital has approximately 800 beds in 26 wards and 6 special care units. DGH Matale comprises over 900 healthcare staff members, including 32 consultants, 150 medical officers, 325 nursing officers, 47 paramedical staff, and 270 minor staff members. Although there is no special unit for the treatment of dengue patients in the hospital, treatment is provided by two medical wards and two pediatric wards under the supervision of four visiting physicians.

Morbidity-related data were obtained from the Notification Register maintained in the DGH Matale. Demographic data of dengue cases reported among hospitalized patients in the DGH Matale from January 2017 to December 2021 were collected. The demographic profile of each dengue case consists of the patient's name, age, gender, residential address, date of admission, and bedhead ticket number. The data were analyzed anonymously, and it was assumed that each infection occurred at the given residential address of the patient. However, the details of the patients transferred to other hospitals were not considered in this study because of the unavailability of data. The number of dengue cases reported in Matale district during the study period was obtained from the National Dengue Control Unit of the Ministry of Health [5].

Population data on dengue cases were manually extracted from patient records and entered into Microsoft Excel for data pre-processing and analysis. The annual number of dengue patients admitted to DGH Matale per 1000 people from each GN division was calculated from 2017 to 2021 by dividing the yearly dengue cases by the mid-year population and multiplying the result by 1000. Further analysis was carried out in two stages: from 2017 to 2019, before the COVID-19 pandemic, and from 2020 to 2021, during the pandemic. Additionally, the age ranges of dengue patients were divided into youth (0 – 14), young adulthood (15-24), middle adulthood (25-44), older adulthood (45-64), and retirement age (>65). Meteorological data, particularly rainfall data, were obtained and used to correlate precipitation with the number of patients reported to the DGH Matale during the study period [14].

Population data were obtained from the Department of Census and Statistics, 2012 Sri Lanka [15]. The shapefiles consisting of the Province, District, and GN boundaries of Sri Lanka were sourced from the Humanitarian Data Exchange website [16].

The GN division of each patient was identified using the residential address because coordinates for the location of each patient were unavailable. Patient locations were converted into a UTM coordinate system (EPSG:5235) before saving them as separate layers for each year. A GIS-based map for dengue patients reported to DGH Matale and residing within the Matale district between 2017 and 2021 was developed using QGIS (version 3.28) software.

Administrative clearance was obtained from the Ministry of Health of Sri Lanka.

Results

A total number of 7407 dengue cases were reported in the Matale district from 2017 to 2021, with the highest number of cases reported in 2017 (n=3171) and 2019 (n=2445). A low number of dengue cases were reported in the Matale district in 2020 (n=595) and 2021 (N=290) during the COVID-19 pandemic. Among them, 4039 patients (54.52%) were admitted to the DGH Matale and sought treatment during the study period. The highest number of patients were admitted in 2019 (n=1856), followed by 2017 (n=1029), and a total of 387 and 230 were admitted to the DGH Matale in 2020 and 2021, respectively. Out of the 1856 dengue patients admitted to the DGH Matale in 2019, 1474 patients were residents of the Matale District, while 382 patients were from other districts of the country. Furthermore, the hospital has treated 939, 473, 330, and 209 dengue patients residing in Matale District and 90, 64, 57, and 21 people from other districts in 2017, 2018, 2020, and 2021, respectively (Figure 1).

The proportion of dengue patients admitted to the DGH Matale from the total number of dengue cases reported within the Matale district has gradually increased from 29.6% to 72.0%, although a depletion (55.4%) was reported in 2020. While the percentage of dengue patients from other districts admitted to the hospital has increased from 8.7% in 2017 to 20.6% in 2019, this figure has decreased to 14.7% in 2020 and 9.1% in 2021 (Figure 1(b)). Among the patients admitted from other districts of the country, the majority were from Kandy (84.7%) and Kurunegala (4.9%). Of the patients admitted from the Kandy district, the majority were from Alawathugoda (26.9%) and Akurana (16.9%) GN divisions, which are located in proximity to DGH Matale.

The spatial distribution of dengue patients reported to DGH Matale further indicates that the number of GN divisions with dengue patients and dengue patients per 1000 people reported to DGH Matale from each GN division has reduced significantly in 2020 and 2021 compared to 2017 to 2019 (Figure 2). The average population density of the district is 248 persons/Km^2 [15]. The majority of the people in the districts are located in the Western, Northwestern, and Southwestern parts of the district, while the population density of the majority of GN divisions, located in the North, Central, East, and South-east parts of the district lie below the average population density of the district (Figure 2a). According to the spatial distribution of the number of dengue patients admitted to DGH Matale, the majority of dengue patients were reported for treatment in the southwestern part of the district (Figure 2 (b-f)). There was no overall change in the spatial distribution pattern of dengue patients reported to the DGH Matale between 2017 and 2021. However, the spatial distribution of dengue patients admitted to the hospital shows the occasional appearance of some GN divisions, with a higher number of dengue patients from the central, eastern, and southeastern parts of the district during the study period. The average distance from the GN divisions to DGH Matale lies between 20 and 50 km.

Most dengue cases admitted to DGH Matale from the Matale District (on average 80.6% ± 3%) were aged between 1 and 45 years (Figure 3 (a, b)). In general, most patients (on average 29.5% 5 years of data) with reported dengue cases were in middle adulthood (25-44 years old) during the study period, followed by 26.9% for youth (1-14) and 24.3% for youth adulthood (15-24). The total number of patients consistently declined with age > 45 years (Figure 3(a, b)). Furthermore, more male dengue patients (57%) than female dengue patients (43%) were admitted to the DGH Matale from 2017 to 2021 (Figure 3 c).

Three prominent timeframes with a higher number of dengue cases admitted to the hospital were identified during the study period (Figure 4). In 2017, the highest proportion (68%) was admitted from May to July, when the precipitation ranged between 53 and 74 mm. Even though the number of dengue patients admitted was low compared to that in 2017 and 2019, the maximum proportion (57%) of patients was admitted between April and July 2018, where the highest rainfall was reported in May (86 mm). The highest proportion of patients (85%) was admitted to the hospital between October and December 2019 when the average monthly rainfall fluctuated between 80 and 117 mm. In 2020, the highest proportion of dengue patients from Matale district (67%) was admitted to the hospital between January and March before the COVID-19 pandemic. Although higher rainfall was reported from December 2020 to February 2021 and May to July 2021, only 11 and 67 patients were admitted in December 2020 and July 2021, respectively.

Discussion

The pattern of dengue cases reported in the district during the study period followed the general pattern of dengue cases reported in the country, with the highest levels reported in 2017 and 2019 [8,5,17-19]. This is related to the meteorological factors in the country, where precipitation and humidity are positively correlated and temperate, and wind speed is negatively correlated with dengue transmission [8]. The lowest number of dengue cases was reported in the DHG Matale in 2020 and 2021, following the general pattern of Sri Lanka. The number of dengue cases per month from March 2020 to April 2021 in all districts of Sri Lanka was lower than the number of dengue cases predicted from data for the five years (2015-2019) concerning the COVID-19 pandemic [9,10].

Even though a lower number of dengue cases were reported in 2019 than in 2017 in Matale District, the number of patients admitted to DGH Matale was higher in 2019 than in 2017. Similarly, the proportion of dengue patients admitted to the DGH Matale from the total number of dengue cases reported within the Matale District increased gradually over five years from 2017, although it showed a depletion in 2020 associated with the COVID-19 pandemic.

According to the spatial distribution of patients reported from other districts, the majority of patients resided in the GN division close to the DGH Matale. The percentage of patients with dengue admitted to hospitals from other districts increased gradually from 2017 to 2019. This trend may be due to the proximity to the tertiary care hospital and the quality of health services provided by DGH Matale. Studies have reported that the travelling distance and time to the healthcare facility, difficulties in travelling to health centers, availability of resources, and availability of competent healthcare professionals are some of the major factors contributing to healthcare seeking among dengue patients [19]. When lockdown measures and travel restrictions were imposed due to the COVID-19 pandemic, the number of dengue patients admitted to DGH Matale from other districts reduced between 2020 and 2021.

A reduction in the spatial distribution of dengue patients reported to DGH Matale (the number of GN divisions with dengue patients and dengue patients per 1000 people from each GN) in 2020 and 2021 compared to the period from 2017 to 2019 showed a relationship with the COVID-19 outbreak. Liyanage et al., in 2021, also reported a statistically significant and homogeneous reduction in dengue risk and an 88% reduction in dengue risk island-wide in Sri Lanka due to the mobile restriction imposed during the COVID-19 pandemic [9].

According to population statistics in 2012, the majority of GN divisions with higher population density in Matale District are concentrated in the southern, western, and southwestern parts of the district where the main city and infrastructure facilities were established [15]. The Central and Southwestern regions of the district consist of wetland forests, whereas the northern regions consist of dry region forests, and the population density of these areas is lower.

The association between dengue and higher population density in urbanized areas is well established, and dengue outbreaks in rural areas have also been reported in other parts of Sri Lanka [6,11,12]. The spatial distribution of dengue patients admitted to DGH Matale suggests that there has been no significant change over time, and the majority of patients were reported from the southwestern part of the district, where population density and urbanization are higher (Figure 2). DGH Matale is also located in the southwestern part. According to Ng et al. [19], travel distance and time are the major factors governing the selection of healthcare facilities for dengue treatment. Therefore, this result was noticeable. Furthermore, a considerable number of dengue patients were admitted to DGH Matale during the study period from the GN divisions of Matale District, located between 20 and 50 km away from the hospital. These patients were also admitted to the DGH Matale because of the availability of resources and competent healthcare professionals compared to healthcare institutes in those areas [19].

According to the number of dengue patients admitted to hospitals within the Matale District, there are two distinct dengue peak seasons, May to July and October to September, which can be identified between 2017 and 2019. The peak seasons are directly correlated with the southwest monsoon (May-September) and the northeast monsoon (December-February) [14]. Several studies in Sri Lanka have reported that peak dengue reported to the DGH-Matale is also related to seasons with higher rainfall [6-8,12]. However, with the COVID-19 pandemic-imposed lockdown and travel restrictions in March 2020, a prolonged decline in the number of dengue patients admitted to the hospital was noted despite the higher reported rainfall. Studies have reported that the mobility pattern of the population is an important factor in dengue transmission, and that COVID-19-related mobility restrictions and school closures impact the reduction of dengue cases in Sri Lanka [9,10]. This trend has also been reported in other parts of the world for 2020 and 2021 [2,3,20].

Even though patients from all age groups were admitted to the hospital, the majority of patients were in middle adulthood (25-44 years), youth (0-14 years), and young adulthood (15-24 years), and the majority of them were male. The data suggest that the percentage of patients admitted to the hospital in the age range of 0-14 years reduced while the percentage of patients aged 25-44 years increased from 2019 to 2021. The reduction in the number of youth may be attributed to the closure of educational institutes related to the COVID-19 outbreak. However, the middle adulthood category, the working-age group, appears to be exposed to dengue regardless of the COVID-19 outbreak and admitted to the hospital seeking treatment.

This study demonstrated the potential of using GIS technology to integrate records from hospital registers with geographic boundaries. Analysis of these data helps to identify the potential drainage areas of patients and the potential peak period. This will help hospital administrators forecast the required human resources, infrastructure and laboratory facilities, drugs, and other treatment facilities and financial requirements for the treatment of dengue patients. Furthermore, correction of the socio-demographic data of the patient will help identify the population at high risk of dengue transmission and plan remedial actions. Studying the spatial and temporal distribution of dengue patients reported to the hospital before and during the COVID-19 pandemic provides vital information on the transmission of dengue and the pattern of patients receiving treatment during the global pandemic.

Conclusion and Recommendation

This study provides information on the spatial and temporal patterns of dengue patients admitted to DGH Matale before and during the COVID-19 pandemic. The number of admitted patients was higher during the southwest (May-September) and northeast (December-February) monsoons in 2017 and 2019. Travel restrictions and lockdown measures due to COVID-19 resulted in a lower number of patients visiting the hospital, irrespective of higher rainfall in 2020 and 2021. Patients from other adjacent districts also received treatment for dengue from the DGH Matale, and these numbers were reduced by 2020 and 2021. The majority of patients reported from the GN divisions located in the southwestern part of Matale district, where population density and urbanization were higher, and this pattern remained the same even during the COVID-19 pandemic period. This information can be used to manage dengue outbreaks in the future by strengthening larval, viral, and vector surveillance activities with integrated vector management. In addition, within the hospital setting, resources should be distributed according to priority and laboratory capacity and activities should be strengthened. Furthermore, it helps enhance research and innovation activities in controlling and preventing dengue.

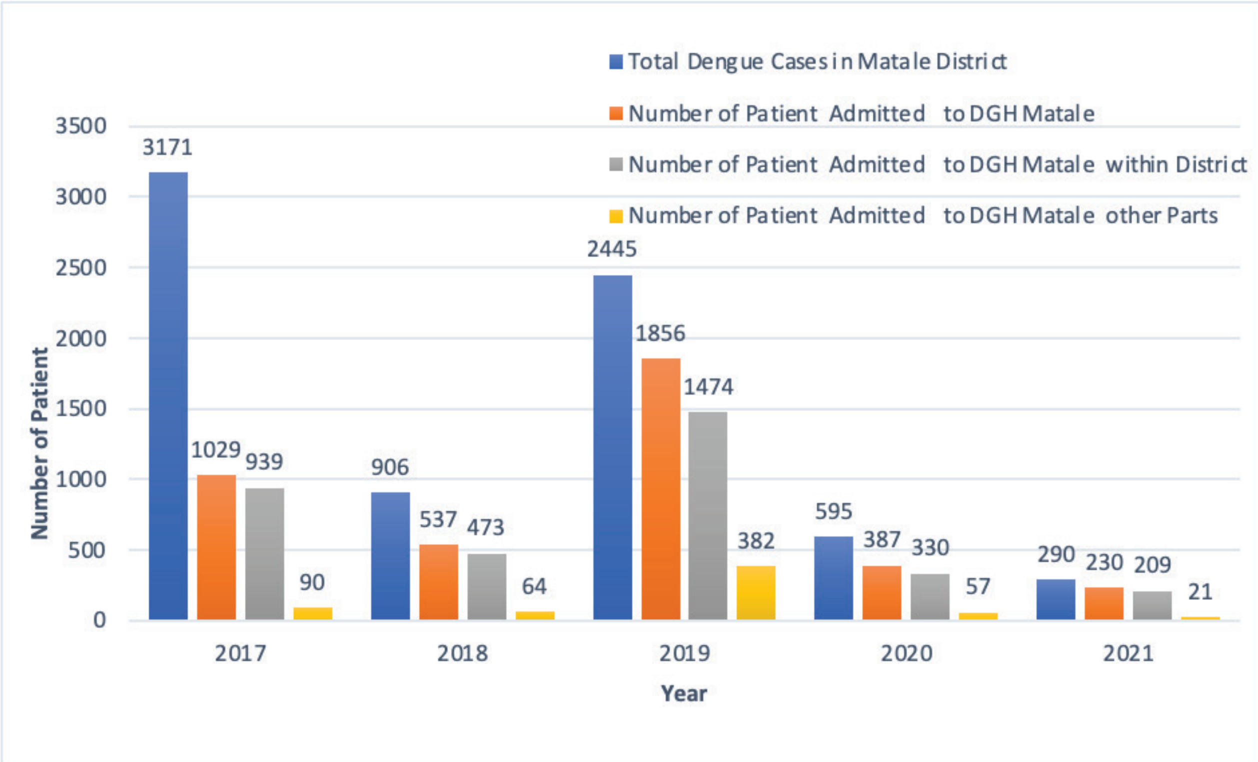

Figure 1a : The number of dengue patients reported in the Matale district and the number of dengue patients admitted to the DGH Matale from 2017 to 2021, according to the Notification Register

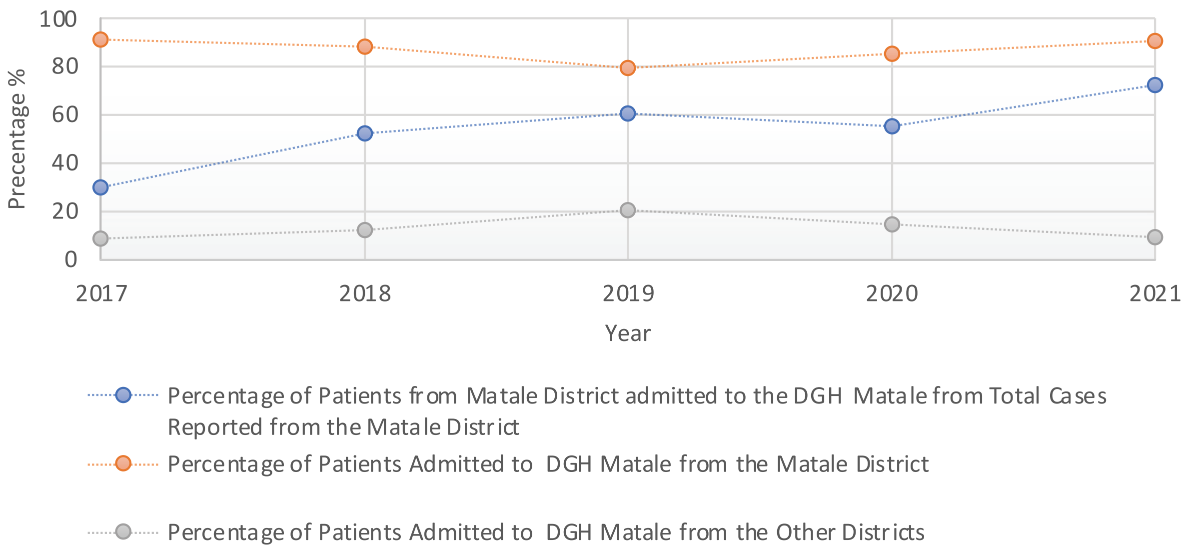

Figure 1b : The number of dengue patients reported in the Matale district and the number of dengue patients admitted to the DGH Matale from 2017 to 2021, according to the Notification Register

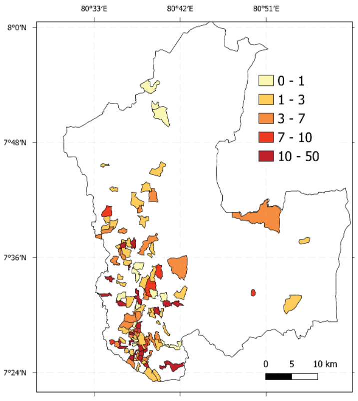

FIGURE 2a

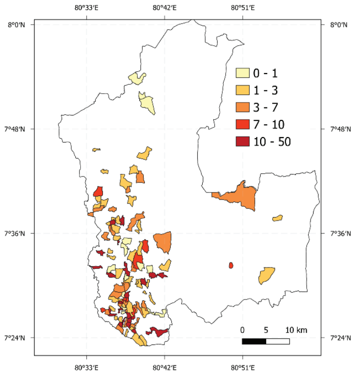

FIGURE 2b

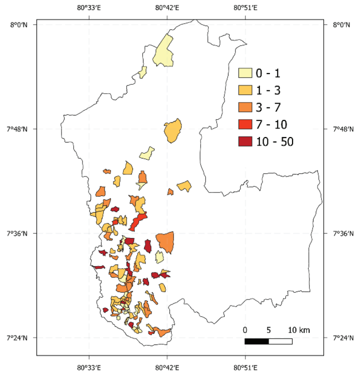

FIGURE 2c

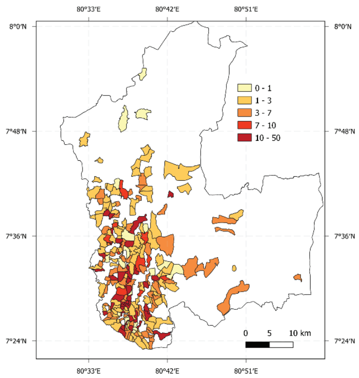

FIGURE 2d

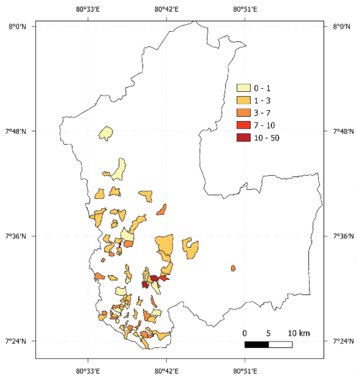

FIGURE 2e

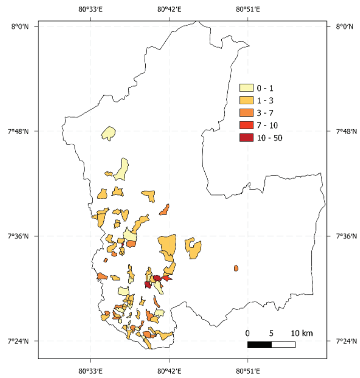

FIGURE 2f

Figure 2 a : **Population density of each GN division of the Matale district (Department of Census and Statistics, 2012)**

Figure 2 b, 2c, 2d, 2e, and 2c: The number of dengue patients admitted to DGH Matale per 1000 people from each GN division in (b) 2017, (c) 2018, (d) 2019, (e) 2020, (f) 2021

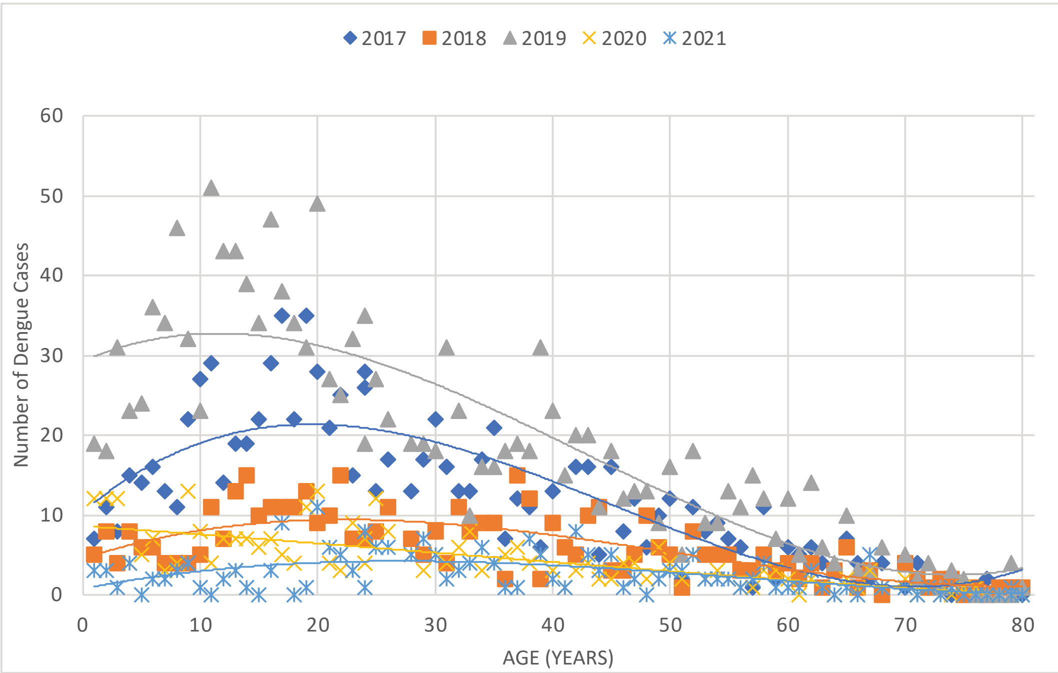

Figure 3a : **The number and age distribution of dengue patients admitted in 2017, 2018, 2019, 2020, and 2021 to DGH Matale from the Matale district.**

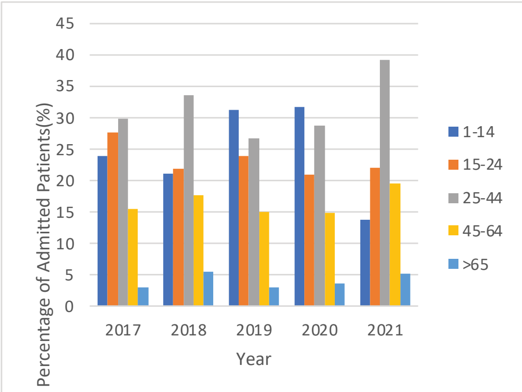

FIGURE 3b

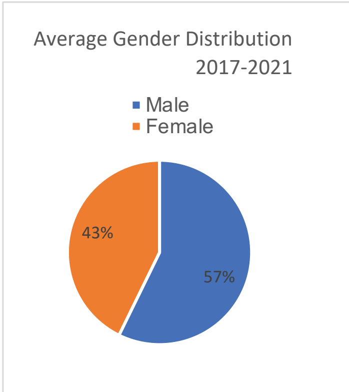

FIGURE 3c

Figure 3b : The number and age distribution of dengue patients admitted in 2017, 2018, 2019, 2020, and 2021 to DGH Matale from the Matale district.

Figure 3c : Gender distribution of dengue patients admitted from 2017 to 2021 to DGH Matale from the Matale district.

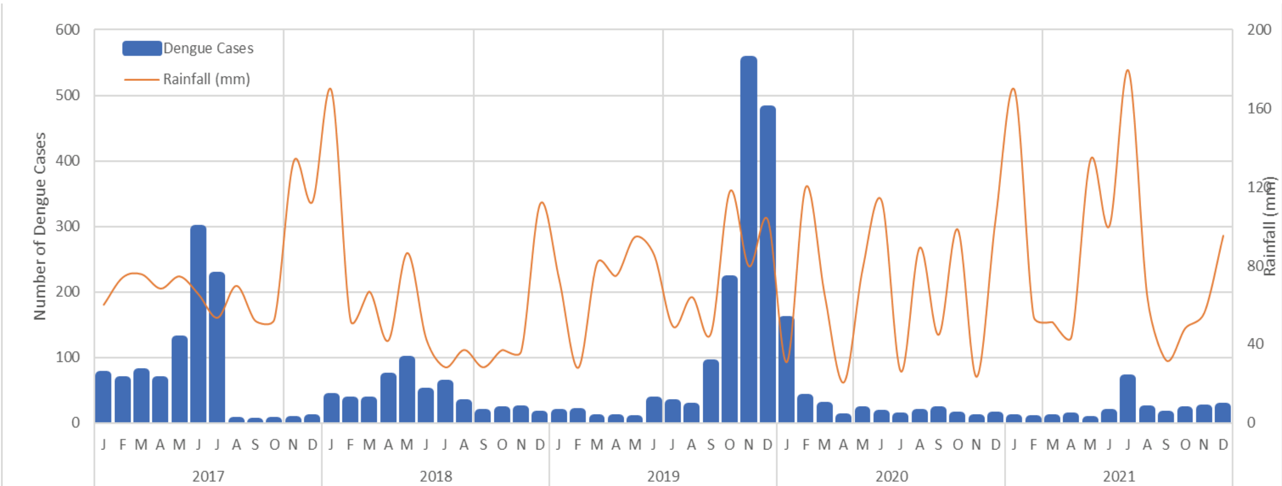

Figure 4 : The number of dengue patients admitted to DGH Matale from Matale district and the monthly average rainfall from 2017 to 2021.

Author declaration

Author contributions: All authors contributed to the conceptualization, design, data analysis, and manuscript preparation of the study. The authors have reviewed and approved the final version of the manuscript.

Conflicts of interest: The authors declare no conflicts of interest.

Ethical Approval and consent to participate: This study did not involve direct patient participation, and was based on the collection and analysis of secondary data conducted following administrative clearance.

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