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Original Research Article

Time series analysis of chickenpox cases admitted in infectious disease hospital in a metropolitan city, Mumbai, India

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ABSTRACT

Background: Chickenpox is a major public health problem; the concern is high as the disease is closely related to climate change.
Methods: This was a retrospective study, conducted for 1 year in an infectious disease hospital in a metropolitan city. Data of chickenpox cases of Mumbai between 2009 to 2018 were obtained. Data was analysed using SPSS-time series analysis and forecasting model.
Results: 88% cases belonged to the 21-40 years, proportion of men affected were more than women. A seasonal distribution of cases was observed. Winter's multiplicative model was used for forecasting.
Conclusions: The trend analysis along with forecasting model helps in being prepared for the year ahead.

Keywords: Chickenpox, Climate change, Forecast, Seasonal trend, Time series analysis

INTRODUCTION

Chickenpox is a highly infectious and acute disease caused by the varicella-zoster virus. According to a WHO position paper, varicella infection has a global disease burden of 140 million cases, 42 million severe sequelae, and 4200 deaths every year. Chickenpox affects 16 persons per 1,000 people annually in high-income countries. With a case fatality rate of 3 per 1,000 instances annually, 3% of these cases have problems, and 5% require hospitalization. Children, who account for more than 90% of cases, 70% of hospital admissions, and 50% of mortality, have the highest disease burden.[1]

In India, chickenpox is seen in both endemic and epidemic forms. Chickenpox cases can be discovered at any time of year. Their numbers, however, are higher from winter to summer, particularly following the rainy season. It is very contagious, with a secondary infection incidence of over 90%. The varicella-zoster virus (VZV) causes chickenpox, a highly contagious disease characterized by a widespread rash. Infection is spread mainly by direct contact with the infectious virus in skin sores or through respiratory secretions spread through the air.[2]

The epidemiology of varicella varies depending on whether you live in a temperate or tropical area. In most temperate regions, more than 90% of persons get infected before adolescence. In contrast, the disease is acquired later in many tropical climes, and adults are more susceptible than children. Changes in population density and risk of exposure, differences in transmissibility of the heat-labile varicella-zoster virus under hot, humid circumstances, environmental and societal factors, or a combination of all of these factors could explain epidemiological variance. Varicella has a seasonal pattern in temperate and tropical areas, peaking in the colder, drier months of winter or spring. VZV is very infectious and can be spread through the air or directly with the infected person's skin sores. Fever, malaise, and the characteristic itchy rash are the first symptoms of clinical varicella, typically developing after a 10–21-day incubation period. Varicella usually is self-limiting, and vesicles build crusts over 7-10 days before disappearing. Until all sores have crusted over, individuals remain contagious.[3]

The development of fever is frequently accompanied by a self-limited, pruritic, vesicular rash; other areas affected include the axilla, palms and soles, and mucosal sites such as conjunctiva, oropharynx and genitourinary tract.[4]

The rash starts as a macule and quickly evolves through the papular and vesicular stages before crusting (in 24-48 hours). Because the blisters erupt in crops, the rash can be at various stages of development on any one part of the body. Lesions are more common on the face and trunk than the limbs and have a central distribution. Varicella lesions are superficial, and crusts fall off within 1-2 weeks, leaving hypopigmented patches that might last for months or scars.[5]

Varicella commonly causes systemic signs and symptoms, including fever, headache, malaise, shivering, cough and cold.

Patients with chickenpox are considered infectious for 1 to 2 days before the rash appears and another 4-5 days afterwards. The foetus and new-borns are at risk of infection occurring during pregnancy. In 2% of cases, congenital varicella syndrome develops when the mother develops varicella during the first 20 weeks of pregnancy. The newborn has a high chance of serious illness if a pregnant woman gets the condition within five days of delivery. The virus can get across the placental barrier.[6]

Because the infection is very contagious, such individuals should be kept apart from family members more susceptible to the disease. Keep your skin clean once the fever has subsided by taking frequent baths or showers. Children should not attend class during the communicability phase, which lasts until the rash crusts. Under IDSP, additional control measures are reported. Isolation of patients for several days the following beginning, with simultaneous disinfection of articles contaminated by nose and throat secretions. Chickenpox does not usually require a laboratory diagnosis.

Moreover, delaying the onset of chickenpox from childhood to adult might be fatal when it is mild. This could result in more frequent or severe herpes zoster in later years than natural conditions. Immunocompromised adolescents, pregnant women, and new-borns exposed to maternal varicella should get passive immunization as a post-prophylaxis.[7]

In children who have already had vaccinations, close contact between a patient with herpes zoster and a susceptible, high-risk patient may lead to passive immunization as prophylactic. Breakthrough varicella is caused by the mild varicella-zoster virus and manifests as a rash 42 days after the child receives the chickenpox vaccine. Because this strain of varicella is contagious, it should be isolated.[8]

People who are at risk for developing complications of chickenpox are: newborn and infants whose mothers never had chickenpox or the vaccine; pregnant women who haven't had chickenpox, people who smoke; people whose has weakened immune systems by medication; such as chemotherapy, radiotherapy or by diseases such as HIV, cancer; people who are taking steroid medications for another disease or condition, such as asthma.[9]

Although the condition is usually minor, it can have serious consequences. It's life-threatening. In babies and those with a weakened immune system, infection is linked to a higher morbidity and mortality rate.

Viruses or bacteria could cause it. The most common complications are secondary bacterial infections, driven primarily by group A-haemolytic streptococci or Staphylococcus aureus. The skin and underlying soft tissue are commonly affected by such illnesses.

Invasive conditions can be life-threatening such as pneumonia, arthritis, osteomyelitis, necrotizing, fasciitis, sepsis. Complications of the central nervous system such as cerebellar ataxia, meningoencephalitis, meningitis and vasculitis affecting small or large vessels.

The clinical diagnosis is usually made based on the characteristics of the vesicular varicella rash. If there's any doubt, a recent history of varicella (or herpes zoster) exposure or the appearance of secondary cases in close contacts can clarify.

In almost all cases, varicella is a self-limiting condition that requires only symptomatic treatment (acetaminophen for fever, lotions for itching, and fluid substitution for hydration). Because of the link between acetylsalicylic acid and Reye syndrome, it is severely avoided in infants. Furthermore, non-steroidal anti-inflammatory medicines may raise the incidence of necrotizing soft tissue infections in children with chickenpox. Antibiotics must be administered quickly in the case of secondary bacterial infections.[10]

Acyclovir is most effective if given intravenously within 72 h of onset of disease. The recommended daily dosage for children is 1500 mg/m^2 per day; for adolescents and adults, it is 30 mg/kg per day in three divided doses. Since the drug is excreted via the kidneys, enough fluids need to be given simultaneously as the drug to avoid renal damage, and dosage should be reduced appropriately in patients with renal dysfunction.[11]

Prevention

Early identification and diagnosis of chickenpox cases. Isolation of patients and clinical management.

These are key strategies to prevent local outbreaks.

Chickenpox disease presents itself as a highly complex pathophysiological, economic and ecological problem. Research needs to be carried out to understand all these

aspects; various studies have been/are being carried out to understand these areas in relation to the morbidity and mortality patterns of the disease.

This study addressed the problem of chickenpox by taking into consideration climate variability with the aim to analyze the seasonal trends of chickenpox cases and identify the factors responsible for the trend.

METHODS

Study design and type

It was an observational retrospective study.

Study period

This study took place from March 2020 to March 2021.

Study setting

This study took place at Kasturba Hospital for Infectious Disease in the city of Mumbai.

Case definition for inclusion of record

Chickenpox case was defined as an illness with acute onset of diffuse maculo-papulovesicular rash without other apparent cause. The rash may also be atypical in appearance (maculopapular with few or no vesicles).

Data source

Data of chickenpox cases admitted in infectious disease hospital for the duration 2009-2018 was obtained with due permission from the medical superintendent of Kasturba Hospital for Infectious Disease. The climatic data of city of Mumbai (coordinates were taken as- latitude 19.11, longitude 72.85) for the same duration was used (data was available on public domain).

The data thus obtained that is A) climate data and B) data of chickenpox cases were used to analyze the trend and factors responsible for increase or decrease in the number of cases of cases of chickenpox.

Data analysis

Data obtained was entered in Microsoft Excel and analyzed using SPSS version 22.0. The time series analysis was performed for analyze the trend and identify forecasting model. Statistical tests like mean, median and correlation were used wherever appropriate.

RESULTS

A total of 27,712 cases of chickenpox were included in the study. The age group maximally affected by disease was 21-40 years, nearly 88% of total cases belonged to this age group, this was followed by 11% of cases belonging to the age group 0-20 years (Figure 1).

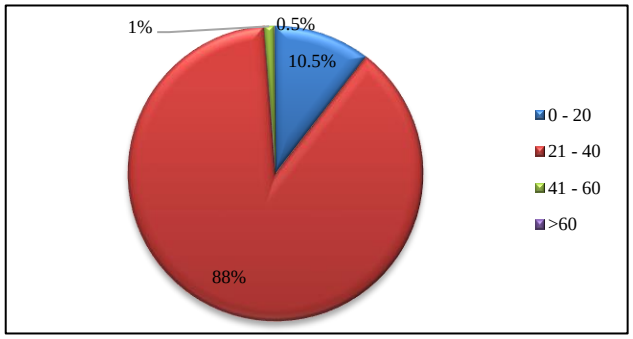

Figure 1: Age group wise distribution of cases.

Of the total cases admitted during the study period 84.6% were men and 15.4% were women, in all the years the number of men affected was slightly more than that of women. In the age group of 2-40 years, of the total cases admitted 86% were men and 14% were women (Figure 2).

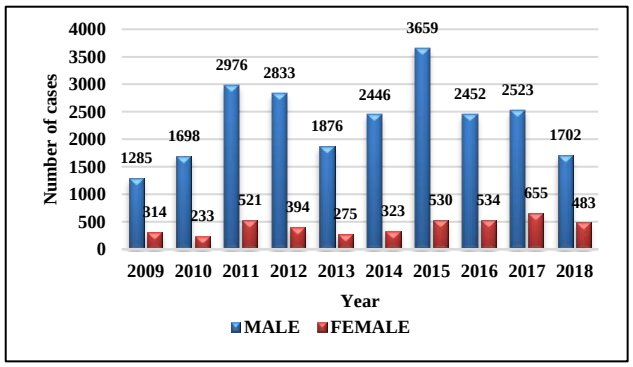

Figure 2: Gender wise distribution of chickenpox cases.

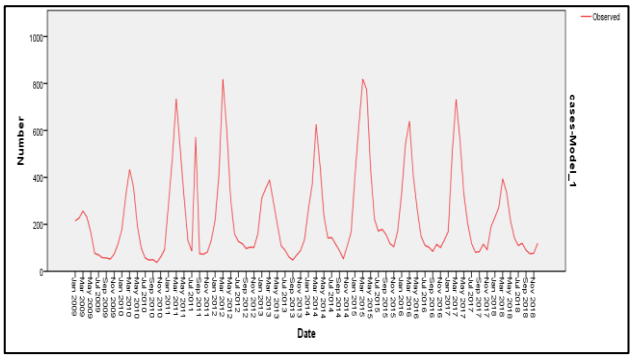

Figure 3: Time series plot for chickenpox cases over 10-year period (from January 2009 to December 2018).

On time series analysis, a notable fluctuation of cases reported over the years was noticed, with a clear seasonal

trend, with maximum cases between January and June. Minimum cases were noticed between July and November (Figure 3).

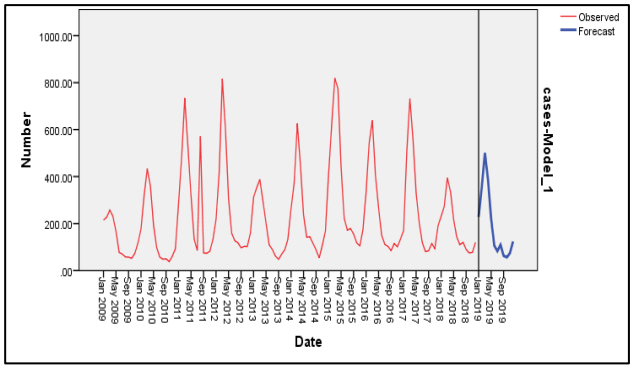

Figure 4: Prediction for the year 2019 using Holt-Winters model.

With the available data of chickenpox cases from 2009 to 2018 a forecast was prepared for the year 2019, model used was Holt Winter's model. 2304 cases are expected in the year of 2019. The forecast showed that will be an increase in the case after January with peak in February to April and fall in cases in May (Figure 4).

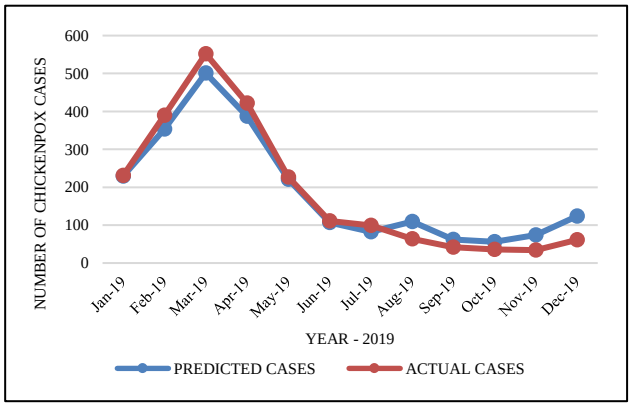

Figure 5: The number of cases as per prediction model and actual number of cases.

The number of cases predicted by model was further compared with actual number of cases that were reported in the year 2019. The cases that were predicted by the model were comparable to the actual number of cases though a slight difference was seen (Figure 5).

On comparison of cases with mean monthly temperature, it was noted that cases begin to get reported as the winter season begins and rise in summer season, decreased during autumn and rainfall in the examined temperate region. A strong correlation was observed between mean monthly temperature, and total number of cases reported (Figure 6).

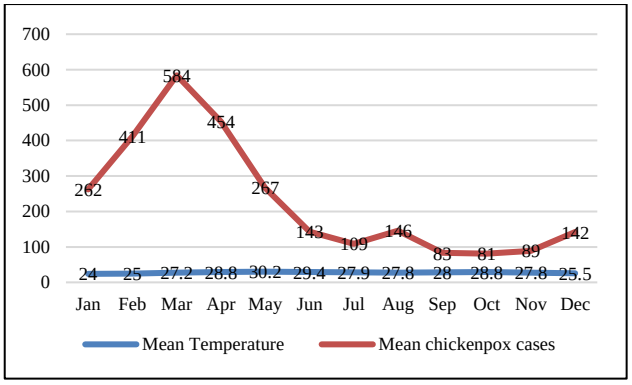

Figure 6: The number of cases as per prediction model and actual number of cases.

On time series analysis, a notable fluctuation of cases reported over the years was noticed, with a clear seasonal trend, with maximum cases between January and June (Figure 7).

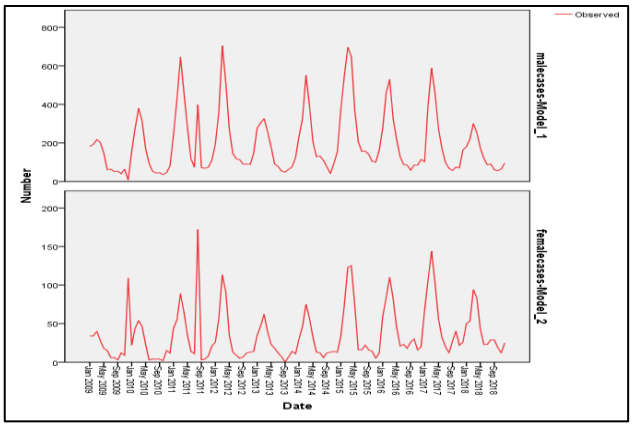

Figure 7: Time series plot for male and female chickenpox cases over 10-year period (from January 2009 to December 2018).

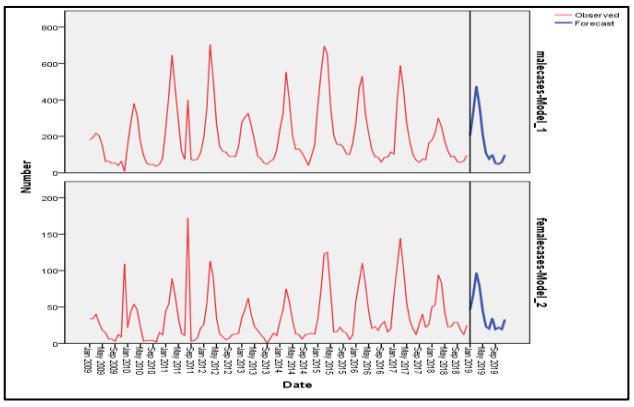

Figure 8: Prediction of gender wise chickenpox cases for 2019 using Holt-Winters model.

With the available data of male and female chickenpox cases from 2009 to 2018 a forecast was prepared for the year 2019, model used was Holt Winter's. 2129 male cases

and 505 female cases were expected in the year of 2019. The forecast showed that there was an increase in the case after January with peak in February, March, April and fall in cases in May (Figure 8).

DISCUSSION

The problem of chickenpox has been the one where many solutions have been found but none have helped in controlling the problem to the fullest. This study was a retrospective study carried out on the data available for chickenpox between 2009 and 2018; a total of 27712 records of chickenpox illness were included in the study. From the study we can understand, the incidence of cases and the climate seems to be closely related to each other. A seasonal trend is observed in the reporting of chicken cases, the temperature pattern has a definite influence on the number of cases. Climatic conditions are strongly associated with the disease.

The age group wise distribution of cases reveals that cases are most prevalent in the age group 21-40 years with slight male female difference, the proportion being higher among men which is in accordance with the study conducted by Saleh et al.[12] It can be understood that the disease affects those in the economically productive age group. A deeper introspection into the economic losses that occur to the nation, family and individual due to this illness is required.

In the present study, the highest average number of cases reported in metropolitan city compared to other cities in India. This is primarily due to the difference in population and migration, and people with severe symptoms admitted in hospital than asymptomatic or people mild symptoms. Seasonality is evident, with the number of cases begin to get reported as the winter season begins and rise in summer season, decreased during autumn and rainfall rainfall seasons. This is also apparent. And a downward trend can be noticed in the data. Similar pattern was observed in Skaf Wadie et al time series forecasting study which was conducted in hungary.[13]

In a study conducted by Critselis et al, where the climatic factors were compared with chickenpox cases incidence it was observed that cases were significantly associated with mean temperature which is quite in accordance with our study where mean monthly temperature correlated with the number of chickenpox cases whereas rainfall did not correlate with number of chickenpox cases.[14] The climate is not under our control but few of factors that lead to changes in the climate are definitely under our control. The measures that are being put forward for the control of the effects of climate change are to be taken seriously and implemented in daily life else the morbidity and mortality due to ill effects of climate change on health will definitely keep on rising.

In the present study, with the available data of chickenpox cases from 2009 to 2018 a forecast was prepared for next year 2019, model used was Holt Winter's. This model was chosen based on the pattern of chickenpox cases, seasonal component was also considered, similar model has been used by Panda et al to predict the spreading of COVID-19 for India and its states.[15] The forecasting will help in being prepared for the year ahead, in terms of logistics required, manpower needed for patient care, bed requirement in hospitals etc. A close inter-sectoral coordination with the meteorology department will also help in being prepared not just chickenpox but also for various other seasonal illnesses.

In this study, we found evidence for a decreasing trend in chicken pox infection, with seasonal peak during summer with slight male female difference, the proportion being higher among men. This suggests that public health interventions targeted at reducing such infectious diseases showed success in controlling the disease among populations in metropolitan city. However, it was found that about three-quarter of cases recorded were in the age group of 21-40 years. This group most probably comprised those who missed the vaccination when they were children. Employing statistical methods like timeseries analysis and forecasting will help in better understanding of the trend and being prepared for the year ahead.

This study was conducted in a hospital setting hence was limited only to the cases that were admitted, the cases treated on the out-patient basis and those not reporting to hospital under study were not included, inclusion of these cases can help in better understanding of the epidemiological determinants of chickenpox.

CONCLUSION

The trend in the reporting of chickenpox cases shows an increasing trend, with slight male female difference, the proportion being higher among men. A clear seasonal distribution of cases is also seen. The climate change has a definite influence on the incidence on the infectious diseases like chickenpox. Employing statistical methods like time series analysis and forecasting will help in better understanding of the trend and being prepared for the year ahead.

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