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Original Work

An analysis of the excess mortality profile during the 2006 Chikungunya Fever epidemic in Mauritius

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ABSTRACT: The Island of Mauritius was affected by a large scale epidemic outbreak of Chikungunya Fever (CHIKF) from February to April 2006. It was observed that this epidemic was associated with an excess mortality during the months of March to May 2006 in Mauritius. This study was aimed to analyze the gender and age group distribution of the excess mortality. Population and mortality data were obtained from the Mauritius Central Statistics Office for the years 2000 to 2006. The excess monthly mortality was computed for 2006 and the distribution of excess mortality according to gender and age groups was analyzed. For both genders combined, the excess mortality was 91.5% in the age group ≥50 years. For the ≥ 50-year age group, the total male excess death rate (EDR) exceeded the total female EDR by 66%. Our results indicate that CHIKF is associated with an increased mortality particularly in the ≥ 50-year age group with males being more vulnerable than females to mortality. Although there have been reports of CHIKF related deaths in other studies, the profile of the excess mortality during a CHIKF outbreak has not been previously described.

KEY WORDS: Chikungunya Fever; Distribution of excess mortality; Gender; Age groups

INTRODUCTION

Chikungunya Fever (CHIKF), an emerging mosquito-borne viral infection, affected more than 1 million people during large-scale epidemic outbreaks, in 2005-2006, in the Indian Ocean islands of Reunion, Mauritius, Comoros, Mayotte and in India[1] after originating in the Kenyan coastal towns of Lamu and Mombassa in November 2004.[2] Population movements, through trade and tourism, then enhanced the propagation of the virus to the Indian Ocean. In Mauritius (population of 1.21 million) and Reunion Island (population of 775,000), two neighboring islands which were formerly CHIKV-free, minor outbreaks occurred in 2005 followed by large-scale outbreaks in 2006[1,3]. In the case of Mauritius, the onset of 2006 outbreak at the beginning of February followed abnormally high rainfall in the island causing a sudden large increase in the population of *Aedes albopictus*, the identified mosquito vector of CHIKV in both Mauritius and Reunion Island.[3] *Aedes aegypti*, an important vector of CHIKV in many countries, was eradicated in Mauritius and nearly eradicated in Reunion Island during the anti-malaria campaigns in the early 1950s. The more recent outbreak of CHIKV in the Ravenna province of Northern Italy[4] has aroused concern that converging factors such as global warming and expanding international trade and tourism[5], the ability of *Aedes albopictus* eggs to overwinter and the possibility of vertical transmission of CHIKV in *Aedes albopictus*[6] may favour the spread of the infection to countries in the northern temperate zone.

CHIKF is usually a self-limiting disease lasting for 5-7 days. Clinical features include fever, severe joint pains, myalgia, headaches and rashes.[7] In the post-viral phase, there may be persistence and recurrence of joint and other symptoms.[8] Severe complications associated with CHIKF such as neurological sequelae have also been described.[7-9] Worryingly, mortality has been observed to be associated with this previously thought non-fatal infection. The 2006-outbreaks in Mauritius,

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Reunion Island and India were accompanied by reports of CHIKF-related deaths and significant excess mortality.[10-12] In Mauritius, crude death rates (CDRs) increased significantly in the months of March, April and May 2006 with a maximum increase in April and a total excess mortality of 746 was observed for these three months.[10] As there were no other identified or probable causes of this excess mortality other than the CHIKF outbreak, the observed excess mortality during the months when CHIKF was prevailing was mostly likely linked to the CHIKF outbreak itself.[10]

There were 11,165 officially reported CHIKF cases in Mauritius in 2006[13] although the actual number of cases may have been more than the recorded official cases.[3] In Reunion Island, there were about 260 excess deaths for 260,000 estimated CHIKF cases during the period January to April 2006.[11] In 213 out of these 260 excess deaths in Reunion, there was evidence on the death certificates that these were directly or indirectly caused by CHIKV.[11]

We have previously reported on the geographical distribution of the excess mortality in Mauritius during the 2006 CHIKF outbreak and seen how this can be used as an epidemic intelligence tool in Chikungunya mapping.[10] In this paper, we describe the age-group and gender distribution of the excess mortality in Mauritius during the months of March, April and May 2006 associated with the CHIKF epidemic and compare the excess mortality profile with published available data from Reunion Island for the months of January, February, March and April 2006.

METHODOLOGY

In Mauritius, the Civil Status Division is responsible for the registration of deaths and for the issue of death certificates. The Central Civil Status Office is responsible for all 43 civil status sub-offices across the island. Any death in Mauritius must be registered within 24 hours at a civil status office in the district where the death occurred or where the deceased resided before his death. The mortality data are then transmitted to the Mauritius Central Statistics Office (MCSO) for compilation and for use in population estimates and projections.

The observed monthly mortality data by age group and gender for the period January 2000 to December 2006 were obtained from the MCSO. The mid-year populations by age group (0-9, 10-19, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80 and over) and gender for 2000-2006 were also obtained from the MCSO. The monthly crude death rates (deaths per 1,000 mid-year population) by age group and gender for the period January 2000 to December 2006 were computed by dividing the monthly mortality for each age group and each gender by the corresponding mid-year population and then multiplying by 1,000.

The predicted mortality for 2006 was also calculated based on figures from 2000-2005. The 2006 predicted monthly mortality for each age group by gender was obtained by multiplying the average monthly CDR for the age group by gender in the period 2000-2005 by the corresponding 2006 mid-year population and then dividing the value obtained by 1,000. The excess monthly mortality was the difference between the observed monthly mortality and the predicted monthly mortality. The excess death rate (EDR) was defined as the excess mortality per 1,000 of the population.

In the case of Reunion Island, the age-distribution at death was available for 203 CHIKF-related deaths for the period 01 January 2006 to 16 April 2006.[14] By extrapolating this data, the age-distribution at death for the 213 deaths related to CHIKF for the period January to end of April 2006 was estimated. Population estimates for 10-year age-groups were also available for Reunion Island.[14]

RESULTS

Excess mortality

Mauritius: The CDRs increased most significantly in April 2006, about one month after the peak of the epidemic.[10] Thus this month was selected to show the age group and gender distribution of excess mortality.

Results are displayed in **Figures 1** and **2** which show the predicted, observed and excess mortality, by 10-year age groups for the male and female populations respectively, for the month of April 2006.

For the months of March, April and May 2006, 91.1% of the total male excess mortality and 92.0% of the total female excess mortality occurred in the $\geq$ 50-year age group. For both genders combined, the excess mortality was 91.5% in this age group.

Reunion Island: During the period January 2006 to end of April 2006, 90.6% of CHIKF-related deaths occurred in the $\geq$ 50-year age group.

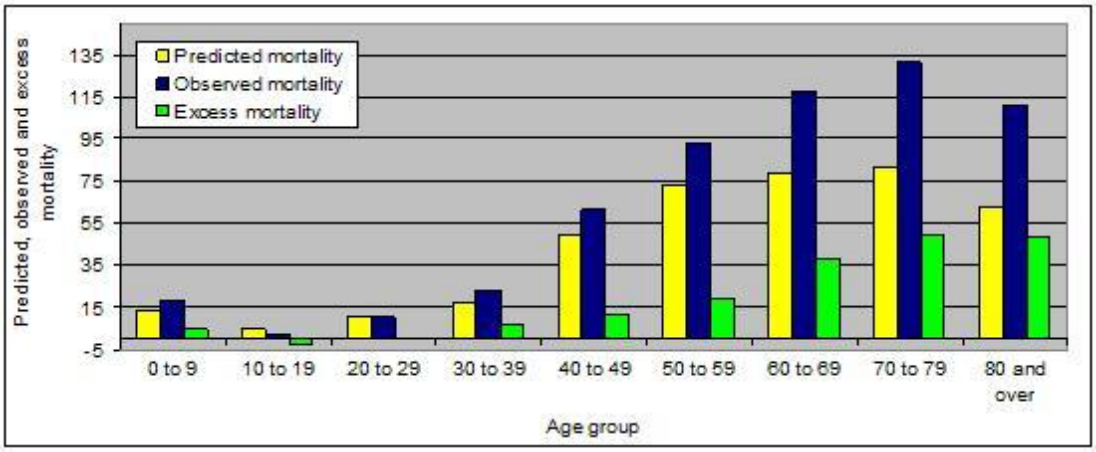

Figure 1: Predicted, observed and excess mortality by 10-year age group for the Male Population in Mauritius for April 2006

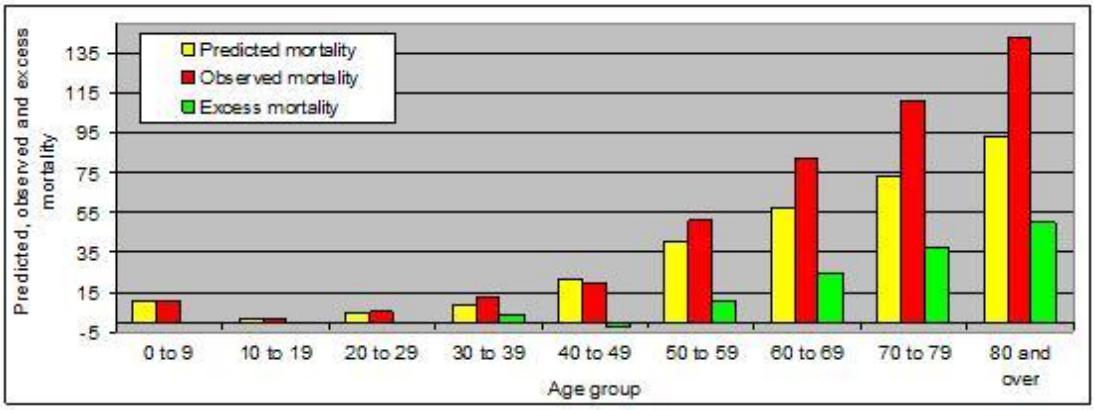

Figure 2: Predicted, observed and excess mortality by 10-year age group for the Female Population in Mauritius for April 2006

Excess death rate (EDR)

Mauritius EDR by age and gender: **Figure 3** shows the EDR from March to May 2006 by gender for the ≥ 50-year age groups.

In the male population, the calculated EDR was statistically significant ($p < 0.01$) for the 60-69, 70-79 and ≥ 80-year age groups. In the female population, the calculated EDR was statistically significant ($p < 0.01$) for the 50-59 and ≥ 80-year age groups. For the ≥ 50-year age group, the total male EDR exceeded the total female EDR by 66%.

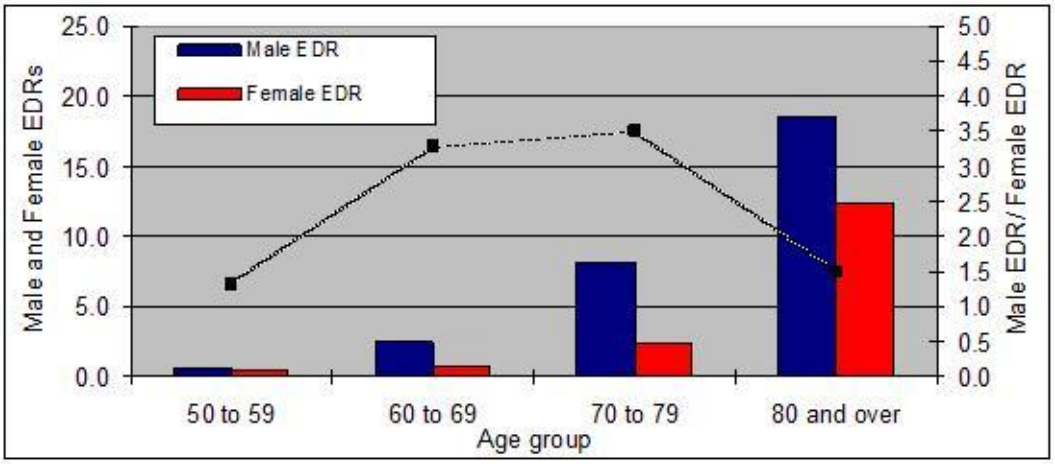

Figure 3: Comparison of the EDR in males and females in Mauritius for the 50-59, 60-69, 70-79, and 80-year and over age groups for the period March to May 2006

Comparison of EDR in Mauritius with Reunion Island in different age groups: **Table 1** compares the EDR in Mauritius (March to May 2006) with the EDR in Reunion Island (January to April 2006), during the respective CHIKF epidemics in each island, in the ≥ 50 age groups.

Table 1: Comparison of EDR in Mauritius vs. EDR in Reunion Island

Age group (Years)	EDR Mauritius/ Reunion Island
50-59	**2.65**
60-69	**2.30**
70-79	**2.64**
≥80	**1.80**

DISCUSSION AND CONCLUSION

To our knowledge, this study is the first to report on the gender and age distribution of excess mortality associated with CHIKF. A major assumption in this study was that the excess mortality observed in Mauritius in 2006 and which occurred over the months of March, April and May 2006 was related to the CHIKF epidemic outbreak. This is a plausible explanation as there was no other known causative phenomenon which could be identified. However the possibility that some of these excess deaths could be due to an unidentified cause is a potential confounding factor. Another limitation of this study was that the actual causes of death from death certificates and autopsies were not available as these are not in the public domain. Nevertheless we obtained high quality data on mortality, gender and age groups from the MCSO which compiles data for the whole country. In addition data from Reunion Island were readily available from recent publications.[14]

Our results indicated that the excess mortality was especially pronounced in the ≥ 50-year age group in both sexes. This finding is similar to reports from other publications.[14,15] This demonstrates the increased vulnerability of people in this age group to the more severe effects of CHIKF. It is plausible that there are factors such as the presence of co-morbidities in this age group that also contribute to the mortality as has been reported in other studies.[15] To confirm this, it would be interesting, in future, to explore whether the excess mortality in the ≥ 50-year age group occurred in previously well people or in those with pre-existing conditions by investigating the medical records of the deceased.

In addition, results of our study show that the male EDR exceeded the female EDR. This gender difference in CHIKF–related mortality is an interesting finding given the reported over-representation of CHIKF in women.[7,14] This gender difference in mortality also needs to be explored further, for example by looking again for the presence of other co-morbidities in both genders, to understand why males appear to be more vulnerable to death related to CHIKF.

However the exact pathophysiology of how CHIKF directly leads to death still remains to be elucidated. In the presence of co-morbidities, it is possible that CHIKF contributes to death by leading to decompensation in chronic conditions. Furthermore, in Mauritius, iatrogenic complications leading to deaths (e.g. gastrointestinal bleeding following the use of non-steroidal anti-inflammatory drugs) have also been observed during the 2006 epidemic outbreak. In Reunion Island, CHIKF was mentioned as the direct cause of death on 121 of the 203 death certificates mentioning CHIKF as a cause of death from 01 January 2006 to 16 April 2006.[14]

Our results also show that CHIKF-related excess deaths have occurred at least twice more frequently in Mauritius than in Reunion Island. Mauritius is a country with a high burden of non-communicable diseases such as diabetes and cardiovascular diseases which are also the two principal causes of mortality in the island. It is possible that this is reflected in the difference in CHIKF-related excess deaths. In addition, this difference may also be a reflection of the per capita expenditure on health care and health delivery quality in the two islands: Reunion Island is a French overseas territory and the per capita expenditure on health of France is nearly six times that of Mauritius.[16] Furthermore it has recently been reported that poverty may influence the epidemiology of CHIKF.[17] It would be interesting to explore further the association of CHIKF related mortality with socioeconomic status in future studies.

In this study, we have characterized the excess mortality due to CHIKF outbreak in Mauritius according to age and sex. We have demonstrated that CHIKF results in increased mortality particularly in the ≥ 50-year age group with males being more vulnerable than females. Since CHIKF is an emerging infectious disease in many parts of the world[4,18], it is important that in future epidemics vulnerable groups are identified and targeted for reinforced preventive measures to prevent mortality.

In addition, with the emergence of new infectious diseases, countries like Mauritius with limited resources must develop new ways of combating the entry and development of infectious diseases, especially those associated with mortality, in their territories. For example, the development of appropriate communicable diseases early warning and response systems which are currently being explored in this region of the Indian Ocean[19] could greatly reduce the cost of public health interventions and mitigate the burden of the diseases. Mortality surveillance could be an important component in such surveillance systems

to allow public health authorities to take timely preventive actions.

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