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Short Communication

Meningitis epidemics shift in sub-Saharan belt

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ABSTRACT

Meningococcal meningitis (MCM) poses a serious threat to public health in Africa. Epidemics appear irregularly every 5–12 years, especially in the regions across sub-Saharan 'meningitis belt'. This study investigated the long-term spatiotemporal dynamics of MCM. It appears that dominant epidemic outbreaks in the meningitis belt spread from west to east over the study period 2006–2016.

Introduction

Meningococcal meningitis (MCM) poses a serious threat to public health in Africa. It is particularly hazardous for African children (WHO, 2017), for whom the case-fatality rate (CFR) is high. During the 2017 meningitis epidemic in northern Nigeria, 14 473 cases (including 1158 deaths) were reported, of which over 50% involved children under the age of 16 years (Nigeria Centre for Disease Control, 2017). In general, the CFR for poorly treated cases can be up to 50% (WHO, 2017; CDC, 2017). The bacterium responsible, *Neisseria meningitidis*, is transmitted among humans aerially (WHO, 2017; CDC, 2017) and the disease is highly contagious.

The long-term dynamics of different strains of MCM is characterized by markedly irregular periodicity (5–12 years), with attack rate reaching 1000 cases per 100 000 population (CDC, 2017; Roberts, 2008). The spatiotemporal dynamics of MCM cases in the sub-Saharan 'meningitis belt', which spans across Africa from Senegal to Ethiopia (first identified by Lapeyssonnie (1963)), has been investigated previously for the period 1980–1999 (Molesworth et al., 2002; Ramakrishnan et al., 2009; Lingani et al., 2015). This short communication reports a geographical shift in pattern of the MCM epidemics in the sub-Saharan meningitis belt, based on publicly available data for the years 2006–2016.

Methods

Annually reported numbers of meningitis cases and deaths, along with the number of epidemic districts, were obtained from the World Health Organization (WHO) Global Health Observatory data repository (see http://apps.who.int/gho/data/node.main.178?lang=en and Lingani et al. (2015)). Weekly reported meningitis cases and deaths for the WHO Africa Region were obtained from the WHO Weekly Reports (Bulletins Hebdomadaires) (see http://www.who.int/csr/disease/meningococcal/epidemiological/en/).

The meningitis epidemiology data reported from January 2006 to December 2016 were studied to explore the spatial pattern of meningitis epidemics in the sub-Saharan meningitis belt (see Figures 1 and 2). Eleven regions were included from west to east: Mali, Côte d'Ivoire, Burkina Faso, Ghana–Togo–Benin region, Niger, Nigeria, Cameroon, Chad, Central African Republic (CAR), Sudan and South Sudan region, and Ethiopia (Figure 1a). These 11 regions encompass 90% of meningitis cases in the sub-Saharan meningitis belt. Reports published by the WHO on the number of 'epidemic districts' in each region that had crossed the meningitis epidemic threshold were analysed. The threshold is defined as a *weekly attack rate of 10 reported cases per 100 000 population* (according to the WHO; see http://www.who.int/immunization/diseases/meningitis/en/) and is a key index used to identify seasonal outbreaks.

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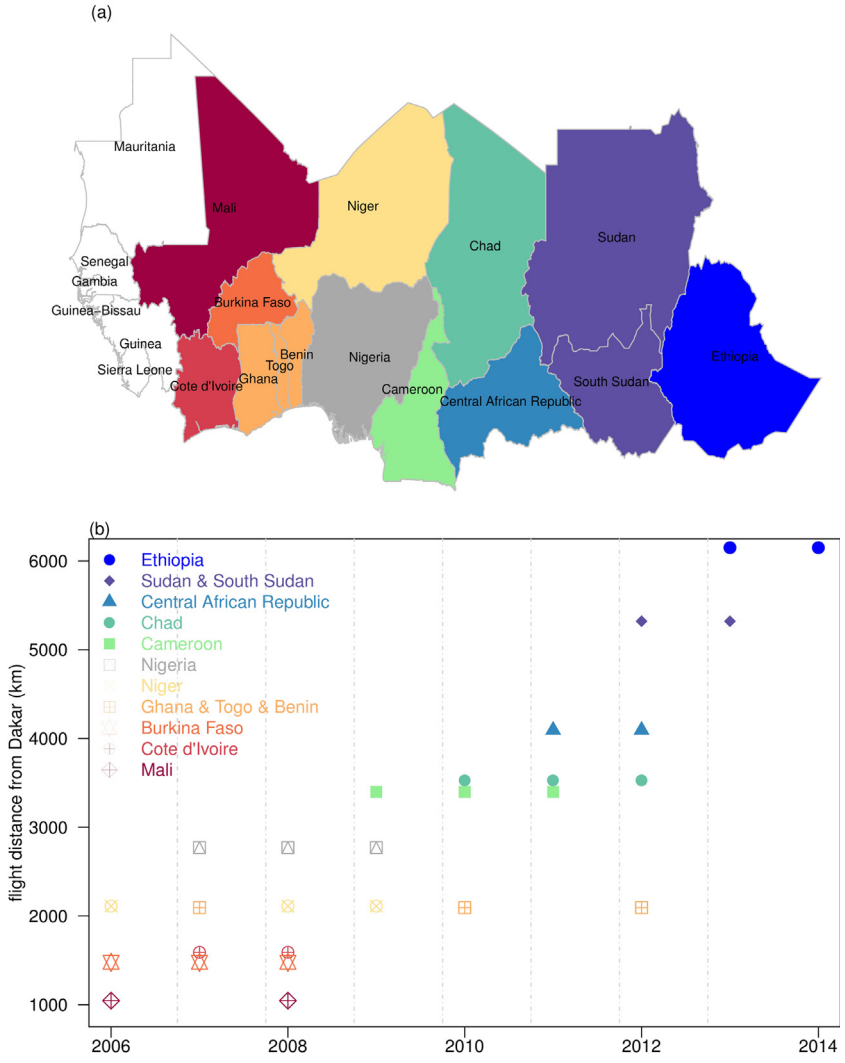

Figure 1. (a) Location of the regions along the sub-Saharan meningitis belt, and (b) the relationship between the dominant epidemic years and the westward distance (the regions in the legend from bottom to top are listed in order of their location from west to east geographically).

Results and discussion

The numbers of cases of MCM in the 11 regions of the sub-Saharan meningitis belt over the study period 2006–2016 are plotted in Figure 2. The time-series indicated that the MCM epidemics were highly irregular, often not annual in period, or annual over several consecutive years followed by fade-outs. Nevertheless, epidemics were apparent in each of the regions over the study period. Due to the difficulty finding any pattern in this disorder, it was found to be more helpful to study changes in the annual number of MCM "epidemic districts" in each of the 11 regions. For each region, the three (or two) calendar years with the largest numbers of epidemic districts were selected. Thus each region could be associated with three (or two) dominant epidemic years. The longitudinal flight distance (in kilometres) between the capitals of each region and the capital of Senegal – Dakar (the most westward point) – was recorded and referred to as the 'westward distance' (the Ghana–Togo–Benin region was represented by the capital of Togo and the Sudan and South Sudan region was represented by the capital of Sudan). The relationship between the dominant epidemic years and the westward distance is shown in Figure 1b: an obvious positive correlation is seen.

On a larger scale, the meningitis outbreaks appeared to be transmitted gradually eastwards, moving from country to country in an almost falling domino-like pattern, indicating the important influence of spatial dynamics. From 2006 to 2008, major outbreaks occurred in the western regions, that is, Mali, Côte d'Ivoire, and Burkina Faso (Figure 2a–c). The intense depletion of susceptible individuals in the regions, possibly to below threshold levels, resulted in die-out over the next years as the disease spread eastwards. Niger and Nigeria both experienced a dominant epidemic year in 2009 (Figure 2e, f), and this was followed by epidemic outbreaks in Cameroon and Chad, which initiated in 2010 and peaked in 2011 (Figure 2g, h). The pattern ends with outbreaks in Sudan in 2013 (Figure 2j) and Ethiopia in 2014 (Figure 2k), although the populations in both countries had been vaccinated since 2010 (WHO, 2015). It is likely that both of the latter outbreaks would have been of greater intensity if vaccination had not been introduced. Similar trends were reported for the MCM epidemics during the period 1980–1999 (Molesworth et al., 2002). This shift in timing of dominant epidemic years from west to east along the sub-Saharan meningitis belt has not been reported previously. However strong spatial dynamics are characteristic of MCM transmission and the disease is known to spread from district to district within

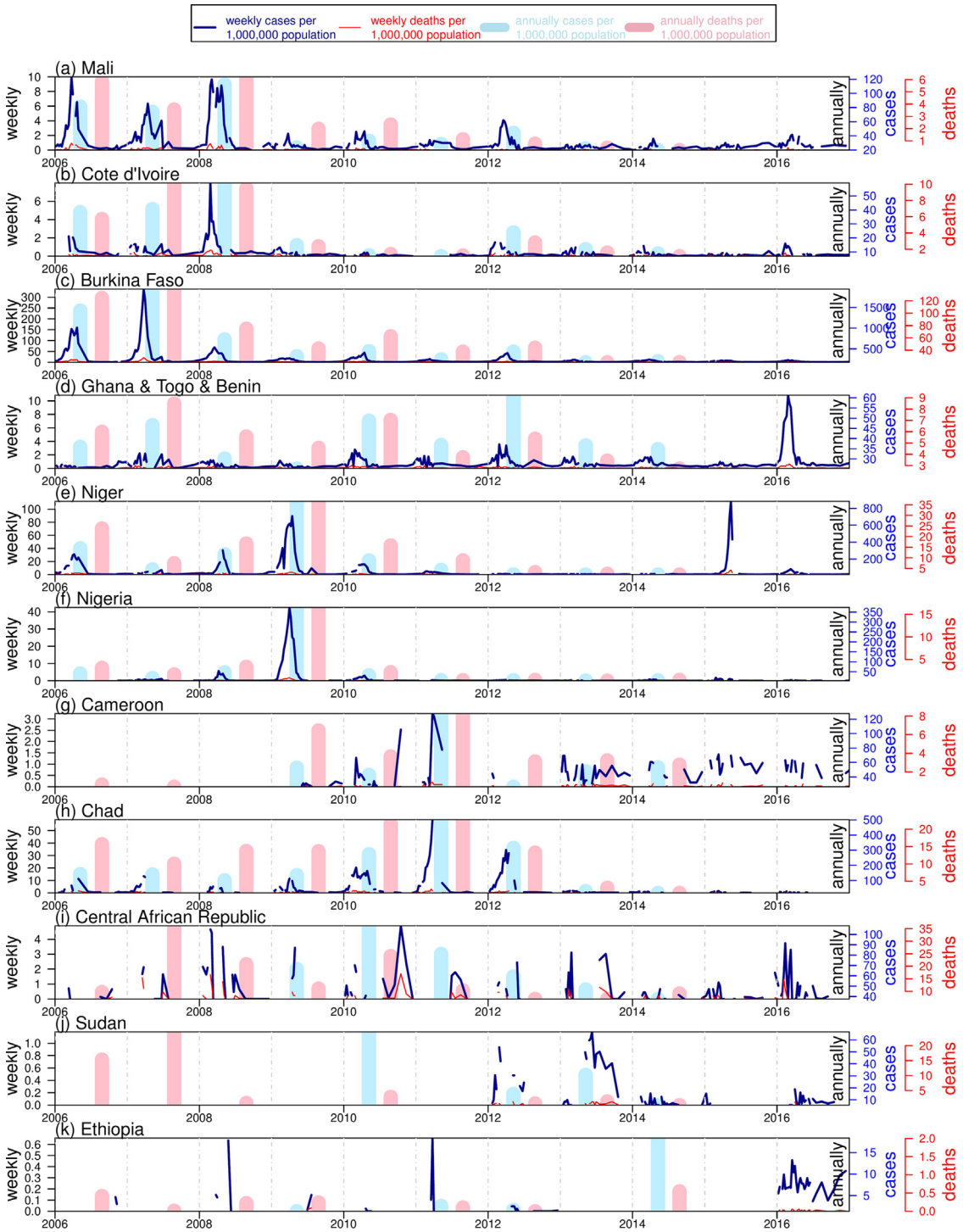

Figure 2. Weekly and annually reported meningitis cases and deaths in 11 regions of the sub-Saharan meningitis belt from 2006 to 2016, listed from west to east. For each panel, the weekly cases and deaths are represented by the dark blue and red lines, respectively; the annual cases and deaths are represented by the light blue and pink bars, respectively. All case and deaths data are scaled by the regional population.

a region (Philippon et al., 2009), while similar phenomena on a regional scale are very common for many infectious diseases.

In the past, the trans-Saharan trade route might have contributed to the spatial transmission across the region. However, it is unlikely that the route has continued to have much of an influence in this century, because the trans-Saharan trade has largely declined (to almost zero). Although epidemics due to meningitis serogroup A are disappearing (this serogroup previously dominated in the sub-Saharan meningitis belt, but is currently under control owing to the mass vaccination programme (WHO, 2017)), other meningitis serotypes can also cause outbreaks (e.g., serotypes C, W, or X, according to the WHO; see http://www.who.int/csr/resources/publications/meningitis/guidelines2014/en/). For example, the most recent meningitis outbreaks in Nigeria (in 2016 and 2017) included over 80% serogroup C cases (Nigeria Centre for Disease Control, 2017). Therefore, the reported epidemic

shift might be due to the herd immunity (against the new predominant meningitis serogroup) among children, which makes the epidemic unlikely to spread back.

Further studies on spatial host migration, climate dynamics, and environmental factors that may be associated with long-term MCM epidemiology are required to fully understand the eastward trend observed. A clearer understanding of the spatial dynamics in the belt has the potential to be of practical importance for predicting and preparing for future MCM outbreaks.

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Ethical approval

Not applicable.

Conflict of interest

The authors declare no conflict of interest.

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