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Estimating the spatial distribution of acute undifferentiated fever (AUF) and associated risk factors using emergency call data in India. A symptom-based approach for public health surveillance

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ABSTRACT

The System for Early-warning based on Emergency Data (SEED) is a pilot project to evaluate the use of emergency call data with the main complaint acute undifferentiated fever (AUF) for syndromic surveillance in India. While spatio-temporal methods provide signals to detect potential disease outbreaks, additional information about socio-ecological exposure factors and the main population at risk is necessary for evidence-based public health interventions and future preparedness strategies. The goal of this study is to investigate whether a spatial epidemiological analysis at the ecological level provides information on urban–rural inequalities, socio-ecological exposure factors and the main population at risk for AUF. Our results displayed higher risks in rural areas with strong local variation. Household industries and proximity to forests were the main socio-ecological exposure factors and scheduled tribes were the main population at risk for AUF. These results provide additional information for syndromic surveillance and could be used for evidence-based public health interventions and future preparedness strategies.

1. Introduction

The burden of disease in India is currently changing from being dominated by communicable diseases to chronic life-style related diseases. The overall burden of disease accounts for approx. 269 million disability adjusted life years (DALY) in India. Despite the epidemiological transition, communicable diseases still account for 50% of DALYs followed by 33% for non-communicable diseases and 17% for injuries (Gupte et al., 2001). Infectious and parasitic diseases are the major contributor to communicable diseases followed by respiratory infections, diarrhoeal diseases and childhood diseases (Gupte et al., 2001). Acute undifferentiated fever (AUF) is a first indicator for infectious diseases and is a major public health problem in India. The aetiology of AUF is fairly diverse and includes a wide range of infectious diseases such as dengue (Reller et al., 2012), malaria (Joshi et al., 2008), typhoid (Gasem et al., 2009), tuberculosis (Abrahamsen et al., 2013), hantavirus (Chandy et al., 2009) and Japanese encephalitis (Robertson et al., 2013).

Socio-economic disparities are a key driver not only of high rates of infectious diseases (Gupta et al., 2011, Pascual Martinez et al., 2012), especially in rural areas (Patil et al., 2002), but also of a wide range of other health problems including neonatal mortality (Kumar et al., 2013), inequalities in immunisation coverage (Lauridsen and Pradhan, 2011), mental disorders (Shidhaye and Patel, 2010) and low birth-weight (Bharati et al., 2011). The vulnerability to infectious diseases among various disadvantaged population sub-groups such as scheduled castes and scheduled tribes varies widely among and within the states of India (Raju et al., 1999), depending on the local interplay between agent, host and environmental factors (Gupte et al., 2001). A spatial epidemiological approach using Geographic Information Systems (GIS) is therefore essential to estimate the impact of socio-economic and

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environmental (socio-ecological) characteristics on the incidence of infectious diseases. Such an approach has shown to deliver substantial background information for evidence-based public health interventions (Weisent et al., 2012, Haque et al., 2012, Khormi and Kumar, 2011). However, reliable and complete surveillance data is scarce in India (Aparajita and Ramanakumar, 2004, John et al., 2011), making the application of spatial epidemiological methods more challenging.

The federal structure of the Indian public health system with its variety of stakeholders and institutions, the increase of the private medical sector, the missing collaboration between the institutions and the multiplicity of vertically organised surveillance programs with their different systems of data collection complicate a uniform surveillance system (John et al., 2011). The Integrated Disease Surveillance Project (IDSP) was initiated in 2004 by the Ministry of Health and Family Welfare (MOHFW) with financial help of the World Bank and technical assistance of the World Health Organization (WHO) and the US Centers for Disease Control and Prevention (CDC). The goal of this project was to connect all district hospitals and medical colleges to establish a decentralised, state-based disease and syndromic surveillance system (Kant and Krishnan, 2010). However, this approach is not spatially inclusive as the IDSP still faces problems to include data from the private medical sector and therefore underestimates the burden of disease. The current approach to estimate the burden of disease relies on fragmentary databases derived usually from public medical facilities that serve only a small fraction of the population (John et al., 2011). The importance of including the private medical sector into disease surveillance can best be described by the following numbers: After the turn of the millennium, 67% of all hospitals, 63% of all pharmacies and 78% of all doctors were employed within the private medical sector (Patil et al., 2002). In addition, the IDSP still remains suboptimal for the control of infectious diseases. The surveillance data is often delayed, unreliable, inconsistent and the reporting rates display strong regional differences (Gaikwad et al., 2010).

The System for Early-warning based on Emergency Data (SEED) is a pilot project set up by GVK Emergency Management Research Institute (GVK EMRI), India's largest private emergency medical service provider, and GEOMED research to evaluate the use of emergency call data with the main complaint fever for syndromic surveillance of infectious diseases in India (Pilot et al., 2011; Jena et al., 2010). The project is closely linked to the European Emergency data-based System for Information on, Detection and Analysis of Risks and Threats to Health (SIDARTHa), (Office, 2014).

GVK EMRI currently operates in 14 states and 2 union territories of India, providing a chance to set up a large-scale syndromic surveillance system covering a large part of the population. The emergency call data are automatically captured using Computer Telephone Integration technology. These data are standardized, available in near real-time, spatially inclusive at fine geographic scales for the covered areas and allow the use of symptom-based data on AUF to estimate the burden of infectious diseases in areas where reliable surveillance data are not available (Joshi et al., 2008, Robertson et al., 2013).

While the general use of syndromic surveillance lies in the observation of spatial variations of common illnesses over time (Cooper et al., 2008, Horst and Coco, 2010) and the detection of potential disease outbreaks (Pilot et al., 2011; Van Den Wijngaard et al., 2010), a purely spatial, cross-sectional epidemiological analysis at the ecological level may provide additional information about socio-economic and environmental risk factors (Robertson et al., 2013, Weisent et al., 2012, Hu et al., 2012).

Infectious diseases presenting with symptoms of fever such as malaria, dengue and typhoid are driven by socio-economic, demographic and environmental characteristics (Winskill et al., 2011, Corner et al., 2013, Khormi and Kumar, 2011) and typically display higher rates in rural areas of India (Patil et al., 2002). Location-based knowledge on socio-ecological exposures and the population at risk is critical to allocate scarce financial resources (Patil et al., 2002). Such knowledge informs future preparedness strategies, for example through targeted distribution of insecticide treated bed nets.

The goal of this study is therefore to examine whether a spatial epidemiological analysis at the ecological level provides background information on the main socio-ecological exposure factors and the population at risk for evidence-based public health interventions and future preparedness strategies. Specifically, we hypothesise (i) that AUF displays higher rates in rural areas as compared to urban areas (ii) that AUF is distributed unequally across space and (iii) that AUF is associated with lower socio-economic status.

2. Methods

2.1. Study area

SEED was set up as a pilot project in three districts of Andhra Pradesh (AP), India. These three districts were selected by GVK EMRI based on their proportion of infant mortality rates, female literacy, urbanisation, proportion of reported fever and infection cases and proportion of scheduled caste and scheduled tribe population to ensure a representative sample within Andhra Pradesh (Jena et al., 2010). Srikakulam district was chosen for this study because it has the largest proportion of fever among the three selected districts. A community level household survey estimated the prevalence of fever to be 16.7%. A more detailed analysis revealed that 18% of these fever cases were attributable to malaria, 8% to typhoid and 4% to dengue and the remaining 72% to AUF (Jena et al., 2010). The district is characterised by a long coastline in the east and forested areas in the northern and north-western parts. Srikakulam has a population of 2.54 mio inhabitants according to the Census of India 2001 (Commissioner, Census Data, 2001). The smallest administrative units in rural areas of India are villages, which can be defined as areas with (i) a maximum population of 5000 inhabitants, (ii) a maximum of 75% of the male population employed in the non-agricultural sector and (iii) a maximum population density of 400 inhabitants per km^2 (Commissioner, Census Data, 2001). Mandals are the smallest administrative unit in AP for which a wide variety of population statistics are available and comprise between 27,141 and 187,132 inhabitants in Srikakulam district (Commissioner, Census Data, 2001) (Fig. 1). The district is predominantly rural and contains 11% of urban population, which is far lower than the average of 27.3% in Andhra Pradesh (Commissioner, Census Data, 2001). The literacy rate may be considered as low with only 54% as compared to 60% for the AP average. Srikakulam has a lower proportion of scheduled caste population with 9.5% as compared to the AP average of 16.0%. The proportion of scheduled tribes is slightly higher with 7.1% than the AP average of 7%.

3. Data

3.1. Outcome variable

Emergency call data with the main complaint AUF were used as indicator for infectious diseases. The emergency call data were provided by GVK EMRI and were available for the time period January 1st to December 31st, 2008. 8062 AUF calls were recorded for the year 2008 in Srikakulam district. The emergency call data were available on village level and were aggregated to mandal