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Spatial variations and determinants of infant and under-five mortality in Bangladesh

Oliver Gruebner[a,b,*], MMH Khan[c,d], Katrin Burkart[e], Sven Lautenbach[f], Tobia Lakes[a], Alexander Krämer[d], S.V. Subramanian[g], Sandro Galea[h]

[a] Humboldt-Universität zu Berlin, Geography Department, Berlin, Germany
[b] University of Zurich, Epidemiology, Biostatistics, and Prevention Institute, Zurich, Switzerland
[c] King Faisal University, College of Applied Medical Sciences, Department of Public Health, Saudi Arabia
[d] University of Bielefeld, School of Public Health, Department of Public Health Medicine, Bielefeld, Germany
[e] Columbia University, Mailman School of Public Health, Department of Environmental Health Sciences, New York City, NY, USA
[f] University of Bonn, Institute of Geodesy and Geoinformation (IGG), Bonn, Germany
[g] Harvard T.H. Chan School of Public Health, Department of Social and Behavioral Sciences, Boston, MA, USA
[h] Boston University, School of Public Health, Boston, MA, USA

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ABSTRACT

Reducing child mortality is a Sustainable Development Goal yet to be achieved by many low-income countries. We applied a subnational and spatial approach based on publicly available datasets and identified permanent insolvency, urbanicity, and malaria endemicity as factors associated with child mortality. We further detected spatial clusters in the east of Bangladesh and noted Sylhet and Jamalpur as those districts that need immediate attention to reduce child mortality. Our approach is transferable to other regions in comparable settings worldwide and may guide future studies to identify subnational regions in need for public health attention. Our study adds to our understanding where we may intervene to more effectively improve health, particularly among disadvantaged populations.

1. Introduction

Child mortality is substantially higher in low- and middle-income countries as compared to high-income countries (United Nations Children's Fund (UNICEF), 2014a). The Sustainable Development Goals (SDG) have committed nearly all governments in the world to reduce under-five mortality, that is, the probability of dying before age five, to at least as low as 25 per 1000 live births by 2030 (United Nations General Assembly, 2015). Yet there remains much to be done to achieve this goal as mortality rates vary largely between populations of lower and higher socio-economic status (SES) (Hajizadeh et al., 2014). Those with higher SES typically experience less mortality risk due to, for example, better education and thereby better health knowledge, nutrition or health care seeking behavior, as opposed to lower SES groups (Black et al., 2003; Hossain, 2015; Khatun et al., 2012; Najnin et al., 2011; Schell et al., 2007). Research has also shown that mortality is lower in urban areas where there is usually better access to health and social care as compared to rural areas (Van de Poel et al., 2007). However, urban agglomerations go along with a large number of adverse factors, for example, higher levels of pollution, violence, that affect mostly the urban poor (Rocha et al., 2015).

Over the last 25 years, Bangladesh achieved a great deal of reduction in child mortality with under-five mortality declining from 144 per 1000 live births in 1990 to 41 in 2013 (United Nations Children's Fund (UNICEF), 2014b). Similarly, infant mortality, that is the probability of dying before the age of one, declined from 100 per 1000 live births in 1990 to 33 in 2013 (United Nations Children's Fund (UNICEF), 2014b). Yet, the leading causes of death (except unspecified group) in children under 5 years in 2013 were prematurity, birth asphyxia, acute respiratory infections, neonatal sepsis, congenital anomalies, injuries, diarrhea, measles, malaria, and `HIV/AIDS (WHO, 2015), most of which are preventable.

There is evidence that mortality varies largely by SES and rural-urban place of residence. For example, a study by Raihan Sharif et al. (1993) investigated spatial patterns of crude death rates in 1990 and found regional variation across Bangladesh, with the lowest mortality level in the South-western part of the country, which they attributed to main economic activity groups and higher in-migration rates into the major cities and towns in this area. Ahmed et al. (2011) found that maternal mortality varied significantly by district in Bangladesh with

* Corresponding author at: Humboldt-Universität zu Berlin, Geography Department, Berlin, Germany.
E-mail address: oliver.gruebner@gmail.com (O. Gruebner).

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higher mortality in the eastern, coastal and hill tract regions of the country, which they attributed to economic disadvantage, poor transportation systems, and social conservatism. These findings suggest that also child mortality is likely to vary across sub-national administrative borders. For example, Huda et al. (2016) investigated child mortality in Bangladesh and found that mother's age, education of both parents, mother's autonomy to take decisions, household SES, geographic region, and road conditions were significant exposure factors.

However, very few studies have looked into spatial variations of child mortality (Alam et al., 2010; Hanifi et al., 2010; Sohel et al., 2010) and these were only covering selected parts of the country, with only some notable exceptions in this regard. For example Mercer et al. (2015) introduced space-time smoothing of complex survey data for child mortality in Tanzania and Gruebner et al. (2015b) investigated place of residence and its associations with infant death in Kenya. However, none of them systematically assessed the spatial distribution in child health, that is, whether child mortality risk clustered in space. Furthermore, it is symptomatic that most subnational studies to date are often either based on the non-georeferenced versions of Demographic and Health Surveys (DHS) or on local surveys that are not particularly designed to assess the spatial variation in health indicators or do not cover the entire territory of a country, respectively. We therefore have limited knowledge about subnational regions, where infant and under-five mortality significantly clusters above or below the national average. Such knowledge informs about public health needs in different population groups distributed across subnational regions. Such knowledge may also guide policy-makers and practitioners in allocating scarce resources into those areas and populations within them mostly in need.

Therefore, we combined publicly available data from various sources and set out to test the feasibility of a subnational approach on the spatial distribution of factors that are associated with outcomes of child mortality in Bangladesh. Specifically, our aims were to 1) identify socio-ecological factors associated with infant and under-five mortality at the district level in Bangladesh in 2010 (Zilas, $n = 64$), to 2) investigate spatial clusters in both outcomes, and to 3) detect and map districts that would need attention for public health intervention.

2. Methods

We used cross-sectional secondary data including a broad range of different explanatory variables at the district (Zila) level (n = 64). The district level was used as level of analysis because all data except malaria endemicity were available at this unit. Furthermore, all data were freely available through online PDF reports on the respective websites.

2.1. Variables

2.1.1. Outcomes

Two outcome variables namely infant mortality rate (IMR) and under-five mortality rate (U5MR) by 1000 live births in 2010 were taken from the Bangladesh District Level Socio-demographic and Health Care Utilization Indicators report (National Institute of Population Research and Training (NIPORT), et al., 2011).

2.1.2. Explanatory variables

We based our study on previous work (Gruebner et al., 2015b) and the well cited conceptual framework for cities and population health of Galea et al. (2005) and its extension in the low resource and megacity context (Gruebner et al., 2011). The frame work (and its extension) distinguishes exposure factors into factors from the social (e.g., socio-economic status [SES]) or the physical environments (e.g., housing quality, environmental deprivation) being associated with health at various scales (including individual, neighborhood, and subnational levels). As such, the framework guided the initial variable selection for this study and helped in the interpretation of the findings. In this study, we focused primarily on differential distributions of SES and urbanicity and their associations with child mortality (infant and under-five mortality rates) across the entire country. Furthermore, we used malaria endemicity primarily as a control factor for these associations but interpret its associations with child mortality nevertheless.

The district-level variables *percentage of household with sanitary toilet (flush/pit with slab)* and *percentage of antenatal care (ANC) visit (at least one visit)* were taken from the Bangladesh District Level Socio-demographic and Health Care Utilization Indicators report (National Institute of Population Research and Training (NIPORT), et al., 2011). Households with sanitary toilets have been shown to report better health outcomes as compared to those households that do not have access to sanitary installations and using open and uncovered latrines increases the likelihood of infectious disease transmission, amongst others (Galea et al., 2005; Gruebner et al., 2011). Hence, a larger proportion of households having access to sanitary toilets at the community level will indicate less child death due to for example infectious diseases. Likewise, districts that report higher percentages of health care resources such as antenatal care are expected to report less child death as health information and health care coverage may increase precautionary measures and the likelihood of child survival even in high poverty areas such as in slums (Galea et al., 2005; Gruebner et al., 2011).

The *percentage of households with permanent insolvency in 2010* was taken from the Report on Sample Vital Registration System 2010 (Bangladesh Bureau of Statistics (BBS), 2011). The socio-economic status of a household largely defines the frame of action in which households can respond when a mother or child gets ill (Galea et al., 2005; Gruebner et al., 2011). As such, higher proportions of insolvent households in an area inform about potential risk of higher child death rates.

The variables *percentage of school attendance at secondary level (11–15 years, both boys and girls), percentage of female headed households (both rural and urban),* and *percentage of population living in urban areas in 2011* were taken from the Child Equity Atlas: Pockets of Social Deprivation in Bangladesh (Bangladesh Bureau of Statistics (BBS), et al., 2013), a report based on the 2011 Bangladesh Population and Housing Census (Bangladesh Bureau of Statistics, 2012). School attendance rate informs about health education and is a proxy for socio-economic status in the neighborhood, which has been shown associated with child health in other studies (Galea et al., 2005; Gruebner et al., 2011). Women often carry an increased burden of poverty, gender discrimination, and the absence of support as household heads (Buvinić and Gupta, 1997). However female headed households have also been found to reduce child mortality (Doctor, 2011). The proportion of population living in urban areas informs about the degree of urbanicity in a district, which is an important indicator as it suggests better access to health care and other social services. Urbanicity, however can also be viewed as a stress factor as city living can also be associated with social isolation and discrimination as well as with extreme poverty in one's neighborhood (Galea et al., 2005; Gruebner et al., 2011, 2017).

Total fertility rate 2012–2013 was taken from Bangladesh Multiple Indicator Cluster Survey (MICS) that was carried out in 2012–2013 by BBS together with UNICEF Bangladesh as part of the global MICS program (Bangladesh Bureau of Statistics (BBS) UNICEF Bangladesh, 2014). Fertility rate is interlinked with child mortality as, for example, mothers who delay reproduction can improve survival rates (Nettle, 2011).

Finally, we used *malaria endemicity* as a control variable and calculated mean values for each district (Zila) in Bangladesh based on the age-standardized Plasmodium falciparum parasite rate, which describes the estimated proportion of 2–10 year olds in the general population that are infected with P. falciparum at any one time, averaged over the 12 months of 2010 (Gething et al., 2011). This data