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Original Research

Estimating areas of common risk in low birth weight and infant mortality in Namibia: A joint spatial analysis at sub-regional level

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ABSTRACT

There is lots of literature documenting a positive association between low birth weight (LBW) and infant mortality (IM), however, little is known how the risk of LBW and IM are geographically co-distributed. We fitted joint spatial models of LBW and IM, and used data from Namibia, to examine their geographical variability. We used a Bayesian approach to measure and rank areas according to specific and shared risk of LBW and IM. Our findings show some degree of similarities in the spatial pattern of LBW and IM, with high risk in the central and north-eastern parts of the country. Results suggest a need for comprehensive programming of maternal and newborn interventions that reach areas of spatially concentrated risk of LBW and IM. It further presents an opportunity for generating hypotheses for further research aimed at improving child health, especially in higher risk constituencies thus identified.

1. Introduction

Early childhood mortality is a well-studied subject in epidemiology (McCormick, 1985; Wilson, 2001; Yasmin et al., 2001; Kalanda et al., 2009). A huge burden of early childhood mortality is still persistent in the global south, mostly in the sub-Saharan Africa and South-east Asia regions (UNICEF, 2013). The importance of birth weight as a determinant of perinatal, neonatal and postnatal outcomes is also abundant (McCormick, 1985; Wilson, 2001; Yasmin et al., 2001; Kalanda et al., 2009). Poor intra-uterine growth increases the risk of neonatal and infant mortality. Particularly, low birth weight (LBW) children are typically 20 or more times likely to die in the first year of life than heavier children (Wilson, 2001). In the long-term, LBW predisposes individuals to diseases such as cardiovascular diseases, diabetes, obesity, asthma and atopic dermatitis, among others (Steffensen et al., 2000; Wilson, 2001).

The reduction of neonatal and infant mortality is central to achieving Millennium Development Goal number 4 (MDG4), since the infant mortality rate is used as an indicator of socio-economic and general population health status (Black et al., 2003). The LBW is one such target for interventions to improve infant survival (Wilson, 2001; Yasmin et al., 2001; Kalanda et al., 2009). The prevention of LBW is an integral part of public health policy towards ameliorating newborn and maternal health in many countries (UNICEF, 2013). Considering the strong positive association between LBW and early childhood mortality, the study of co-distribution of the two outcomes has generated interest in recent years (Yasmin et al., 2001; Kalanda et al., 2009), generally geared towards informing targeted interventions for accelerated achievement of developmental goals. Therefore, quantifying the spatial effects constitute

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the first step in the process of understanding the underlying mechanism connecting LBW and early childhood mortality at area level.

This study investigates the co-existence of LBW and infant mortality (IM) in Namibia. As a middle-income country, Namibia is grappling with a relatively high incidence of early childhood mortality compared to other countries of similar economic ranking (UNICEF, 2013). In 1990, infant mortality was recorded at 57 deaths per 1000 live births, while in 2006 this was reported at 46 per 1000 live births. For the same period, neonatal mortality was 24 deaths per 1000 live births in 2006, a decrease from 32 deaths per 1000 live births in 1990. Recent estimates from UNICEF show these have stabilized at 30 and 20 deaths per 1000 live births for infant and neonatal mortality, respectively (UNICEF, 2013). Despite this decline, there are still large differences across regions or areas (MoHSS and Macro, 2008). Many factors have been attributed towards these differential rates, including socio-economic differences across regions (NSA, 2012).

This paper analyzed sub-regional distribution of IM in relation to LBW, with the goal of identifying geographical clusters. The identification of geographical clusters of high risk in LBW and IM is critical for policy design. Recently the use of spatial techniques to answer epidemiological questions has received much attention (Lawson, 2001). In part, the availability of geographically indexed data and advances in statistical methods of handling spatial data have generated interest towards evidence-based medicine and emergence of a subfield called spatial epidemiology (Lawson, 2001). The use of spatial models in the study of low birth-weight (Francis et al., 2012; Tu et al., 2012; Tian et al., 2013) and infant mortality (Kazembe et al., 2007; Barufi et al., 2012) is abundant, however, the joint distribution of LBW and IM has not been widely researched (Grady and Enander, 2009).

Borrowing from Held et al. (2005), we developed a Bayesian hierarchical modeling framework for joint spatial analysis of LBW and IM in Namibia. In particular, we fitted a bivariate logit spatial model with LBW specified in one model and IM fitted on the other, with correlated random effects. Our formulation seeks to measure and highlight areas of shared or common risk of LBW and IM, and simultaneously estimate specific spatial patterns of LBW and IM while controlling for covariates. Common risk areas may suggest shared environmental or socio-economic risk factors.

2. Methods

2.1. Source of data

This study used data from the 2006/2007 Namibia Demographic and Health Survey (DHS). The DHS follows a cross-sectional multi-stage survey design. In the Namibian context, a two-stage stratified sampling design was implemented to collect the data and provide direct estimates at national and regional level. At first stage, a total of 500 enumeration areas (EA), out of 3750 EA demarcated in the 2001 Population and Housing Census, were selected stratified by urban–rural status with sampling probability proportional to the population of the EA. At the second stage, a fixed number of households were randomly selected in each EA. All women of age 15–49 years were eligible for interview. Those who agreed to participate were asked questions pertaining to birth history and health mostly for children under the age of five or of those children who were born within three years preceding the survey date. Full details about the survey instruments and implementation can be found in the DHS report (MoHSS and Macro, 2008).

The two primary response outcomes, infant mortality and low birth weight, were measured as follows. Infant mortality, defined as deaths reported to have occurred before the first birthday of life, was based on reported deaths and imputed age at death from the interviewed women. Low birth weight was defined as birth weight of 2500 g or less, if extracted from health cards. Where the card was missing, it was based parental recall, and LBW was classified as smaller than average or very small. About 90.7% of the birth weights were from health cards, while 9.3% were from parental-recall. To reduce recall bias, questions on births and deaths were restricted to all birth histories that occurred in the last three years preceding the survey date. Table 1 gives summaries of the two response outcomes and corresponding sample sizes.

The following bio-demographic and socio-economic variables known to be associated with the response outcomes (Kazembe et al., 2007; Francis et al., 2012; Tu et al., 2012; Tian et al., 2013), were extracted from the DHS database and fitted in the models as covariates. They included socio-economic variables such as place of residence, which was recorded as city, rural or small town; and wealth index categorized into five groups from the lowest to the highest quintile. The wealth index was computed using principal component analysis based on questions asked on available household assets (e.g., radio, TV, car, oxcart, bicycle, refrigerator) and housing characteristics (electricity; type of roof, wall and floor; water source and time to waterpoint). The resulting principal component was categorized into quintiles of lowest, low, medium, high and highest categories. Details of how the wealth index is generated can be found in Rutstein and Kiersten (2004). Maternal factors considered for the analysis included maternal education, which was captured as none, primary school or secondary and higher education levels; maternal age which was classified as <20 years,

Table 1
Constituency (sub-regional) level summaries of the sample size, and prevalence (%) of infant mortality (IM) and low birth weight (LBW) based on 2006/7 Namibian DHS.

Statistic	Sample size (n)	Infant mortality (%)	Low birth weight (%)
Mean	94	2.8	5.5
Median	84	2.4	5.3
1st Quartile	46	1.0	3.0
3rd Quartile	114	4.0	7.0
Maximum	309	15.0	16.3
Minimum	11	0	0
Total (n)	9804	237	539