Spatial and Spatio-temporal Epidemiology 6 (2013) 25–35

Contents lists available at SciVerse ScienceDirect

Spatial and Spatio-temporal Epidemiology

journal homepage: www.elsevier.com/locate/sste

Multivariate bayesian spatial model of preterm birth and cardiovascular disease among georgia women: Evidence for life course social determinants of health

Michael R. Kramer *, Rebecca Williamson

Department of Epidemiology, Rollins School of Public Health, Emory University, 1518 Clifton Road NE, Atlanta, GA 30322, United States

ARTICLE INFO

Article history:
Received 26 June 2012
Revised 20 May 2013
Accepted 27 May 2013
Available online 31 May 2013

Keywords:
Preterm birth
Cardiovascular disease
Bayesian spatial model
Social determinants of health
Health disparities

ABSTRACT

Background: There is epidemiologic evidence that women who experience preterm birth (PTB) are at elevated risk for cardiovascular disease (CVD) later in life. Each outcome independently has noted spatial and socioeconomic gradients; we test for spatial structure in the population correlation of the two.

Methods: Exploratory spatial data analysis and multivariate Bayesian spatial models were fit to describe the spatial correlation of PTB with CVD among women in Georgia counties from 2002 to 2006.

Results: Global Moran's I and local-indicators of spatial association statistics suggest significant co-occurrence of CVD and PTB. Bayesian posterior estimates for multivariate correlation of these outcomes range from $r = 0.11–0.34$ for CVD and PTB. Significant spatial correlation persists with control for county covariates among whites but not blacks.

Conclusion: Modest evidence for spatial structure of the ecologic correlation of PTB and women's CVD is consistent with a lifecourse perspective on socially clustered determinants of health.

1. Introduction

Cardiovascular disease (CVD) is the leading cause of death among women (Centers for Disease Control and Prevention, 2011a,b) and preterm birth (PTB) is the leading cause of infant mortality, and morbidities including cerebral palsy, intellectual disability, and poor school performance (Yeargin-Allsopp et al., 2008; Aarnoudse-Moens et al., 2009; Behrman and Butler, 2007; Williams et al., in press). These two leading health indicators have been highlighted for intensified public health action in statements of national priorities such as the Healthy People 2020 (U.S. Department of Health and Human Services, 2011). While PTB and CVD are seemingly independent of one another—affecting different body systems at different stages of women's life course—there is early epidemiologic evidence that women who experience a pregnancy ending in preterm birth are themselves at 2–4 times the risk of subsequent incident CVD and CVD-related mortality (Catov et al., 2010; Irgens et al., 2001; Lykke et al., 2010; Smith et al., 2001). At the individual level the linkage may not be as surprising as at first it appears: inflammation, hypertension, and vasculopathy have been hypothesized to play an important role in PTB, and are well established as risk factors for CVD (Goldenberg et al., 2008; O'Keefe et al., 2009). The finding of such disease clustering within individual women thus highlights the life course perspective of cumulative and dynamic exposures patterning health

Abbreviations: PTB, preterm birth; VPTB, very preterm birth; CVD, cardiovascular disease; LISA, local indicator of spatial association; DIC, deviance information criteria; MCAR, multivariate conditional autoregressive.

* Corresponding author. Tel.: +1 404 727 9818; fax: +1 404 727 8737.
E-mail addresses: mkram02@emory.edu (M.R. Kramer), rebecca.williamson@choa.org (R. Williamson).

1877-5845/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.sste.2013.05.002

and illness though women's lives (Rich-Edwards et al., 2010; Ben-Shlomo and Kuh, 2002).

While the evidence to date of within-woman correlation of PTB and CVD is growing, it remains unclear how the propensity to experience each is distributed at the population level. There are well-known racial, economic, and geographic disparities in each outcome separately, and thus it is plausible that common social and environmental contextual characteristics may give rise to population-level correlations as well. Exploration of the spatial structure and patterns of chronic and reproductive disease has made an important contribution to understanding the social and environmental determinants of population health patterns. In the case of PTB and CVD, national, regional, and local scale spatial variation in risk have been tied to spatial patterning of racial residential settlement, wealth and income, health services, and the built and food environments (Kramer et al., 2010; Tassone et al., 2009; Casper et al., 2000; Kramer and Hogue, 2009a). In this paper we briefly summarize the epidemiology of preterm birth and cardiovascular disease, and then propose a method for investigating the spatial structure and possible correlation of the two outcomes using county-aggregated data in the state of Georgia. Using exploratory spatial data analysis followed by spatial Bayesian modeling we aim to describe the spatial structure and correlation of aggregate rates of each outcome under varying model specifications.

1.1. Epidemiology of preterm birth

Preterm birth (birth prior to the 37th week of gestation) and very preterm birth (VPTB: birth prior to the 32nd week of gestation) occurred in 12.2% and 2%, respectively, of all live births in 2009 (Martin et al., 2011). There are persistent racial and economic disparities in risk with US Black women experiencing 50% higher risk of PTB and 2.5 times the risk of VPTB as compared with US White women (Martin et al., 2011). Individual-level risk factors for PTB include maternal infection and inflammation, chronic and pregnancy-induced hypertension, socioeconomic status, and maternal stress (Goldenberg et al., 2008). However, these and other identified risk factors only explain a portion of the racial and economic disparities in PTB, raising questions of unmeasured individual and environmental-contextual factors (Kramer and Hogue, 2009b). In particular, geographic variation in overall and race-specific risk for PTB suggests that spatially-varying factors such as residential segregation, access to and quality of healthcare, income inequality, and the built environment could spatially pattern population risk and disparities (Kramer and Hogue, 2008; Kramer et al., 2010; Gray et al., 2008; Lhila, 2009).

1.2. Epidemiology of cardiovascular disease

Cardiovascular disease is a collection of conditions including hypertension, ischemic heart disease, stroke, and atherosclerosis. The mortality rate from CVD among US woman ranks the twelfth highest out of thirty-six developed nations (Lloyd-Jones et al., 2010). Within the US there are both notable geographic and racial variations (Lloyd-Jones et al., 2010). Black women have 40% higher CVD prevalence than White women, although CVD mortality rates are slightly higher in White women as compared to Black women (Heron et al., 2009). Geographically, CVD mortality rates are highest in the Ohio and Mississippi river valleys, and lowest in the Southwest and Plains states (Centers for Disease Control and Prevention, 2011a,b). Small-area and regional variations in CVD disease incidence and mortality have been attributed to neighborhood poverty and deprivation (Chaix, 2009; Christensen et al., 2008; Pedigo et al., 2011), pollution and climate (Franz and Bailey, 2004; Hu and Rao, 2009), health behaviors (Glasser et al., 2008; Popham, 2011), and medical care practices (Fang and Alderman, 2003; Welch et al., 2011). While these factors explain a portion of the geographic variation, residual spatial variation after controlling for these measured characteristics suggests unmeasured place-based effects persist (Howard et al., 2009). We aim to estimate the spatial correlation of CVD and PTB or VPTB among black and white Georgia women.

2. Methods

2.1. Population data

Pregnancy outcome and hospital discharge data were obtained from the Office of Health Indicators for Planning (OHIP) of the Georgia Department of Public Health (Georgia Department of Public Health, 2011). We categorized all singleton live births as very preterm (<32 weeks gestation), preterm (<37 weeks) or term (37+ weeks), and then calculated overall, race-specific (non-Hispanic Black, non-Hispanic White), and age-specific (10–20 years, 21–35 years, 35+ years of age) risk for each PTB or VPTB in each of Georgia's 159 counties for 2002–2006. We also obtained de-duplicated counts for hospital discharges with diagnosis of obstructive and ischemic heart disease (ICD-9 410-414, 429.2) from 2002 to 2006 for women over thirty years of age, by race (non-Hispanic Black, non-Hispanic White), age (30–44 years, 45–64 years, 65+ years of age), and county ($n = 159$). The denominator for hospital discharge rates was the county race- and age-specific female population over age 30 as estimated in the 2005–2009 American Community Survey. The numerator and denominator data for CVD discharge rates was restricted to ages greater than 30 because this represents the greatest burden of CVD, and thus CVD prior to 30 is pathophysiologically atypical. To approximate local poverty and racial composition we also calculated the proportion of county households with income below the federal poverty line, and proportion of total population self-identifying as Black or African American.

2.2. Exploratory spatial data analysis (ESDA)

All exploratory spatial analysis was conducted in GeoDa® using a binary contiguity spatial weights matrix with the neighborhood defined as all counties sharing a boundary with the index county (e.g. 'queen contiguity') (Anselin et al., 2006). Univariate global spatial autocorrelation of each crude disease rate was assessed with the global