The United States is experiencing a crisis in women's mortality. Women's mortality increased in over 40 percent of U.S. counties between 1992 and 2006 [1]. Moreover, the county-level mortality trends exhibit a strong geographic pattern. The trends have been most disconcerting in the Deep South, Appalachia, along the Mississippi river, and parts of the Midwest and Texas, and most favorable in the Northeast and West coast [2]. The reasons for the geographic pattern in women's mortality trends are poorly understood. It is unclear whether the pattern reflects structural characteristics of the geographic areas, such as state tax policies, or individual-level characteristics of their populations, such as educational attainment.

In this study, we investigate state-level variation in women's mortality trends. We assess the extent to which the states' economic, sociopolitical, infrastructural, and tobacco characteristics explain the variation, net of individual-level characteristics such as women's educational attainment. We hypothesize that women's mortality trends were most disconcerting in states with poor economic performance, regressive social policies, physical infrastructure that burdens the economically disadvantaged (e.g., limited public transportation), and high tobacco consumption, net of individual characteristics. The results will highlight strategies from the best performing states that may be implemented in underperforming states to improve women's mortality.

Background

Since the mid-1980s, mortality has increased or stalled among a large fraction of U.S. women. Not only has women's mortality increased in over 40 percent of U.S. counties in recent decades [1], it has also increased among women who did not graduate high school, stalled among high school graduates, and declined among the college-educated [3]

Two approaches have been employed to understand the troubling mortality trends among U.S. women; however, the trends remain poorly understood. The *ecological approach* has focused on county-level mortality trends [1, 2, 4-7]. This approach is largely descriptive and has failed to distinguish whether the trends' spatial pattern reflects differences in geographic context or population composition. Moreover, state-level characteristics have been neglected. States

determine the bulk of policies and environmental factors that affect mortality [8-10]. For example, half of the variation in life expectancy between counties can be explained simply by the state they belong to [11]. The *socioeconomic approach* has examined mortality trends by educational attainment at the national level [3, 12-25]. This approach has failed to fully explain the trends partly because it neglects to account for geographic variation in the opportunities women have to translate education into lower mortality. For instance, while the rising importance of education for women's economic well-being and smoking behavior are key reasons for the diverging mortality across education levels, these factors explain just 33 percent of the divergence at the national level [16].

In this study, we merge the ecological and socioeconomic approaches for understanding women's mortality trends into a more comprehensive, multilevel approach that distinguishes the contribution of state-level and individual-level characteristics. We assess four types of state-level characteristics that we expect to be important based on prior research [16, 26]: economic, sociopolitical, infrastructural, and tobacco. We focus on educational attainment as the main individual-level characteristics, but also incorporate several economic pathways through which education can shape mortality, such as employment and income.

Data, Measures, and Method

Data. The analyses are based on data from the National Longitudinal Mortality Study (NLMS), one of the largest and most comprehensive datasets available for examining demographic and socioeconomic differentials in U.S. mortality [27]. The NLMS was created by linking respondents in multiple waves of the Current Population Survey (CPS) and a subset of the 1980 Census to death certificate information provided by the National Center for Health Statistics. The NLMS currently contains CPS surveys from 1973 to 1998 with mortality follow-up through 2002 (soon to be extended through 2008).

Our analytic sample includes U.S.-born women aged 35-84 years during mortality follow-up. We create a person-year file starting with each woman's interview year and ending with her

year of death or end of the follow-up if she survived. Age and year are incremented with each person-year record, where year reflects the calendar year of exposure to the risk of death.

Mortality. The NLMS data contain the date and cause of death among decedents. For this study, we focus on all-cause mortality.

State Characteristics. *State of residence* includes the 50 U.S. states. We include 20 state-level variables that capture the four characteristics of interest: economic, sociopolitical, infrastructural, tobacco. The variables are listed in Table 1 in the appendix. We also include several demographic controls for the composition of the female population in each state, such as educational attainment. Because we are interested in explaining mortality variation among states in the early 1980s, as well as subsequent mortality trends, we measure each variable in the early 1980s and early 2000s; the exact years depend on data availability. We then condense the information in the 20 variables into latent factors using Confirmatory Factor Analysis.

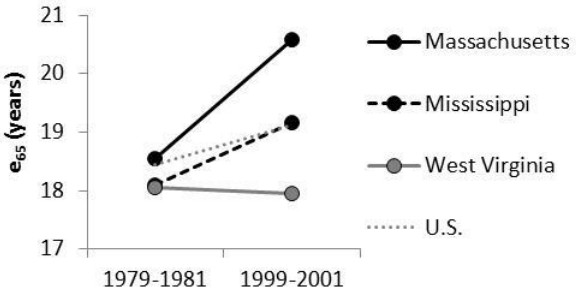
Individual Characteristics. The primary characteristic of interest is *educational attainment*, categorized as 0-11 years, a high school credential or some college, or a bachelor's degree and higher [15, 16]. We also include three economic mediators of the education-mortality association. *Employment* is categorized as employed or not employed. *Family income* is the standard CPS measure of money income specified as deciles within each survey year. *Legal marital status* is defined as currently married, previously married, or never married. In all analyses, we adjust for *age* and *race/ethnicity (*non-Hispanic white, non-Hispanic black, other).

Method. We estimate a series of multilevel event history models using MLwiN [28]. The models allow us to capture both the initial degree of state variation in mortality as well as trends in that variation over time. Specifically, the models estimate state variation in women's mortality rates around the national rate in the early 1980s, and state variation in women's mortality trends around the national trend after that time. To illustrate, Figure 1 shows that female life expectancy at 65 varied by state in 1980, and more so in 2000, and state variation in the trends was sub-

stantial. The multilevel models then allow us to partition the variation in mortality levels and trends that are due to state-level versus individual-level characteristics.

In our multi-level models, level-1 contains the individual characteristics: age, race/ethnicity, and year. Year is specified as a random effect to allow mortality trends to differ across states. Level-2 is state of residence. The basic model form is below. In the model, β_{0j} allows the ln(odds) of death to vary across states by estimating an *intercept* for each state; β_{1j} allows *trends* in the ln(odds) of death to vary across states [31-33].

Fig 1. Female life expectancy at 65 in three U.S. states



$$\text{Level 1: } \ln(p_{ij}/(1-p_{ij}) = \beta_{0j} + \beta_{1j}(year_{ij}) + \beta_2(age_{ij}) + \beta_3(white_{ij}) + \beta_4(black_{ij})$$

$$\text{Level 2: } \beta_{0j} = \gamma_{00} + \gamma_{01}(state_j) + \mu_{0j}$$

$$\text{Level 2: } \beta_{1j} = \gamma_{10} + \gamma_{11}(state_j) + \mu_{1j}$$

We then determine how much of the variation in women's mortality rates (i.e., model intercepts) and mortality trends (i.e., model slopes) is explained by the states' characteristics, net of women's characteristics. We do this by estimating three additional models that progressively include the following variables.

1. Women's educational attainment added to level-1.
2. Women's employment, family income, and marital status added to level-1.
3. The state-level latent factors (see Table 1 in appendix) added to level-2.

Results

Our preliminary results (not included) strongly suggest that certain state-level characteristics have played an important role in the geographically-patterned trends in U.S. women's mortality since the early 1980s.

Appendix

Table 1. Characteristics of U.S. states

Economic

1. Gross state product per capita
2. Unemployment rate
3. Percent of females in the labor force
4. Percent of jobs in creative, working, and service classes
5. Household income inequality

Sociopolitical

1. Public welfare expenditures per capita
2. Expenditures on elementary and secondary education per capita
3. Political ideology of government (0-100 conservative-liberal scale)
4. Progressive taxes (% of federal EITC[a] offered by state EITC)
5. Regressive taxes (% of tax revenue from sales tax)
6. Medicaid (comprehensive program score)

Infrastructural

1. Urbanization (% population in standard metropolitan statistical area)
2. Affordable housing (median rent as % of income)
3. Public transportation (% of workers taking public transportation)

Tobacco

1. Production (tobacco manufacturing as % of gross state product)
2. Control (state tax as % of retail price of cigarettes)
3. Consumption (cigarette pack sales per capita)

Composition

1. Education (% of adults 25 and older without a high school credential)
2. Race/ethnicity (% non-Hispanic white)
3. Immigration (% immigrants)

[a] EITC = Earned Income Tax Credit

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