INTRODUCTION

Our investigation addresses the fundamental issue of “place versus people” as the cause for observed characteristics. Specifically, when unusual mortality or morbidity rates are observed for a geographic area (county, city, or state), it is unclear whether the cause is associated with the characteristics of the people who live there, or physical and environmental characteristics of the place, or some combination of or interaction between the two elements. These relationships must be better understood in order to direct further research into the determinants of health status/outcomes as well as target interventions and preventative efforts – since everyone must inhabit a place and it is in that place that interventions must occur. Though there frequently exists fairly detailed data about the stock (births and deaths) in a given geography, there is typically no measurement of how those demographic processes, in conjunction with flow (migration), effect the composition of the population in that place, how the composition changes over time, and how, ultimately, that population mixing effects observed health status (e.g., chronic disease prevalence) or health outcomes (e.g., mortality). We propose to quantify the effects of population mixing on a place’s health status and complete the argument for the inclusion of migration into demographic standardization techniques.

This research addresses a fundamental issue in demography: the effect that stock versus flow has on place-based measures. We begin by examining two states of population movement —in-migration and out-migration—as they relate to county-level mortality rates. A careful analysis of these population movements in conjunction with mortality rates will allow us to assess the role of “place” in health determinants controlling for population mixing. Thus, this research addresses the validity of current calculations of county-level mortality incidence, which do not take migration into account.

We measure the role and effect that an important demographic process (migration) has on heath status and health outcomes. Most health metrics are measured in a place. The geographic place (county, city or state) is treated as the container for the population under study. But individuals cross geographic boundaries—both temporarily and permanently. When they move (either in or out) they bring/take with them their genetic make-up, in-vitro experiences and any influences from the physical or social environment. This population mixing changes the composition of the resident population continuously. Different compositional changes can affect health metrics. We propose to quantify the effects and the magnitudes of change that migration can have on health measures. This is a departure from previous research which has focused on assessment and policy implications. This is a return to basic demographic research – delineating the causes and consequences of underlying population processes.

PREVIOUS RESEARCH

Previous research indicates that mortality rates have clustered over time in small-areas of geography (Cossman et al. 2007) and that these clusters are associated with an increasing rural mortality penalty in the U.S. (Cosby et al. 2008). We also know from previous research that migration in recent years tends toward urban growth and rural decline (Schachter et al. 2003). What has not been thoroughly explored in the United States is how high and low rates of migration influence small-area estimates of mortality and other health measures. There is self-selection in migration; that is, healthy people are more likely to move from unhealthy places while unhealthy people remain in unhealthy places (Brimblecombe et al. 2000). More recently, illness-related migration has been noted, where unhealthy people move toward health care

(McHugh and Mings, 1994), as has poverty-related migration (Nord, 1998). This research will explore the relationships between county-level migration rates and county-level mortality rates, documenting empirical evidence that migration estimates are a critical component of small-area mortality estimates and laying the foundation for a reliable migration measure.

Population mixing can have dramatic health effects, as seen with the Spanish introduction of smallpox to New World inhabitants (Mann, 2006). Health effects can also be subtle, especially given the long latency of some diseases (e.g., cancers). Assessment of the population stability is necessary to correctly determine the "at-risk" population for the incidence or prevalence of morbidity/mortality within a population.

Health investigators frequently need to quantify the stability of the at-risk population and this "at-risk" population must be spatially stable over time to properly calculate incidence or risk rates (Gatrell, 2001; Stimson, 1983; Polissar, 1980). Alternatively, researchers may consider the level of population movement or migration, also known as population mixing (Boyle, 2002, Brimblecombe et al. 2000). Either approach will indicate the true dimensions of the "at-risk" population. Regardless, changes in population size are associated with mortality (Davey Smith et al. 1998); however, they are rarely taken into consideration in mortality and morbidity analyses.

As early as Ravenstein (1885, 1889), it has been recognized that voluntary migrants tend to be healthier than non-migrants, an indicator of self-selection. More recently, Brimblecombe et al. (2000) has found that when the health of migrants is taken into account, healthy migrants tend to move from unhealthy places, while unhealthy residents tend to remain in unhealthy places. Depending on the direction of migration, two effects are possible.

First, county in-migrants, who are assumed to be healthier than non-movers, could boost the overall health of the place to which they migrate. Migrants tend to be younger, which is also a potential proxy for better health, both of the individual and potentially the receiving population. Also, internal migrants in the U.S. who cross county or state lines are more likely to be migrating for job-related reasons (Schachter, 2001; Sharma, 1995; Borjas et al., 1992; Williams and Jobes, 1990; Murdock, 1984). Such job-related migration will tend to be skewed toward higher education, skill and pay-grade jobs, which are also highly correlated with better health (Borjas et al. 1992).

If the flow of migration is outward, comparable outcomes are possible. Assuming those who migrate out are healthier than those who remain, migration could lead to an aggregate measure of general health reflective of the remaining population in that county – that is, higher rates of disease and death. This would be apparent if persistent out-migration had occurred in past waves, resulting in present day stable populations (e.g., little present in- or out-migration). Thus population stability in a place may be associated with higher mortality rates, a conclusion Brimblecombe et al. (1999, 2000) reached as a primary reason for health inequalities among districts in Britain. That is, healthy people tended to migrate away from unhealthy places, while unhealthy individuals remained in unhealthy places. The relationship between migration, population mixing and relative deprivation has been confirmed by Boyle and his colleagues (Boyle et al. 2001, 2004; Norman et al. 2005). While these relationships have been closely studied and documented in England and Scotland, no studies of the relationships between migration and mortality, focusing on migration's effect on small-area mortality rate calculation, have been completed in the United States to date.

This research is novel because we will quantify the importance and role that changes in the composition of the resident population, through migration, has on health measures in small-areas, making the argument for the addition of a new dimension — migration — to the customary demographic standardization of population processes (age, sex and race). Whereas a great deal of effort has been spent on the more easily quantified population events – birth, aging, death – geographers, demographers and others researchers have not had the tools or standards to assess the role that migration plays in place-based measures. The immediate objective is to statistically quantify the effect that migration can have on small-area health measures and provide confirmation that migration is a significant factor that must be included in demographic standardizations. The longer term objective is to develop a direct or proxy measure of migration that can be used to standardize small-area populations. Results of this research will affect both ends of the spectrum of small-area health investigation – academically speaking, it will address the fundamental question of place versus people (and the related question of ecological fallacy, see Houghton and Kelleher, 2003) and, practically speaking, it will help target, geographically, the delivery of medical interventions.

METHODOLOGY

Data – The unit of observation is the county. As births and deaths are reported at the county level in the U.S., using counties allows for the standardization and thus comparison between counties, which is fundamental to the hypothesis that small area migration affects health outcomes such as mortality. The outcome variable *mortality* is drawn from National Vital Statistics Service all-causes death rates per hundred thousand between 1998 and 2002, standardized by age using the US 2000 standard million and mean-centered on the year 2000. The key predictor variable *migration* is composed of county-level net migration rates per hundred persons during the 2000s, with rates calculated by Winkler and colleagues (2013) using the residual method.

Control variables are also included in this study. The variable *high school diploma* is the proportion of the population aged at least 25 years with at least a high-school diploma (or GED) as a percent of the entire population aged at least 25 years. The variable *non-white* is the percent of the population with a self-reported race other than white alone. The variable *property value* is the median value of owner-occupied housing units in a county, expressed in thousands of dollars. The variable *rurality* is the percent of the population living in census-designated rural places. The variable *poverty* is the proportion of the population with incomes below the poverty line in 1999, expressed as a percent of all persons in the county for whom poverty status is determined. The variable *unemployment* is the percent of the population aged at least 16 years that was unemployed in 1999. Finally, the variable *intercept* is simply the *mortality* constant that was estimated for each model.

Method – There are three statistical methods used in this study: ordinary-least-squares (OLS) multivariate regression; spatial lag regression, and; spatial error regression. For the spatial lag and spatial error models, the queen-1 contiguity will be used to generate the spatial weights matrix. The regression coefficients are unstandardized, so they can be interpreted in terms of number-person-change in age-standardized mortality rate (ASMR) per unit-increase in the corresponding independent variable, controlling for the other included predictor variables. The model fit parameter *Adjusted* R^2 will also be included in Table 2 for OLS regression. Counties will be compared all together (Tables 2 and 3,) then separately based on census region (Table 4, i.e., South, Northeast, Midwest, and West,) then sign of net-migration (Table 5, i.e., net in-migration vs net out-migration as either positive or negative,) and then by separately based on sign of net migration and census region (Table 6.) The analysis is subset by census region in order to test the persistent mortality clusters hypothesis (Cossman *et al*. 2007).

Hypotheses – In the present study, five hypotheses are tested, specifically that mortality at the county level is (1) negatively associated with migration among counties with net in-migration, (2) positively associated with migration among counties with net out-migration, and (3) differentially associated with migration and based on the census region of residence, controlling for socioeconomic status. Finally, the claims that (4) healthy people are attracted to healthy places and (5) unhealthy people remain in unhealthy places will also be evaluated.

RESULTS

Descriptives – Table 1 lists descriptive statistics for the variables used, as well as the Moran's I statistic for spatial autocorrelation. The descriptive statistics in Table 1 show that, though most of the variables included in the present study are fairly normally distributed, there is also a significant level of spatial autocorrelation. Thus, it is safe to assume that the underlying assumptions of OLS regression are not prohibitively violated by this data set, when including spatial dependence.

All counties: classic OLS – Table 2 presents the regression coefficients of four models testing the relationship between county-level ASMR and: each included independent variable at the bivariate level (Model 1); net migration controlling for select social and economic characteristics (Models 2 and 3) and; all included variables (Model 4). Model 1 demonstrates several zero-order statistically significant relationships between most of the included variables and mortality, with the exceptions of migration and rurality. Additionally, each of the statistically significant independent predictors covary with mortality in manners commensurate with other research on mortality correlates. In other words, the positive relationships in Model 1 between mortality and each of poverty, non-white, and unemployment support current research on correlates of mortality, as do the negative relationships between mortality and each of property value, Hispanic, and high school diploma.

When controlling for select social and demographic characteristics (Models 2 and 3,) migration becomes a significant predictor of mortality, suggesting an omitted variable bias. This omitted variable bias means that when examining the effects of migration on mortality, it is necessary to include local population characteristics, and vice versa. Thus, when assessing correlates of mortality among all US counties, the act of not including migration will significantly bias any statistical estimates.

All counties: spatial regression – Table 3 presents the regression coefficients of ten models predicting ASMR with the aforementioned variables, with the first five models being estimated using spatial lag regression and the last five being estimated using spatial error regression. Generally speaking, at the bivariate level there is a negative relationship between migration and mortality, but this relationship is significant only when using the spatial error model. When controlling for the other included independent variables, the sign of the migration coefficient changes from negative to positive, suggesting that the control variables moderate the relationship between migration and mortality. However, this suggestion is not equally supported among all regions or equally among counties by sign of net migration.

Counties by census region – Table 4 presents the regression coefficients of sixteen models predicting ASMR with the aforementioned variables by census region, with the first eight models being estimated using spatial lag regression and the last eight being estimated using spatial error regression. The odd-numbered models regress mortality against only migration and mortality's spatial weight matrix, in order to simulate a bivariate relationship using a spatial regression method. The even-numbered models are full models that include all aforementioned control variables. Parsing the counties by census region permit exploration of regional variations and also to test hypothesis 3. Generally speaking, there are substantial differences between the various census regions. Models 1, 2, 9, and 10 show that in the South there is a negative relationship between migration and mortality that is mediated by the control variables. The eight models for the Northeast and Midwest show that there is a positive relationship between migration and mortality when controlling for omitted variable biases. Finally, the four models for the West show no significant relationship between migration and mortality. A key difference with the West counties is that up until this point in the study, all spatial models are better than their non-spatial peers (as evidenced by the LR tests being significant) except for the full models for the West counties. This regional variation in mortality correlates is substantial evidence in support of hypothesis 3.

All counties: sign of net migration – Table 5 presents the regression coefficients of twelve models predicting ASMR with the aforementioned variables by sign of net migration, with the first six models being estimated using spatial lag regression and the last six models being estimated using spatial error regression. Models 1, 4, 7, and 10 regress mortality against only migration and mortality's spatial weight matrix, so that a bivariate relationship may be simulated within a spatial regression method. Models 1 and 7 show a negative relationship between migration and mortality among counties with net in-migration, demonstrating support for hypothesis 1.

However, this evidence should be taken with caution, as models 3 and 9 suggest moderation of the relationship between mortality and migration, as the sign of the migration coefficient changes when controlling for the other included variables. This is in contrast to Model 10, which shows a positive bivariate relationship between mortality and migration among counties with net out-migration, undermining support for hypothesis 2. In other words, as net out-migration decreases, mortality increases. This relationship holds even when controlling for local population characteristics in Model 12.

Table 5 also suggests circumstantial support for hypotheses 4 and 5. This is evidenced by the lower intercept in Model 1 relative to the intercept of Model 4. In other words, it could be argued that, because the constant for counties with net in-migration is lower than that for counties with net out-migration, places with lower mortality rates tend to attract migrants (supporting hypothesis 4) while places with relatively higher mortality rates tend to repel migrants (supporting hypothesis 5). Again, this is circumstantial, as there could be any number of intermediary variables confounding these relationships, as the full models (Models 3, 6, 9, and 12) suggest.

Counties by census region and sign of net migration – Table 6 presents the regression coefficients of thirty-two models predicting ASMR with the aforementioned variables by census region and sign of net migration, with the first 16 models being estimated using spatial lag regression and the last sixteen being estimated using spatial error regression. Models 1, 9, 17, and 25 demonstrate a negative relationship between migration and mortality among counties in the South with net in-migration, mediated by the included control variables; this is evidence in support of hypothesis 1. Models 3, 11, 19, and 27 demonstrate the same trend among counties in the Midwest with net in-migration; again, this is evidence for hypothesis 1. Models 2, 10, 18 and 26 show a positive relationship in Northeast counties between migration and mortality among counties with net in-migration, net of control variables; this is evidence against hypothesis 1. However, given that Northeast counties with net in-migration are outnumbered by counties in the South and Midwest nearly ten to one, these conflicted findings are not likely to be generalizable to the rest of the United States. Models 4, 12, 20, and 28 show no significant relationship between migration and mortality among counties with net in-migration in the West.

Among counties with net out-migration, the findings are more varied. In regions where migration is statistically significant with mortality, the relationship tends to be negative, in that decreasing net out-migration is positively associated with mortality, even when controlling for local population characteristics. However, one consistent trend in support of hypothesis 4 is that among most regions, counties with net in-migration tend to have lower initial levels of mortality than counties with net out-migration.

DISCUSSION

The present study has illustrated several important insights about the relationship between migration and mortality. First, migration indeed plays a non-trivial role in stratification of mortality rates among US counties. Second, net migration is negatively associated with mortality, at least at the bivariate level among counties with net in-migration. When controlling for socioeconomic and regional variations, however, this relationship is situational. Third, socioeconomic status can moderate – and even mediate in some cases – the relationship between migration and mortality, presumably through migrant populations mixing with indigenous ones. Fourth, net out-migration is differentially associated with mortality, controlling for socioeconomic status, offering circumstantial evidence that those with the social capital might be inclined to leave unhealthy/undesirable places do indeed leave, taking their social capital to more desirable places, augmenting the mortality rate of counties in favor of counties with net in-migration. Fifth, the findings are also consistent with the literature on socioeconomic and sociodemographic determinants of mortality at both the national and community levels, if the county is used as a proxy for community.

Additionally, the findings of the present study support findings by Johnson and colleagues (2005) on distinct net migration “signature patterns” that seem to generate a typology of counties that vary based on socioeconomic status and demographic profile, and are grouped by what census region they are in as well as their sign of net migration. In general, counties with net in-migration tend to receive a mortality benefit, while counties with net out-migration tend to receive an inconsistent mortality penalty, though both of these relationships are heavily moderated by socioeconomic status and census region. These relationships presumably are affected by in-migrants, as in-migrants do tend to give counties a statistically significant mortality reduction in most counties, independent of net migration.

Curiously, counties with net out-migration tend to have higher initial levels of mortality than counties with net in-migration, even when controlling for socioeconomic status. This suggests not that initial claims of the present study are wrong, but conversely that the counties experiencing higher mortality associated with higher net out-migration are so penalized because their healthy members are leaving, which reinforces the claims of the present study. Another interpretation might argue that the penalty among counties with net out-migration could be the result of the unique socioeconomic profile of counties with net out-migration.

For future direction of research, the present study can be replicated at the individual level, pairing American Community Survey data by Metropolitan Statistical Areas or even Public-Use Microdata Area as the fixed geographic unit, as this would further test the assertion that counties develop a mortality differential based on their migrant population. Another benefit of the individual-level approach is that that migration streams could be better observed, though at the expense of spatial explanatory power. However, given that most PUMAs intersect with county lines, it should not be too big a compromise.

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Table 1. Descriptive and Moran's-I statistics (n=3,109)

variable	mean	SD	Skewness	Kurtosis	Moran's I
Mortality	900.5	155.5	-1.4	10.7	0.445
Migration	1.5	9.4	-0.1	5.6	0.419
Rurality	59.3	31.3	-0.2	-1.1	0.316
Hispanic	6.1	12.0	3.9	17.7	0.826
Non-white	14.1	16.0	1.7	2.7	0.674
Property value	78.5	42.9	3.1	20.3	0.674
Unemployment	3.3	1.4	1.1	5.7	0.423
Poverty	14.2	6.5	1.3	2.9	0.609
High school diploma	77.3	8.7	-0.6	0.1	0.657

Table 2. Classic OLS regression of mortality among US counties, 1998-2002

variable	Model 1	Model 2	Model 3	Model 4
Migration	.05 (p=.876)	2.86	1.90	2.07
Rurality	-.04 (p=.667)	-.63		-1.00
Property value	-1.03	-.70		-.50
Poverty	10.34	10.16		-.55 (p=.343)
Hispanic	-1.64		-4.18	-4.63
Non-white	3.86		2.05	1.57
Unemployment	35.16		19.37	22.52
High school diploma	-9.17		-8.57	-9.05
Intercept	---	845.07	1493.00	1635.20
Adjusted R2	---	0.242	0.430	0.468
AIC	---	39,348	38,461	38,247
Log likelihood	---	-19,669	-19,224	-19,115

NOTES:

---Unless otherwise indicated, all coefficients are significant at the $p<.05$ level.

---All Model 1 coefficients are for bivariate regression against mortality.

---Highlighted coefficients are not significantly correlated with migration; mediation/moderation/OVB does not apply.

Table 3. Spatial regression of mortality among US counties, 1998-2002

Spatial lag regression					
variable	Model 1	Model 2	Model 3	Model 4	Model 5
Migration	-.37 (p=.114)	1.48	1.24		1.48
Rurality		-.59		-.87	-.85
Property value		-.48		-.38	-.47
Poverty		6.51		-1.13	-.59 (p=.286)
Hispanic			-2.88	-3.33	-3.35
Non-white			1.58	1.14	1.23
Unemployment			17.64	20.72	20.80
High school diploma			-6.04	-6.75	-6.59
Intercept	310.41	393.31	988.74	1149.21	1151.20
rho	.656	.539	.348	.340	.318
AIC	39,090	38,617	38,208	38,072	38,031
LR test vs. classic OLS	1,118	733	255	253	218

Spatial error regression					
variable	Model 6	Model 7	Model 8	Model 9	Model 10
Migration	-.78	1.64	1.24		1.96
Rurality		-.56		-.89	-.87
Property value		-.68		-.38	-.49
Poverty		9.46		-.69 (p=.278)	-1.33 (p=.833)
Hispanic			-2.88	-4.29	-4.23
Non-white			1.58	1.69	1.85
Unemployment			17.64	21.94	21.72
High school diploma			-6.04	-8.23	-8.09
Intercept	901.88	850.74	988.74	1559.64	1543.31
lambda	.657	.597	.348	.402	.388
AIC	39,084	38,543	38,208	38,071	38,015
LR test vs. classic OLS	1123	805	255	252	232

NOTES:

---Unless otherwise indicated, all coefficients are significant at at least the p<.05 level.

---LR tests are conducted with one degree of freedom, the lambda coefficient.

---Highlighted coefficients are not significantly correlated with migration; mediation/moderation/OVB does not apply.

Table 4. Spatial regression of mortality among US counties by Census region, 1998-2002

Spatial lag regression

	South (n=1,355)		Northeast (n=217)		Midwest (n=1,055)		West (n=413)	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Migration	-1.75	.48 (p=.110)	.46 (p=.531)	1.82	.98 (p=.067)	3.20	.58 (p=.523)	0.98 (p=.257)
Rurality		-1.05		0.08 (p=.612)		-0.46		-1.31
Property value		-0.86		-0.15 (p=.056)		-0.76		-0.93
Poverty		.37 (p=.640)		2.55 (p=.063)		-5.00		-4.55
Hispanic		-4.05		-3.11		-2.79		-1.75
Non-white		0.55		1.30 (p=.057)		4.61		1.95
Unemployment		7.63		12.53		28.26		25.02
High school diploma		-5.76		-3.14		-7.05		-2.30 (p=.219)
Intercept	438.59	1275.33	404.97	789.25	342.24	1097.03	637.88	1098.15
rho	0.557	0.228	0.524	0.310	0.596	0.435	0.207	.044 (p=.538)
AIC	16,609	16,224	2,382	2,295	13,239	12,786	5,418	5,319
LR test vs. classic OLS	312	40	42	15	265	154	8	0.37 (p=.544)

Spatial error regression

	South		Northeast		Midwest		West	
	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16
Migration	-2.11	0.58 (p=.071)	.38 (p=637)	1.37	0.52 (p=.413)	3.73	0.54 (p=.596)	1.06 (p=.226)
Rurality		-1.20		0.08 (p=.605)		-0.47		-1.29
Property value		-0.97		-0.18		-0.81		-0.94
Poverty		1.16 (p=.179)		4.03		-5.26		-4.75
Hispanic		-4.75		-2.53		-5.31		-1.77
Non-white		0.58		0.34 (p=.625)		4.96		2.04
Unemployment		7.67		11.98		31.67		25.94
High school diploma		-6.47		-3.59		-8.57		-2.39 (p=.209)
Intercept	984.25	1556.52	852.42	1085.09	843.56	1590.05	805.04	1139.33
lambda	0.564	0.292	0.525	0.457	0.601	0.528	0.206	.083 (p=.289)
AIC	16,609	16,212	2,381	2,287	13,239	12,767	5,417	5,317
LR test vs. classic OLS	311	49	42	22	262	171	7	1.02 (p=.314)

NOTES:

---Unless otherwise indicated, all coefficients are significant at at least the p<.05 level.

---LR tests are conducted with one degree of freedom, the lambda coefficient.

---Highlighted coefficients are not significantly correlated with migration; mediation/moderation/OVB does not apply.

Table 5. Spatial regression of mortality among US counties by sign of net migration

Spatial lag regression

	Net in-migration (n=1,691)			Net out-migration (n=1,346)		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Migration	-1.48		0.78	1.23 (p=.089)		3.69
Rurality		-0.91	-0.92		-1.16	-1.07
Property value		-0.64	-0.66		-0.38	-0.43
Poverty		-1.69	-1.53		-.87 (p=.373)	.23 (p=.817)
Hispanic		-4.32	-4.40		-4.09	-3.91
Non-white		1.40	1.34		1.22	1.59
Unemployment		10.51	11.06		32.03	28.76
High school diploma		-9.03	-9.07		-7.57	-6.98
Intercept	654.99	1630.24	1630.37	698.64	1427.22	1386.74
rho	0.293	0.093	0.089	0.236	0.068	0.070
AIC	21,036	20,082	20,078	17,665	16,989	16,957
LR test vs. classic OLS	294	42	38	139	16	17

Table 5, continued

Spatial error regression

	Net in-migration			Net out-migration		
	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Migration	-1.99		0.83	1.9		3.78
Rurality		-0.94	-0.96		-1.05	-0.93
Property value		-0.61	-0.62		-0.38	-0.44
Poverty		-1.57	-1.38 (p=.060)		-0.01 (p=.994)	1.06 (p=.313)
Hispanic		-4.49	-4.56		-4.07	-3.89
Non-white		1.43	1.39		1.49	1.87
Unemployment		9.83	10.22		31.75	28.72
High school diploma		-9.57	-9.63		-6.66	-6.11
Intercept	911.88	1753.58	1751.99	906.36	1392.47	1355.49
lambda	0.581	0.283	0.278	0.518	0.265	0.269
AIC	20,733	20,022	20,018	17,440	16,937	16,904
LR test vs. classic OLS	594	100	96	362	66	69

NOTES:

---Unless otherwise indicated, all coefficients are significant at at least the p<.05 level.

---LR tests are conducted with one degree of freedom, the lambda coefficient.

---Highlighted coefficients are not significantly correlated with migration; mediation/moderation/OVB does not apply.

Table 6. Spatial regression of mortality among US counties by sign of net migration by Census region

Spatial lag regression

	Net in-migration				Net out-migration			
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
	South (N=876)	Northeast (N=120)	Midwest (N=405)	West (N=290)	South (N=479)	Northeast (N=97)	Midwest (N=648)	West (N=122)
Migration (alone)	-4.00	3.77	-1.95	0.17 (p=.903)	0.57 (p=.475)	-3.98 (p=.151)	5.59	11.29
Intercept	779.14	817.00	747.49	633.91	884.75	821.63	628.65	925.78
rho	.232	.018 (p=.623)	.151	.212	.133	.033 (p=.264)	.286	<.01 (p=.399)
AIC	10,476	1,336	4,901	3,761	6,170	1,080	8,385	1,626
LR test vs. classic OLS	109	0.25 (p=.619)	43	13	28	1.27 (p=.259)	60	0.70 (p=.402)
	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16
Migration	-0.61 (p=.138)	3.45	.65 (p=.383)	1.43 (p=.234)	1.26 (p=.062)	-.09 (p=.967)	8.91	10.75
Rurality	-0.46	0.22 (p=.327)	-1.02	-1.46	-1.96	-0.08 (p=.754)	-.16 (p=.424)	-1.15
Property value	-0.74	-0.25 (p=.183)	.07 (p=.746)	-0.83	-1.52	-.29	-0.56 (p=.073)	-0.91
Poverty	0.24 (p=.791)	1.79 (p=.406)	-1.53 (p=.266)	-4.93	1.71 (p=.255)	4.16	-4.07	1.64 (p=.697)
Hispanic	-3.76	-7.12	-5.40	-4.09	-5.45	-2.69	-1.71 (p=.153)	0.54 (p=.596)
Non-white	1.07	4.48	1.48 (p=.067)	1.51 (p=.278)	0.03 (p=.916)	.71 (p=.379)	5.28	2.24 (p=.132)
Unemployment	8.26	12.46	12.78	18.23	11.49	19.33	32.78	22.98
High school diploma	-5.33	-5.06	-13.08	-8.21	-5.22	.56 (p=.734)	-6.79	8.48
Intercept	1306.39	1206.77	1917.17	1624.67	1534.84	754.28	1247.67	46.25 (p=.437)
rho	.118	<.01 (p=.995)	.064	.064 (p=.250)	.015 (p=.499)	<.01 (p=.287)	.193	<.01 (p=.233)
AIC	10,161	1,284	4,468	3,674	5,943	1,025	8,049	1,605
LR test vs. classic OLS	35	<.01 (p=.995)	159	1.36 (p=.244)	0.47 (p=.494)	1.12 (p=.289)	39	1.43 (p=.232)

Table 6, continued

Spatial error regression

	Net in-migration				Net out-migration			
	Model 17	Model 18	Model 19	Model 20	Model 21	Model 22	Model 23	Model 24
	South	Northeast	Midwest	West	South	Northeast	Midwest	West
Migration (alone)	-3.67	2.79	-2.06	.11 (p=.936)	0.11 (p=.890)	-3.42 (p=.199)	4.16	11.80
Intercept	991.99	838.89	864.09	800.82	1003.52	849.52	856.00	895.41
lambda	.466	.422	.544	.294	.407	.329	.449	.039 (p=.688)
AIC	10,434	1,318	4,796	3,756	6,118	1,066	8,343	1,625
LR test vs. classic OLS	148	16	146	16	78	13	100	0.14 (p=.706)
	Model 25	Model 26	Model 27	Model 28	Model 29	Model 30	Model 31	Model 32
Migration	-0.32 (p=.455)	2.83	.82 (p=.263)	1.37 (p=.256)	1.23 (p=.072)	.48 (p=.818)	8.09	10.61
Rurality	-0.46	0.23 (p=.281)	-.96	-1.46	-1.96	<.01 (p=.994)	-.133 (p=.504)	-1.22
Property value	-0.74	-0.20 (p=.277)	-.19 (p=.430)	-.80	-1.62	-.21	-0.60 (p=.094)	-.91
Poverty	0.24 (p=.791)	3.53 (p=.095)	-2.61 (p=.065)	-5.30	1.85 (p=.221)	5.31	-4.30	1.36 (p=.746)
Hispanic	-4.49	-7.22	-4.94	-4.46	-5.49	-1.60 (p=.139)	-3.03	.55 (p=.583)
Non-white	0.91	3.94	1.56 (p=.051)	1.64 (p=.251)	0.05 (p=.891)	-.14 (p=.861)	5.60	2.15 (p=.146)
Unemployment	5.83 (p=.070)	6.07 (p=.330)	9.86	18.89	11.64	19.24	34.79	23.35
High school diploma	-6.33	-5.96	-12.73	-9.04	-5.11	.67 (p=.669)	-6.60	8.55
Intercept	1489.67	1287.44	1977.04	1745.62	1542.88	707.59	1384.40	)4.82 (p=.517)
lambda	.345	.397	.344	.126 (p=.113)	.039 (p=.484)	.275	.407	<.01 (p=.850)
AIC	10,126	1,270	4,637	3,671	5,941	1,019	8,008	1,604
LR test vs. classic OLS	283	12	42	2.37 (p=.124)	0.50 (p=.481)	5	78	.03 (p=.870)

NOTES:

---Unless otherwise indicated, all coefficients are significant at at least the p<.05 level.

---LR tests are conducted with one degree of freedom, the rho coefficient in the lag models and the lambda coefficient in the error models.