Residential Segregation and Infant Mortality: A Multilevel Study Using Iranian Census Data

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Abstract

Background: There is a great amount of literature concerning the effect of racial segregation on health outcomes but few papers have discussed the effect of segregation on the basis of social, demographic and economic characteristics on health. We estimated the independent effect of segregation of determinants of socioeconomic status on infant mortality in Iranian population.

Methods: For measuring segregation, we used generalized dissimilarity index for two group and multi group nominal variables and ordinal information theory index for ordinal variables. Sample data was obtained from Iranian latest national census and multilevel modeling with individual variables at level one and segregation indices measured at province level for socioeconomic status variables at level two were used to assess the effect of segregation on infant mortality.

Results: Among individual factors, mother activity was a risk factor for infant mortality. Segregated provinces in regard to size of the house, ownership of a house and motorcycle, number of literate individual in the family and use of natural gas for cooking and heating had higher infant mortality. Segregation indices measured for education level, migration history, activity, marital status and existence of bathroom were negatively associated with infant mortality.

Conclusion: Segregation of different contextual characteristics of neighborhood had different effects on health outcomes. Studying segregation of social, economic, and demographic factors, especially in communities, which are racially homogenous, might reveal new insights into dissimilarities in health.

Keywords: Residential segregation, Infant mortality, Generalized dissimilarity index, Information theory index

Introduction

One of the interesting issues in the fields of epidemiology and social science is the relation between the pattern of health outcomes and the context of where people live. During the past decade sociologists and epidemiologists have shown interest in how these contextual factors influence health. An important subset of these researches is concerned with whether differences in health outcomes like death, disease, having a risk factor among population subgroups like racial subgroups or groups defined by socioeconomic status or residential place are attributed to or at least associated

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with the patterns of racial, educational, marital, occupational residential segregation.

Most researchers in this field have investigated the effect of racial residential segregation on death outcomes so far. One of their common findings is that segregation is associated with black mortality (1-5). Some other studies have investigated the effect of racial residential segregation on non death outcomes like tuberculosis (6), cardiovascular disease, early adolescence sexual activity (7-8), black homicide rate (9), poor self related health, high body mass index (10), low birth weight (11-12), health service use (13) and preterm birth in black population (14).

Although most researches about segregation and health mention a negative effect, some show a positive effect of segregation (15-16).

Previous works on segregation had some limitations. First, segregation literature to date is mostly consisted of researches about racial segregation and the effect of segregation of socioeconomic and demographic factors on health outcomes has not been fully reviewed.

Second, most measuring instruments have been limited to calculating segregation between two categories of a variable. These indices are not appropriate for multi group nominal or ordinal variables. Third, the effect of segregation has been widely evaluated in western context and few studies have been performed in eastern societies.

This paper departs from theses traditions. With the help of the advanced methods of measuring segregation we measured segregation indices for multi group categorical and ordinal variables, using the national census data of one eastern country to evaluate the effect of segregation of markers of socioeconomic status on infant mortality. We are going to answer the following questions. Dose infant mortality varies across provinces? Are individual factors related to infant mortality? Dose residential segregation indices of socioeconomic factors account for the variation in infant mortality across the provinces? And do these contextual factors explain the impact of individual level variables on infant mortality?

Materials and Methods

General population and housing census is one of the largest data gathering projects in Iran, and it is undertaken every ten years. A variety of information regarding demographic, social and financial factors is gathered through this process. A specific characteristic of the recent census in 2006 was that in addition to the standard census questions, some questions specific to health outcomes such as infant mortality were added (17).

The census data was presented as two large stratified random sample databases by Iranian National Statistic Center. One sample database contained individual data, in which each record within it contained the data of one person. The other sample database contained family data, in which each record within it contained the data of one family. Individual sample database contained the data of over 1,300,000 persons and family sample database contained the data of over 334,000 families.

Variables

Data for the following variables were extracted from individual database: age (as a continuous variable), sex, migration (migration history in the previous 10 years), education (illiterate, primary school, guidance school, highs school, university degree), activity (according to definition presented by technical guideline of the census, active denotes to individuals who have a job or waiting to begin a new job and nonactive denotes to others like individuals without job, students, housewives and etc) (18), number of remarrying and parity of the mother.

Segregation indices

Segregation can be thought of as the extent to which individuals of different groups occupy or experience different residential environments. In this paper, using the work of Reardon and Firebaugh (19) we measured generalized dissimilarity index for dichotomous and multi group nominal variables and ordinal information theory index for multi group ordinal variables (20). These two indices measure evenness dimension of segregation (21). Dissimilarity can be written as (22):

$$D = \sum_{r \in R} \frac{t_r |\pi_{rm} - \pi_m|}{2T\pi_m(1 - \pi_m)};$$

Where t is the population of municipality zone r and T is the population of province, m defines the levels of the variable for which segregation is measured, such as education level or age group.

Information theory index measures variation in diversity across sub-areas (municipality zones) and diversity of the population is defined as the entropy (E) of the population:

$$E = \sum_{m-1}^{M} \pi_m \, ln \frac{1}{\pi_m}$$

The information theory index is defined as:

$$H = \sum_{r \in R} \frac{t_r (E - E_r)}{TE}$$

Where E_r is the entropy of municipality space r (23). Both these indices range from 0(0%), which is complete interaction to 1(100%), which is complete segregation.

To measure residential segregation, one must define the appropriate area and its component parts (its units of analysis). In United States census report segregation indices were measured for each metropolitan statistical area (MSAs). A MSA is a geographical region with a relatively high population density at its core and close economic ties throughout the area. A typical metropolitan area sometimes contains a single large city that wields substantial influence over the region (e.g. Chicago). However, some metropolitan areas contain more than one large city with no single municipality holding a substantially dominant position (24).

In this study for measuring segregation we used Iranian provinces as metropolitan statistical areas and measured segregation inside each province between smaller geographic areas. Islamic Republic of Iran in 2006 was composed of 30 provinces and 1012 cities. Among these cities there were metropolises like Tehran with population more

than 10% of the country, hence like the work of Ethington (25) for Los Angeles city we divided each cities into their municipal districts and considered them as subunit of analysis in each province. For example Tehran city consisted of 22 municipal districts. There were totally 1135"municipal spaces" in the country. These municipal districts were standard census tracts in the Iranian national census of 2006.

Segregation indices were measured for every province among its municipal spaces. For 30 provinces we measured 30 indices for each contextual variable.

We used 'Seg" command in Stata software to compute measures of segregation for two-group and multi group nominal variables and double checked the results by computing the indices manually in the Excel software. For multi group ordinal variables we used the two methods presented by Reardon (20) for measuring ordinal segregation indices and both methods produced the same results. On the premise that wealthier families are more likely to own a given set of assets and characteristics, like the work of Hosseinpoor in measuring socioeconomic inequality in infant mortality in Iran we used the residential segregation indices measured for the variables presented in table 1 which were standard questions of country national census (26).

Outcome definition

We studied the relation of segregation and infant mortality. In the census, every woman aged from 10 to 54 years old was asked whether she had given birth to a live infant in the 365 days preceding the census. If the answer was positive, she was asked whether her infant was still alive or not. The mothers who had lost their infant considered as outcome positive and the others were considered outcome negative. The individual sample database contained the data of 20,607 mothers who had given birth to a live infant in the period of 365-days preceding the census.

Table 1: Description of Contextual Variables (Segregation Indices)

Code	Segregation index	Description	Dataset
1	Age[1]	Categorical variable	Individual
2	Education[2]	Ordinal variable	Individual
3	Migration[1]	Binary variable	Individual
4	Activity status[1]	Categorical variable	Individual
5	Marital status[1]	Categorical variable	Individual
6	Owning an automobile[1]	Binary variable	Family
7	Owning a motorcycle[1]	Binary variable	Family
8	Household size[2]	Ordinal variable	Family
9	Owning a house[1]	Binary variable	Family
10	Use of natural gas for heating and cooking[1]	Binary variable	Family
11	Number of literate individuals in family[2]	Ordinal variable	Family
12	Number of individuals with job in family[2]	Ordinal variable	Family
13	Owning a telephone[1]	Binary variable	Family
14	Owning a bathroom[1]	Binary variable	Family
15	Type of bathroom effluent disposal[1]	Binary variable	Family
16	Main source of drinking water[1]	Binary variable	Family
17	Number of rooms per capita[1]	Binary variable	Family
18	Separate kitchen[1]	Binary variable	Family

1- Generalized dissimilarity index
2- Ordinal Information Theory Index

Modeling

Considering the hierarchical structure of the data we used multilevel logistic regression to account for the clustering of individuals within geographical units (provinces) while allowing for the estimation of effect of the contextual factors after controlling for individual covariates. Descriptive statistics for the outcome were calculated with "svy" procedure and multilevel modeling with "xtmelogit" procedure in the Stata software package. The default method used by "xtmelogit" is adaptive Gaussian quadrature (AGQ) with seven quadrature points per level (27). The models were run in order of increasing complexity. Nested models were compared according to likelihood ratio test and the best model was selected according to this test. Stata software uses direct maximum likelihood via numerical integration to fit the model. There are also a number of other estimation procedures such as marginal and penalized quasi-likelihood methods and Markov chain Monte Carlo (MCMC) methods which are used in other

software like Mlwin but maximum likelihood via numerical integration is generally the preferred method for relatively simple random effects models (27).

The goals of the study were as follows:
Goal 1: To assess whether infant mortality vary across provinces.
The first model was a random intercept model which was fitted without any covariates to assess whether infant mortality vary across provinces.
Goal 2: To evaluate the relationship between level-one variables and infant mortality.
The second model was a random intercept model that measured the effect of individual variables on infant mortality. We added explanatory level-one variables to model one to estimate the net effect of these variables on the outcome of interest. The slope of these level-one variables was considered fixed, as opposed to random, because we did not assume a priori that the effect of these variables on infant mortality varied among provinces

Goal 3: To determine whether contextual variables (segregation indices) account for variation in infant mortality.

The third model was a random intercept model the same as the second model but the segregation indices were added to measure the effect of increasing level of segregation on the outcome controlled for individual variables.

Goal 4: To determine whether the contextual variables (segregation indices) can explain the impact of level-one variables on infant mortality.

To respond to this research question we continued the analysis in the following way. For variables which both individual and segregation index were in the model, if the effect of individual variable was statistically significant we first checked the randomness of the coefficient of the individual variable by fitting a random slop model and likelihood ratio test comparing the random slope

model with random intercept model. If according to the likelihood ratio test, random slop model was better than random intercept model, then the cross level interaction term was added to random slop mode, otherwise it was added to the random intercept model.

Results

According to the Iranian National Census 2006 the country population was 70,495,782. The sample database which included individual data consisted of 1,367,310 records. The sample family database included the data of 334,322 families. Segregation indices measured for socioeconomic status variables are presented in Table 2.

Table 2: Mean, Standard deviation, Minimum, Maximum and Median of Segregation Indices Measured for the Variables Mentioned in Table 1 Using 2006 Iranian National Census Data

| Index	Age	Education	Migration	Activity status	Marital status	Owning an automobile	Owning a motorcycle	Household size	Owning a house
Mean	6.217	2.43	14.499	6.995	4.632	17.036	28.534	3.370	13.466
Sd	1.654	1.19	5.475	1.513	1.110	4.657	7.922	2.014	5.492
Min	2.440	0.55	6.730	3.130	2.610	8.850	8.780	1.280	5.470
Max	10.230	6.26	32.690	11.680	7.700	26.620	41.020	10.961	28.990
Median	6.265	2.35	13.775	6.94	4.555	17.100	28.545	2.724	11.365
Index	Use of natural gas	Number of literate individuals in family	Number of individuals with job in family	Owning a telephone	Owning a bathroom	Type of bathroom effluent disposal	Main source of drinking water	Number of room per capita	Separate kitchen
Mean	50.614	1.114	1.405	19.186	23.004	54.077	41.053	15.046	42.125
Sd	19.025	0.470	0.571	7.536	7.440	16.847	19.365	4.280	12.753
Min	9.810	0.538	0.652	7.650	11.620	29.360	2.310	8.570	12.600
Max	78.210	2.796	3.619	39.330	42.790	90.470	78.450	25.860	62.680
Median	54.605	1.013	1.272	18.520	21.545	50.720	40.235	14.940	43.855

There were 20607 women in the database who had born live infants in the year preceding census. We began by fitting the model one that is a model with only intercept and province effect. The log-odds of infant mortality in an average province was -3.102 (odds=0.045). The intercept for province (j) was equal to $-3.102 + u_{0j}$ where the variance of u_{0j} was estimated as: $\sigma_{uj}^2 = 0.184$. The likelihood ratio statistic for testing the null hypothesis that $\sigma_{uj}^2 = 0$, was 89.27 (P < 0.0001). This means that infant mortality varied across provinces and the ef-

fect of province was significant. The plot in Fig. 1 shows the predicted level two residuals and 95% confidence interval for all thirty provinces. For seven of the provinces the 95% confidence interval is above the horizontal line at zero, indication that the infant mortality in these provinces is significantly above the average. In just two provinces it is below the average.
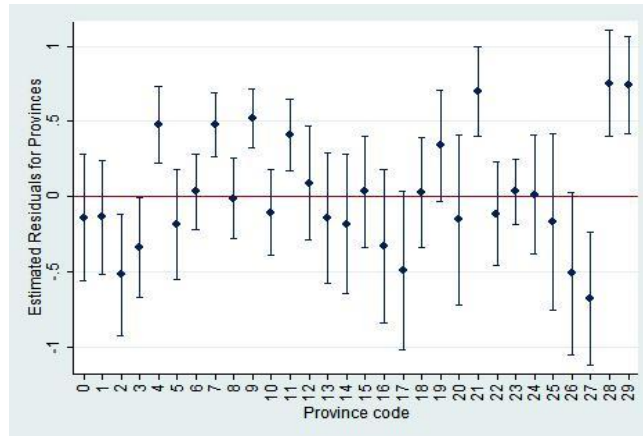
Fig. 1: Predicted Level 2 Residuals of Infant Mortality from Model 1 According to Iranian 2006 Census Data

The result of the model two and model three are presented in Table 3. From the individual factors in model two, level of education and activity of the mother were associated with infant mortality. The odds of infant mortality in mothers with primary school and high school was 1.29 (1.04-1.61) and 1.34 (1.05-1.7) in comparison to illiterate mothers respectively. The odds ratio of infant mortality in active mothers (mothers who had a job) versus inactive mothers was 1.40 (1.12-1.75).

Residential segregation indices had different effects on infant mortality. Segregation indices measured for age groups, ownership of a motorcycle, size of the house, ownership of the house, number of literate individuals in the family, and use of natural gas for cooking and heating were positively associated with infant mortality. The odds ratio of infant mortality for one standard deviation increment in segregation of age groups was 1.44 (1.07-1.94), for size of the house was 1.56 (1.26-1.92), for ownership of a house was 1.44 (1.12-1.85), for number of literate individuals in the family was 1.79 (1.33-2.39) and for use of natural gas for cooking and heating was 1.45 (1.27-1.66). On the contrary, segregation indices measured for education level, migration history, type of activity, marital status and existence of bathroom in the house were associated negatively with infant mortality. Odds ratio of infant mortality for one standard deviation decrease in segregation of education level was 1.75 (1.2-2.57), for migration history was 1.23 (1.03-1.48), for type of activity was 1.27 (1.04-1.55), for marital status was 1.41 (1.16-1.72) and for existence of bathroom was 1.69 (1.37-2.07).

Likelihood ratio test comparing the model two to model one and model three to model two were significant (Table 3).

From the variables in the model, level of education and activity were associated with infant mortality as both individual factor and segregation index. For estimating whether there is any cross-level interaction, we first checked whether variability of mother activity and education level differs in the provinces in separate random slope models. The likelihood ratio tests were not significant. Then, the cross level interaction terms were added to separate random intercept modes. The likelihood ratio test comparing models with interaction terms and modes without them were not significant.

Table 3: Estimated coefficients for the association of individual variables (model 2) and segregation indices controlled for individual variables (model 3) with infant mortality

	Covariates	Model 2 - OR (95%	Model 3 - OR (95%
Individual - level 1 covariates	Age (10 years increment)	1.04(0.90-1.19)	1.04(0.90-1.19)
	Education level illiterate	1	1
	Primary school	1.29(1.04-1.61)*	1.29(1.04-1.61)*
	Guidance school	1.17(0.91-1.51)	1.17(0.91-1.51)
	High school	1.34(1.05-1.71)*	1.34(1.05-1.71)*
	University degree	1.03(0.74-1.44)	1.03(0.74-1.44)
	Migration (no=0)	1.10(0.95-1.27)	1.10(0.95-1.27)
	Number of Remarrying	0.66(0.33-1.35)	0.66(0.33-1.35)
	Activity (Unemployed=0)	1.40(1.12-1.75)**	1.40(1.12-1.75)**
	Parity	1.04(0.98-1.10)	1.04(0.98-1.10)
Segregation Indices - Level 2 covariates	Age		1.44(1.07-1.94)*
	Education		0.57(0.39-0.83)**
	Migration		0.81(0.68-0.97)*
	Activity		0.79(0.64-0.96)*
	Marital Status		0.71(0.58-0.86)***
	Car Ownership		1.07(0.91-1.26)
	Owning a Motorcycle		1.00(1.00-1.00)*
	Household Size		1.56(1.26-1.92)***
	House Ownership		1.44(1.12-1.85)**
	Use of natural gas for heating		1.45(1.27-1.66)***
	Number of literate individuals in family		1.79(1.33-2.39)***
	Number of family members in employment		0.96(0.75-1.22)
	Owning a telephone		1.09(0.89-1.35)
	Separate bathroom		0.59(0.48-0.73)***
	Effluent Disposal system		1.07(0.92-1.26)
	Main source of drinking water		0.89(0.78-1.01)
	Number of room per capita		0.92(0.79-1.07)
	Separate Kitchen		1.13(0.92-1.38)
Intercept	Constant	0.05(0.02-0.11)***	0.04(0.01-0.14)***
Likelihood ratio test test	compared to previous model	P >Chi2 (9)^s: 0.010	P >Chi2 (18)^s: 0.0000

*** P=< 0.001,   ** P=<0.01 ,   * P=<0.05 ^{s} degree of freedom of likelihood ratio test
# For segregation indices odds ratio was calculated for one standard deviation increment in segregation index.

Discussion

This study is one of the first to show the spatial distribution of residential segregation of some socioeconomic status determinants within a country and the effect of segregation of these factors on infant mortality in a racially homogenous eastern country.

Iranian population is white race. There is no racial segregation, but for distribution of some of determinants of socioeconomic status, many of the provinces are highly segregated (table 1). Hosseinpoor et al. showed in their study about socioeconomic inequality in Iran that there was a descending trend in infant mortality rate as a function of socioeconomic quintiles in some of the Iranian provinces as observed at the national level (26).

We estimated the independent effect of living in more segregated provinces concerning important socioeconomic status variables on infant mortality. Generalized dissimilarity index and ordinal information theory index were used to measure segregation. Dissimilarity can be interpreted as the percentage of all individuals who would have to transfer among residential units to equalize the group proportions across residential units, divided by the percentage who would have to transfer if the system started in a state of complete segregation (19). Since dissimilarity is not appropriate for ordinal categorical variables, we used Information theory index for ordinal variables. This index measures the variation in diversity across subareas and is equal to ratio of within unit diversity to total diversity (20, 23).

The results show that distribution of some determinants of socioeconomic status in each province across its municipality spaces had different effects on infant mortality in that province.

Infant mortality rate in Iran in 2005-2006 according to the Ministry of Health was 19 and according to UNICEF was 29 in 1000 live births (28).

As figure one shows infant mortality was different between provinces. In Western Azerbaijan, Fars, Khorasan Razavi, Sistan & Baluchistan, Yazd, North, and South Khorasan it was higher than

country average and in Golestan and Mazandaran it was below country average.

Our results at the individual level show a direct association between mother activity and infant mortality. Mothers who were attached to the labor market had higher probability of infant mortality. The effect of mother occupation on infant mortality is varied in different countries. In a study in Ethiopia, the relative risk of infant mortality in mothers in manual and agricultural jobs was higher than mothers with professional, clerical, and technical jobs (29). In another study in India, mortality rate of infants and children were higher if mother was employed (30).

In this study mother education at the level of university degree and guidance school were not statistically associated with infant mortality but in educated women at level of primary school and high school there was a weak positive association with infant mortality.

Segregation of different determinates of socioeconomic status affect differently the infant mortality. In provinces where the contextual characteristics of municipality spaces in regard to the size of the houses families reside in the neighborhood, whether families own their residential place or not, whether they use natural gas for heating and cooking, number of literate individuals in the family and age group proportions were different from each other and from the mean proportions in the province, infant mortality was higher than provinces which these contextual characteristics were more evenly distributed. The effect of segregation of number of literate individuals in the family and size of the house were stronger than other factors.

A vast literature describes the effect of segregation on infant mortality (31-33) and overall mortality (1, 34) but in almost all these literature the effect of racial segregation on health outcomes is being reviewed. Laveist showed in his studies that segregation measured by dissimilarity was positively associated with black infant mortality rate and postneonatal mortality rate after adjusting for socioeconomic factors (31, 35-36).

There are different theories about the mechanism of influence of segregation patterns on health. The residential place is important because it defines how close individuals are to important resources (37). These resources might be institutional, social and even potential hazards. This proximity affects health outcomes. It is also hypothesized that residential segregation, isolates women from amenities, opportunities, and resources, and this isolation might result in stress full conditions and life style changes affecting infant survivals (12).

People do not choose their residential place randomly. The cultural settings and contextual characteristics of a place including the characteristics of people living there affect the stigma of a residential place and people's choices. Residence in highly segregated areas concerning some socioeconomic characteristics may be associated with chronic exposure to stressful social conditions and reduced probability for social engagement. Cumulative negative effect of being forced to adapt to various psychosocial challenges and stressful events and lack or inefficient coping mechanisms build mothers' allostatic load, which is associated with cardiovascular disease, physical or cognitive malfunctioning, and mortality (38).

So far literature about segregation has explained different mechanisms through which segregation affect its negative impact on health but our study showed that segregation of some other contextual characteristics of neighborhood might have positive effects on health. Segregated provinces for education level, type of activity, migration history, marital status and existence of a bathroom had lower infant mortality than integrated provinces. One probable mechanism is through influence on social cohesion. Reidpath (39) defines social cohesion as the degree to which groups of people fell connected, share resources, and provide moral support. It might be conceptualized that neighborhoods which their residents are more similar in regard to mentioned characteristics but the group proportions are different from mean province proportions (which result in higher segregation at the province level), social cohesion between residents grows stronger and the strength of this so-

cial cohesion and the support which people that are common in some characteristic can give to each other might be more important for health outcomes than the negative effects of segregation. Future researches should be carried out to improve our understanding of predictors of social capital and levels of social cohesion for women living in socially segregated neighborhoods and causal mechanism through which segregation affect.

This study is of high value because it considers how the segregation in other aspects of social characteristics, affects health outcomes that in literature have not been fully reviewed Future work is needed to investigate the effect of different aspects of social segregation on different health outcomes. Evaluating the trend of change in segregation and its effect on health outcomes using data of next censuses can be a good work.

Limitation.

Our results are subject to limitations associated with the use of census data. The choice of variables for measuring segregation of socioeconomic status was limited to the variables, which were standard questions of the census. The benefit of choosing these variables is the possibility for trend checking in later surveys, but it is possible that segregation indices for some other important socioeconomic factors better describe the health disparities .We used province as the level of analysis and segregation was computed among municipality spaces for each province. It is possible that the relation between segregation and health outcomes varies depending on the size of the geographic area and number of residents (40). Analysis at city levels instead of provinces may provide a better understanding of the effect of social segregation on health.

In this article segregation was considered as an inter province exposure. There is another approach, which considers segregation as a local exposure in intra province research for the effect of segregation on health. The second researches which are the extension of neighborhood-effects literature have the ability to show how outcomes vary by neighborhood within province but according to Oakes (41) they are confounded by forces

that allot individuals into neighborhoods. This article follows the first approach but further multilevel studies including individuals nested within neighborhoods nested in provinces could present new insights (42).

This cross sectional multilevel analysis also says nothing about the history of provinces, whether they are segregated for a long time or just recently segregated.

Despite these limitations, our data was a good sample of census data and our method and analytic approach was rigorous.

Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely observed by the authors.

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