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Health Care Segregation and Race Disparities in Infectious Disease: The Case of Nursing Homes and Seasonal Influenza Vaccinations*

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Abstract

Examining nursing home segregation and race disparities in influenza vaccinations, this article demonstrates that segregation may increase both susceptibility and exposure to seasonal flu for black Americans. Evidence based on the 2004 U.S. National Nursing Home Survey shows that individuals in nursing homes with a high percentage of black residents have less personal immunity to flu since they are less likely to have been vaccinated against the disease; they may also be more likely to be exposed to flu since more of their co-residents are also unvaccinated. This implies that segregation may generate dual disease hazards for contagious conditions. Segregation appears to limit black Americans' access to personal preventative measures against infection, while also spatially concentrating those people who are most likely to become contagious.

Research shows that segregation generates racial health disparities in the U.S. (Williams and Collins 2001). However, most of this work focuses on chronic diseases, while very few authors consider how segregation may shape both susceptibility and exposure to infectious agents. The contagious nature of infectious disease means that segregation may generate dual disease hazards at individual- and community-levels. At the individual-level, racial segregation may to limit black Americans' abilities to take personal preventative measures against infection. At the community-level, segregation also concentrates those people who are most likely to become infected, and consequently contagious, within certain areas. This means that disadvantaged black Americans are not only more likely to be susceptible to an infectious agent, they are also more likely to be exposed to that agent. This paper explores this relationship between segregation and infectious disease by examining how the racial composition of U.S. nursing homes shapes individual access to seasonal influenza vaccinations, while further clustering unvaccinated residents in separate homes.

Immunity to infection can vary at individual- and group-levels. Consider the case of vaccinations. Getting vaccinated reduces each vaccinated persons' susceptibility by increasing individual-level immunity. However, dynamics of contagion mean that most efforts that people take to protect themselves from infection have additional positive "externalities" (i.e., effects on other people besides the person engaging in the behavior) that benefit the larger community. As the proportion of people immune to a disease increases through vaccination, the odds that a susceptible individual comes in contact with a

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contagious individual are reduced, making it more difficult for pathogens to spread. Higher vaccination rates within a community can, therefore, increase the group's immunity to infection.

Using the 2004 U.S. National Nursing Home Survey (NNHS), I examine how segregation of nursing homes relates to race differences in both individual- and group-level immunity. As documented elsewhere, nursing homes in the U.S. are highly segregated with black elderly concentrated in lower quality homes (Smith 1990). I first test whether the racial composition of nursing homes is associated with individual residents' odds of vaccination, and whether this association varies by resident's race. Given externalities of vaccinations, I next test whether the racial composition of homes is associated with home-level vaccination rates. If being in a home with a higher percentage of black residents is associated with lower individual odds of vaccination and a lower home vaccination rate, nursing home segregation may pose dual disease hazards by increasing individual susceptibility to flu while also surrounding one with other people who are more likely to be contagious.

"Reemerging infections" within the U.S. are disproportionately borne by black Americans. For instance, new diseases/strains, such as HIV/AIDS and drug-resistant tuberculosis, are most prevalent among black Americans (Bloch et al. 1994, Morris et al. 2006). It is worthwhile to consider how sociological variables, like segregation, may contribute to infectious disease. While this analysis focuses on nursing homes and influenza, results should provide insight into a range of infectious outcomes.

Race Disparities in Influenza Vaccinations

Black Americans have the highest influenza/pneumonia mortality rates in the U.S., with the largest disparity among the elderly (Hutchins et al. 2009). People age 65 and older and all nursing home residents are special risk groups for influenza-related complications, and are supposed to be vaccinated against flu each year (CDC n.d.). Annual vaccination rates, however, are relatively low and characterized by race disparities. In recent years, approximately 67% of white and 47% of black non-institutionalized elderly were vaccinated against flu (Hutchins et al. 2009). Among nursing home residents, approximately 69% of non-blacks and 62% of blacks were vaccinated (see Table 1). While disparities are smaller among nursing home residents, relative to non-institutionalized elderly, the risk of influenza-related complications is higher for nursing home residents who tend to be frailer than non-institutionalized elderly. This implies that even relatively modest vaccine disparities may have substantial consequences for morbidity and mortality among nursing home residents.

Nursing Home Segregation, Institutional Resources, and Quality

Nursing homes are highly racially segregated. According to white-black dissimilarity indices, about 70% of black residents would need to relocate to obtain an equitable distribution of groups across homes (see Table 1). This is higher than residential segregation in typical metropolitan areas where about 65% of black residents would need to relocate to obtain equity (Glaeser et al. 2001).

Black nursing home residents are nearly four times as likely as white residents to reside in homes with poor performance scores and less qualified staff (Mor et al. 2004). Black residents are also concentrated in homes where a high percentage of residents' care is covered by Medicaid and a low percentage is covered by private out-of-pocket payments (Mor et al. 2004). Since Medicaid reimbursements are lower than typical out-of-pocket payments, there is usually less income entering institutions with high percentages of black residents.

Three Explanations for Vaccine Disparities among Nursing Home Residents: Individual and Institutional Factors

1. Individual variation in behaviors/attitudes

At the individual-level, disparities could results from nursing home employees being less likely to recommend vaccines to black residents. Black residents might also be more likely to refuse vaccines, perhaps because of a history of exploitation by health care institutions (e.g., memories of Tuskegee may make black residents more wary [Corbie-Smith, Thomas, and St George 2002]). Positive attitudes toward vaccinations among white residents could make them more likely to request vaccines (Hebert et al. 2005). While differences in health insurance certainly contribute to health care disparities in the general population, it seems unlikely that insurance plays a critical role in a nursing home population because most nursing home residents have Medicaid and/or Medicare, both of which reimburse for flu vaccinations.

2. Racial segregation and overall institutional environment

Alternative explanations suggest that segregation and concentrated disadvantage mean that black residents are overrepresented in lower quality institutions, which provide uniformly lower quality care to all residents, regardless of their race. In this case, race does not create disparities because, for instance, homes are less likely to vaccinate their black residents. Rather, some homes are better than others, better homes are more likely to vaccinate all their residents, but blacks are less likely to be in better homes.

Institutions factors should contribute to vaccine disparities among nursing home residents. Homes have primary responsibility for vaccinating residents, and most residents receive vaccines in the home rather than, say, in private doctors' offices (Health and Human Services 2000). Various institutional strategies are associated with higher home vaccination rates including having written protocols for immunizations, routine review of facility-wide vaccine coverage, and consistent records documenting residents' vaccination statuses (Bardenheirer et al. 2011). None of these strategies require major financial investments or institutional resources. However, they do require effective administration and staff knowledge and motivation, which may be less available in lower quality institutions. For instance, maintaining good record-keeping and routine reviews of vaccine coverage will be harder if there is lots of staff turn-over or staff is frustrated by bad work conditions.

3. Racial segregation and individual behaviors/attitudes

Finally, segregation may augment race differences in individual behaviors and attitudes related to vaccinations. For instance, a higher proportion of black residents could increase the salience of race in a home; this might heighten discriminatory behaviors among employees, or augment a culture of distrust toward medicine and vaccines among black residents. Unlike the second explanation, which emphasizes institutional quality and assumes that black and white residents are similarly affected by racial composition, these explanations emphasize behaviors and norms and assume that racial composition has differential effects by resident race.

Recent studies suggest that segregation of U.S. hospitals contributes to race disparities in medical treatments (e.g., preventative care, procedures following heart attack, etc.). Authors find that individual-level disparities are significantly reduced by adjusting for the racial composition of patients, and that both white and black patients fare worse in hospitals with high proportions of black patients (Baicker et al. 2005, Barnato et al. 2005). This supports the second explanation above, suggesting racial composition shapes the overall quality of care in an institution. Studies of nursing home segregation are less common and yield more mixed results. Gruneir et al. (2008) find that homes with a high proportion of black residents are more likely to hospitalize residents in the last days of life (presumably because they lack resources for palliative and end-of-life care). On the other hand, Miller et al. (2006) find that homes with high proportions of black residents are less likely to physically restrain residents.

The following models predicting individual vaccinations add to existing research on race disparities in health care quality. While researchers have shown that the racial composition of hospitals impacts the odds that pneumonia patients receive flu vaccines (Hausmann et al 2009), I am not aware of any studies examining nursing home racial composition and vaccinations. Since nursing homes provide longer-term care than hospitals, determinants of vaccination may differ and warrant unique attention. More importantly, though, virtually none of the work on the racial compositions of health care facilities (either hospitals or nursing homes) has considered disparities in access to positive externalities of other patients' treatments. The following models predicting home-level vaccination rates address this gap by showing that segregation may not only limit one's own immunity to disease, but potentially also limit benefits from other residents' immunity as well.

Sociological and Infectious Disease Epidemiological Perspectives on Spatial Clustering

Sociologists are primarily interested in the clustering of people according to dimensions of social stratification (e.g., race, socioeconomic status); infectious disease epidemiologists, on the other hand, are primarily interested in clustering according to dimensions of immunity (i.e., whether one is susceptible or immune to infection). However, disparities in infectious disease mean that social stratification and disease immunity are interrelated. Drawing on the concepts of "place stratification" from sociology and "herd immunity" from epidemiology, we can begin to conceptualize links between segregation and disease immunity.

Place Stratification

The place stratification framework, rooted in urban sociology, assumes there are reciprocal pathways between spatial clustering and social inequality (Logan and Molotch 1988). Clustering according to race and socioeconomic status concentrates (dis)advantage and creates disparities in the quality of places. Neighborhood segregation limits access to resources (e.g., good schools, public services). It can also shape behavioral norms and foster or hinder community efficacy (Sampson et al. 2002).

A place stratification framework further assumes that spatial clustering is driven by racial and socioeconomic hierarchies in broader society. While this article is concerned primarily with consequences of nursing home segregation, it is worth briefly discussing potential causes. Preferences for living among one's own racial group likely contribute to racial clustering across homes. Fewer economic resources should also help concentrate black individuals into lower quality homes. It is unlikely, however, that nursing home segregation can be reduced to individual preferences or finances. Historically, nursing homes have had few incentives to follow federal integration laws since, during the 1960s and 1970s, when most integration efforts were underway, nursing homes received very little federal funding (Smith 1990). Residential segregation may continue to lead people of different racial groups into distinct homes as people often prefer nursing homes that are close to family members' homes. Although discrimination has not been systematically documented in nursing home markets (e.g., using audit studies), there are many opportunities for it to occur. For instance, social workers within hospitals may "steer" people to different homes depending on race.

Nursing home administrators may assume that white residents prefer to be among other whites and so resist admitting black residents to avoid "white flight" out of the home.

Herd Immunity

Herd immunity (i.e., group-level immunity) is based on disrupting chains of infection in contagious diseases. For pathogens to survive, they must be passed from one host to the next, which requires some minimum level of contact between contagious and susceptible individuals. All else equal, the probability that susceptible and contagious individuals come into contact falls as more of the herd becomes immune. The rate of immunity within the herd is, therefore, an important group-level resource in disease prevention. Another critical factor is mixing between immune and non-immune individuals. If immune and non-immune individuals are relatively isolated from one another, there will be less contact between contagious and susceptible individual and chains of infection are more likely to be disrupted (Anderson and May 2006).

Within complex social structures, human "herds" could be defined as institutions, neighborhoods, cities, nations, etc. Drawing on a place stratification framework, we would expect group immunity to be unequally distributed across such communities. If discriminatory mechanisms cluster people into distinct communities according to race, and race is correlated with disease immunity, there will be race disparities in people's access to protection from herd immunity. Segregation may generate areas with high proportions of blacks and low rates of immunity that are relatively isolated from whiter areas that likely have higher rates of immunity. This may create many uninterrupted chains of infection within predominantly black communities, but relatively fewer chains of infection passing into or around white communities.

There have been few attempts to understand how segregation relates to herd immunity. To facilitate modeling, epidemiologists frequently assume uniform susceptibility and random mixing among people (for critiques see Acevedo-Garcia 2000, Morris 1993). Sociologists, on the other hand, rarely consider herd immunity, although it is intuitive that chains of infection are shaped by social structure. The following analysis provides a preliminary step toward bridging this gap.

This analysis treats nursing homes as "little herds." Although visitors and staff circulate in and out, nursing homes contain relatively isolated populations, and conditions within homes are conducive to spread of airborne infection (e.g., residents in close proximity, frequently sharing social spaces). Positive externalities of other residents' vaccinations can, therefore, be important for disease risk, and variation in home-level vaccination rates may create relatively distinct levels of group immunity from one home to the next. Racial segregation across U.S. nursing homes further means that these differences in home-level immunity are likely correlated with race.

Data and Methods

Data come from the 2004 National Nursing Home Survey (NNHS). This nationally representative multi-level dataset provides information on resident's race and vaccination status, and identifies residents sharing homes (NCHS 2009). After sampling 1,174 homes, up to 12 residents are randomly sampled within each home. The vast majority of homes, 93%, report on the full 12 residents. Nursing homes are very small relative to the communities (e.g., neighborhoods, states) that social scientists typically analyze in multi-level models. Indeed, 94% of homes in this analysis have less than 200 beds. Samples of 12 residents reflect a substantial proportion of most homes' populations, capturing many more individuals per community than is typical within social science literature. All information is from nursing homes' records. Including all residents with valid data for relevant variables yields 12,501 residents across 1,140 homes. Descriptive statistics are in Table 1.

Individual-Level Variables

Individual Vaccination, the first dependent variable, is a dichotomous indicator for whether the resident was vaccinated against influenza in the past year.

I use four mutually-exclusive categories to adjust for the resident's primary payment source in the first and most recent month of his/her stay.

- **i.** *Medicaid (no Medicare)*: bills covered by Medicaid, but not Medicare (reference category).
- **ii.** *Medicare and/or Medicaid*: bills covered by Medicare only or both Medicare and Medicaid.
- **iii.** *Out-of-pocket and miscellaneous*: bills not covered by Medicare or Medicaid, but rather by private out-of-pocket payments or alternative sources (e.g., veteran's affairs, long-term care insurance). The large majority of this category makes private out-of-pocket payments.
- **iv.** *Unknown payment sources:* the home did not know how the resident was paying his/her bills.

These categories generate eight dichotomous indicators—four for the first month, and four for the most recent month. How people finance nursing home care often changes over time. Many people make private out-of-pocket payments at the beginning of their stay, but, after spending down assets, they qualify for and finance their care with Medicaid. Medicare typically covers nursing home costs for only a short period immediately following a hospital stay (Health and Human Services n.d.). Payment sources in the most recent month should be more indicative of the resident's current access to medical treatments, whereas payment sources in the first month are more likely to reflect access to different types of homes.

Models include dichotomous indicators for how a resident makes daily decisions (*independently* [reference category], *modified independently, impaired,* and *highly impaired*). *Months in home* is a continuous measure of how long the resident has been in the home. Finally, models adjust for sociodemographic characteristics. *Black, other,* and, *white* (reference category) are dichotomous indicators for the resident's race. *Age* is a continuous measure in years. *Female* is a dichotomous indicator for gender.

Home-Level Variables

Percent home vaccinated, the second dependent variable, is a continuous measure estimating the percentage of residents within the home who were vaccinated against influenza in the past year.

Percent home black, the main covariate of interest, is a continuous variable estimating the home's racial composition.

Using payment categories described above, I construct continuous measures of the home's payment source composition for the most recent month: *percent home with Medicaid (no Medicare), percent home with Medicare and/or Medicaid,* and *percent home with out-of-pocket and other sources*. These provide a general indicator of homes' resources.

All the aggregate percentage variables measuring home compositions were constructed by dividing the number of sampled residents with a given characteristics (e.g., having been vaccinated, being black, etc) by the total number of sampled residents and multiplying by 100.[1]

I include dichotomous indicators for whether the home is *for-profit*, its location in a *metropolitan* area, a *micropolitan* area, or *neither* (metropolitan is the reference category), and its bed-size (*less than 50, 50–99, 100–199,* or *200+* [less than 50 is the reference category]).

When predicting individual vaccination, I include an interaction term between the resident's race (coded one for black) and the home's racial composition. This variable, *Percent Home Black*Resident Black*, tests whether associations between racial composition and odds of vaccination vary by resident's race.

Analytic Strategy and Models

The analysis is presented in three sections: the first focuses on individual vaccinations; the second examines home vaccination rates; and the third tests for race differences in vaccine refusal.

Individual Vaccination—When predicting residents' vaccination statuses, I use a logistic regression model with a nursing home-specific random intercept, $\beta_1 + \varsigma_j$, to account for clustering within homes. The complete model can be written as:

$$\text{logit}\,\{\Pr(y_{ij}=1|\mathbf{x}_{ij},\varsigma_j)\}=\beta_1+\beta_2 x_{2j}+\beta_3 x_{3ij}+\beta_4 x_{2j}*x_{3ij}+\beta_5 x_{4j}+\beta_6 x_{5ij}+\varsigma_j \quad (1)$$

where the subscript i reflects residents and j reflects homes. Y_{ij} measures the resident's vaccination status. X_{2j} is the percentage of black residents in the home, X_{3ij} indicates whether the resident is black, and $X_{2j}*X_{3ij}$ is the interaction term, percent home black*resident black. X_{4j} reflects the home-level control variables, X_{5ij} reflects the resident-level control variables, and ς_j is the random intercept parameter.

Although typical caveats about confounding from unmeasured factors apply, building the above model in a stepwise fashion may help adjudicate between the alternative explanations outlined above. *If individual behaviors/attitudes drive vaccine disparities (i.e., first explanation is correct), being black should lower residents' odds of vaccination, regardless of institutional composition or conditions.* In this case, individual-level race disparities (β_3) should be robust to adjusting for home racial composition, and they should not be modified by racial composition (i.e., the interaction term should be non-significant).

Alternatively, *if segregation affects institutional environment for all residents (i.e., second explanation is correct), a higher percentage of black residents should lower odds of vaccination, regardless of the resident's race.* In this case, correlations between home's racial composition and odds of vaccination (β_2) should be significant, individual-level race disparities should be reduced when adjusting for home racial composition, and black and non-black residents should be similarly affected by racial composition (i.e., the interaction term should be non-significant). If black and non-black residents are equally *vulnerable* to racial composition, this does not imply that segregation is unimportant. Because of

[1]The reliability of home-level aggregate measures will depend on (i) whether a sufficient proportion of level-1 units (residents) were sampled within each level-2 unit (home) and (ii) on how much variance exists across versus within level-2 units (i.e., internal consistency). Because nursing homes are small, samples of 12 residents capture substantial proportions of most homes' populations. Regarding internal consistency, I constructed reliability estimates based on Jones and Norrander (1996). According Jones and Norrander (1996), estimates greater than .7 reflect highly reliable measures. The reliability estimates for my home-level variables all fell above this threshold (percent vaccinated .800; percent black .856; percent Medicaid (no Medicare) .776; percent Medicare and/or Medicaid.708; percent with out-of-pocket or other source .762).

segregation, black residents are much more likely to be *exposed* to a high proportion of black residents in their home. This is demonstrated with predicted probabilities.

Finally, *if segregation heightens race differences in behaviors/attitudes (i.e., third explanation is correct), a higher percentage of black residents should have a stronger negative association with vaccination for black residents than for non-black residents.* In this case, some individual-level race disparities should remain after adjusting for racial composition, but, most importantly, black and non-black residents should be differentially affected by home racial composition (i.e., the interaction term should be significant).

Home Vaccination Rate—I begin this section with a simple thought experiment using descriptive statistics. I then use a standard linear regression model to predict the percentage of residents vaccinated within homes, adjusting for clustering with Huber-White robust estimates of variance (Rogers 1993). The complete model can be written as:

$$y_j|\mathbf{x}_{ij}=\beta_1+\beta_2 x_{2j}+\beta_3 x_{3ij}+\beta_4 x_{4j}+\beta_5 x_{5ij}+\varepsilon_{ij} \quad (2)$$

where the subscript i reflects residents and j reflects homes. Y_j is the percentage of residents vaccinated in the home. X_{2j} is the percentage of black residents and X_{3ij} indicates whether the resident is black. X_{4j} reflects home-level and X_{5ij} reflects resident-level control variables.

Negative correlations between percent black and percent vaccinated (β_2) will suggest that individuals in homes with more black residents may get less benefit from group-level immunity. An important question will be whether this result is robust to adjusting for resident-level characteristics. If β_2 is highly sensitive to controls for residents' race, age, etc., this will raise concerns that the result does not reflect institutional conditions, but rather the selection of residents with varying characteristics into different homes. While we cannot rule out possible selection based on unmeasured characteristics, finding that β_2 is robust to adjustments for several resident characteristics should strengthen our confidence that results reflect institutional conditions, not purely selection.

Vaccine Refusal—Finally, I test whether race differences in vaccine refusals might account for disparities. I replicate the random intercept logistic regression model above (equation 1), conditioning on residents being unvaccinated, and the dependent variable becomes a dichotomous indicator for vaccine refusal (i.e., having refused vaccination is coded one and being unvaccinated for any other reason is coded zero).

If being black or being in a home with more black residents is positively correlated with having refused vaccination, disparities across race groups and homes may be driven, at least in part, by individual differences in attitudes/behaviors. Considering the interaction term, if black residents in homes with a high percentage of other black residents are more likely to refuse vaccinations, segregation may be augmenting race differences in behaviors/attitudes toward vaccination (see third explanation outlined above).

Descriptive statistics are weighted to adjust for sampling design. The regression results, however, are not weighted since the models adjust for the characteristics that define the primary sampling strata—namely, the home's bed size and location in a metropolitan area (Winship and Radbill 1994).

Results

Descriptive Statistics

Table 1 presents descriptive statistics, by resident race. Segregation is high (dissimilarity index=.71), and there are race disparities in vaccinations at both individual- and home-levels. Black residents are more likely to be covered by Medicaid (no Medicare) and less likely to pay out-of-pocket. They are also more likely to be surrounded by a high percentage of other residents covered by Medicaid and a low percentage paying out-of-pocket. Black residents are more likely to be in larger homes, for-profit homes, and homes in metropolitan areas.

Individual Vaccinations

Table 2 presents odds ratios from logistic regression models predicting individual vaccinations. In Model 1, black residents are about 20 percent less likely to be vaccinated than their white counterparts, adjusting for resident's age, gender, months in the home, and decision-making ability. There is no significant difference between the white and other racial categories. Model 2 incorporates controls for residents' payment sources. The white-black disparity is robust to this adjustment, decreasing by less than two percentage points. This suggests that race differences in payment sources do not account for vaccine disparities.

Model 3 incorporates the percent black in the home. For each point increase in the percentage of black residents, the odds of vaccination decreases by 1.3 percent. After adjusting for racial composition, there are no longer individual-level race differences in vaccination (i.e., the black coefficient becomes non-significant). Model 4 adjusts for the percentage of residents with given payment sources. The coefficient for percent black is largely robust to this, implying that the association between racial composition and individual vaccination is not explained by differences in composition of payments sources across homes. Model 5 incorporates controls for the home's size, location, and for-profit status. The association between racial composition and vaccination is robust to this adjustment as well.

Model 6 includes the interaction between percent home black and resident black. This term is statistically insignificant, implying that the association between racial composition and individual vaccination does not differ according to residents' race. This does not imply, however, that consequences of segregation are equally distributed. Typical black and non-black residents reside in homes with very different racial compositions. The median value for % Home Black is 0 for non-black residents, but is 41.7% for black residents.

The implication of differences in *exposure* to racial compositions is demonstrated with predicted marginal probabilities at the bottom of the table.[2] Based on Model 6, the predicted marginal probability of vaccination for a resident in a home with no black residents is .722. For a resident in a home where 41–42% of the residents are black, the predicted marginal probability is .644. This implies a .078 reduction in the probability of vaccination if one is in a home with a composition that is typical for black residents rather than a composition typical for non-black residents.

Turning to the control variables in Model 6, the odds of vaccination are higher for residents who are older, have been in the home for longer, have less decision-making ability, and are

[2]Marginal predicted probabilities were obtained by integrating probabilities over the random-intercept distribution using Stata's gllapred command.

in homes in metropolitan areas. For the first month payment sources, the Medicaid (no Medicare) reference group is less likely to be vaccinated than those who paid out-of-pocket. However, in the most recent month, the Medicaid (no Medicare) group is more likely to be vaccinated than those paying out-of-pocket. Medicaid may have initially limited residents' access to higher quality homes with superior vaccination practices, but once sorted into homes, residents with Medicaid coverage have better access to vaccines. In the most recent month, residents covered by Medicare and/or Medicaid are less likely to be vaccinated than the reference group. This is probably because many residents with Medicare coverage recently arrived in the home following treatment in an acute care hospital.

Home Vaccination Rates

To demonstrate how individual vaccine disparities may interact with segregation to create differences in herd immunity, I begin with a simple thought experiment. According to Table 1, 68% of the total sample, 69% of non-black, and 62% of black residents were vaccinated. If people were randomly distributed across homes so there was *zero segregation*, everyone would be in a home with a vaccination rate approximately equal to the rate for the total sample (68%). In this case, everyone would have the same potential to benefit from positive externalities of other residents' vaccinations. Alternatively, if people were *totally segregated*, so that black residents were randomly distributed only among other black residents, and non-black residents among other non-blacks, everyone would be in a home with a vaccination rate approximately equal to the rate for their race group. Blacks would be in homes with about 62% of residents vaccinated, and non-blacks would be in homes with about 69% of residents vaccinated. In this case, there would be about a 7 percentage point difference in the average home vaccination rates for black and non-blacks residents.

We now compare these extreme hypothetical scenarios of zero segregation (which implies no race differences in home vaccination rates) and total segregation (which implies a 7 percentage point difference) to actual observed home-level vaccination rates. In Table 1, the average resident is in a home with 65.4% of the residents vaccinated. The average non-black resident is in a home with 66.1% of residents vaccinated, and the average black resident is in a home with 59.7% of residents vaccinated. We, therefore, observe a 6.5 percentage point difference in home vaccination rates. This is only about .5 percentage points less than the extreme of total segregation. This thought experiment demonstrates that, when susceptibility is unequally distributed by race, and populations are spatially clustered according to race, segregation may interact with dynamics of contagion to create disparities in herd immunity.

Table 3 presents coefficients from regression models predicting home-level vaccination rates. In Model 1, for each point increase in percent home black, the percent vaccinated declines by .173, adjusting for the home's size, location, and for-profit status. Model 2 incorporates the home's payment source composition. The negative association between percent black and percent vaccinated shrinks only slightly to .158, implying that differences across homes in payment source compositions are not driving associations between racial composition and vaccination rates. Model 3 includes all the individual-level variables. The negative association between percent black and percent vaccinated is very robust to this adjustment and increases slightly to .163.

Predicted home vaccination rates at non-black and black median values for percent home black are at the bottom of the table. Based on Model 3, a typical non-black resident is in a home with 70.1% of residents vaccinated, and a typical black resident is in a home with 62.5% of residents vaccinated. A typical black resident is surrounded by a higher proportion of unvaccinated residents, which, all else equal, should increase contact with contagious individuals.

Turning to control variables in Model 3, homes that are for-profit or in metropolitan areas have lower vaccination rates. The percentage of residents covered by Medicaid (no Medicare) and the percentage paying out-of-pocket are both positively associated with home vaccination rates. The individual-level covariates in these models primarily adjust for selection into homes; it is unlikely these resident characteristics direct affects home vaccination rates. It is worth noting, however, that longer-term residents and residents with less decision-making ability tend to be in homes with higher vaccination rates. Residents covered by Medicare and/or Medicaid in the first month tend to be in homes with slightly lower vaccination rates, while residents covered by Medicare and/or Medicaid in the most recent month tend to be in homes with slightly higher vaccination rates.

Vaccine Refusal

Table 4 presents the analysis of vaccine refusal among non-vaccinated residents. Descriptive statistics show that unvaccinated black residents are less likely than white residents to have refused vaccination. In Model 1, which includes only individual-level predictors, there are no significant race differences in the likelihood of having refused vaccination. In Model 2, which incorporates the home-level variables, being in a home with a higher percentage of black residents is negatively associated with having refused vaccination. There is no evidence that refusals are responsible for lower vaccination rates among black residents or in homes with higher percentages of black residents.

Discussion

This analysis demonstrates how segregation can potentially generate dual disease hazards for contagious outcomes. An individual in a nursing home with the typical (i.e., median) racial composition for black residents is 7.8% less likely to have been vaccinated and is in a home with a vaccination rate that is 7.6 percentage points lower than an individual in a home with the typical composition for non-black residents. This suggests that nursing home segregation may (i) increase black residents' susceptibility to flu by reducing their access to personal immunity obtained from vaccination, and (ii) potentially also increase their exposure to flu by reducing their access to group-level immunity obtained from externalities of other residents' vaccinations.

The above analysis of individual vaccinations suggests that differences in institutional environments/quality are important to vaccine disparities (i.e., the second explanation outlined above). There was little evidence that individual behaviors/attitudes were responsible for disparities (i.e., little support for the first or third explanations). Individual-level disparities were eliminated when adjusting for home racial composition. Being black or being in a home with more black residents did not increase vaccine refusals. Finally, racial composition similarly affected both black and non-black residents (i.e., the interaction term was non-significant for vaccination status and refusals). Overall, these results conform to much of the existing work on hospital segregation. They suggest that segregation of health care institutions contributes to race disparities in care, and that institutional racial composition is associated with quality of care, regardless of individual race.

There are various caveats to note and many opportunities for further research. First, the NNHS does not allow me to identify home characteristics or practices that mediate associations between segregation and vaccination. It is worth highlighting that the results were robust to adjusting for individual residents' payment sources and homes' payment source compositions. This suggests that vaccine disparities cannot be directly reduced to residents' or homes' financial and insurance resources (although more complex relationships between resources, institutional quality, and vaccinations may be at work).

Second, selection into homes based on unmeasured resident characteristics is a significant concern. The association between racial composition and vaccination rate was robust to adjusting for residents' characteristics (see Model 3 in Table 3). This supports a causal effect of institutional composition and suggests that the results probably cannot be entirely reduced to individual-level selection. However, bias from unmeasured characteristics remains possible and interpretation should be descriptive. It is useful to briefly resituate these results within a place stratification framework. Segregation usually results from discriminatory mechanisms that sort more or less advantaged people into different quality places. While a source of exogenous variation in who ends up in which nursing home would help identify a "pure" effect of race composition, the external validity and, more importantly, sociological relevance of such variation could be significantly limited. Despite their descriptive nature, the above results provide a useful demonstration of how segregation may shape susceptibility and exposure to infectious agents.

Third, this analysis could not account for regional or other geographic variation. Regional variation could upwardly bias results if black residents were concentrated in regions with low vaccination rates. However, the majority of black nursing home residents are in the South, and the South has relatively high vaccination rates (Bardenheier et al. 2011; if anything, regional variation could slightly downwardly bias estimates). It is also conceivable that consequences of health care segregation may be moderated by local factors (e.g., inequalities, attitudes, etc.). The above results reflect average associations for a national sample and may not apply to particular regions or geographical subunits.

Finally, the NNHS does not identify flu outbreaks within nursing homes. Further research is needed to understand how specific home vaccination rates might shape influenza disease disparities. Rapid mutation of the influenza virus makes it difficult to generalize about epidemic outcomes (Monto et al. 2001, Patriarca et al. 1985). The severity of circulating strains and how well vaccines are matched to them will impact vaccine effectiveness. Outbreaks within nursing homes may further depend on additional factors that I was unable to measure in this study—for instance, the composition of surrounding communities and staff vaccination rates (Shugarman et al. 2006). The effect of vaccination rates on epidemic outcomes is often non-linear and herd immunity may emerge only beyond a given threshold rate (Anderson and May 2006). Disease consequences for vaccine disparities will likely depend on where vaccination rates fall relative to this threshold.

Conclusion: Broader Implications

This analysis examined seasonal influenza vaccinations among nursing home residents, but problems of segregation and immunity should apply to other cases as well. Consider, for instance, a major concern with "reemerging infections": pandemic flu in the general population. Preliminary evidence suggests that, in the spring/summer of 2009, morbidity and mortality from of the novel H1N1 (swine) flu fell disproportionately on black and Hispanic Americans (CDC 2009a and 2009b). While plans for mass immunization and treatment of pandemic flu are yet to be tested, most experts agree that disadvantaged communities of color will be difficult to reach and most susceptible to infection (Hutchins et al 2009). With high degrees of segregation across neighborhoods, schools, and workplaces, most people go through daily life interacting primarily with people of similar racial-ethnic backgrounds. Given likely disparities in susceptibility to pandemic flu, segregation means that minorities are at greater risk of contact with contagious individuals. Thus, as with seasonal influenza and nursing homes, the spatial clustering of populations along racial lines is likely to generate disparities in exposure and spread of pandemic flu. At this point, such an outcome remains conjecture. However, the potential for social structure and inequality to shape dynamics of reemerging infections seems undeniable, and sociological models and theories have the potential to make important contributions in this area.

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Biography

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Table 1

Nursing Home Dissimilarity Index and Sample Means, by Resident Race[a,b]

Nursing home dissimilarity index: 71.1	**Total**	**Black**	**Non-Black**	**Difference**
Resident-Level Variables				
Influenza Vaccination	.682	.619	.691	−.072**
Resident Race:				
White (Reference group)	.862	-------	.979	---------
Black	.120	-------	--------	---------
Other	.018	--------	.021	---------
Age	80.555 (.236)	74.849 (.648)	81.330 (.214)	−6.481***
Female	.714	.634	.725	−.091***
Months in Home	28.571 (.544)	28.681 (1.217)	28.556 (.559)	.125
Makes Daily Decisions:				
Independently (Reference group)	.194	.170	.198	−.028
Modified Independently	.228	.230	.228	.002
Impaired	.396	.397	.395	.002
Highly Impaired	.182	.202	.179	.023
Payment Source First Month:				
Medicaid (no Medicare) (Reference group)	.298	.448	.278	.161***
Medicare and/or Medicaid	.361	.320	.367	−.047*
Out-of-Pocket & Other	.200	.076	.216	−.140***
Unknown Payment Source	.141	.156	.138	.018
Payment Source Most Recent Month:				
Medicaid (no Medicare) (Reference group)	.605	.765	.583	.182***
Medicare and/or Medicaid	.088	.072	.090	−.018
Out-of-Pocket & Other	.193	.047	.213	−.166***
Unknown Payment Source	.114	.116	.113	.003
Home-Level Variables				
% Home Vaccinated	65.370 (.806)	59.667 (2.083)	66.144 (.794)	−6.477**
% Home Black	12.055	47.938	7.184	40.754***

Nursing home dissimilarity index: 71.1	**Total**	**Black**	**Non-Black**	**Difference**
% Home Black*Resident Black	5.730 (.611)	47.938 (2.610)	--------	--------
% Home Medicaid (no Medicare)	59.581 (.845)	69.888 (1.554)	58.182 (.854)	11.706 ***
% Home Medicare and/or Medicaid	8.965 (.433)	8.482 (.750)	9.031 (.443)	−.549
% Home Out-of-Pocket & Other	19.366 (.648)	9.443 (.875)	20.712 (.678)	−11.269 ***
Home Bedsize:				
Less than 50 Beds (Reference group)	.043	.019	.047	−.028 **
50–99 Beds	.287	.208	.297	−.089 **
100–199 Beds	.523	.539	.521	.018
200+ Beds	.147	.234	.136	.098 **
Home Location				
Metropolitan (Reference group)	.753	.845	.740	.105 ***
Micropolitan	.136	.091	.142	−.051 **
Neither Micropolitan nor Metropolitan	.112	.064	.118	−.054 **
Home for Profit	.612	.756	.592	.154 ***
# Individuals [# Homes]	12,501 [1,140]	1,237 [421]	11,264 [1,127]	

Notes:

[a] Standard deviations for continuous variables in parentheses;

[b] * $p<.05$;

** $p<.01$;

*** $p<.001$

Table 2

Odds Ratios from Logistic Regression Models Predicting Individual Influenza Vaccination[a]

	(1)	(2)	(3)	(4)	(5)	(6)
Resident Race:						
Black	.801* (.075)	.784* (.075)	.933 (.096)	.930 (.095)	.930 (.095)	.932 (.160)
Other	.992 (.212)	.987 (.216)	.984 (.215)	.988 (.216)	.998 (.218)	.998 (.218)
% Home Black			.987*** (.003)	.989*** (.003)	.991** (.003)	.991** (.003)
% Home Black*Resident Black						1.000 (.004)
Resident-Level Control Variables						
Age	1.011*** (.002)	1.013*** (.002)	1.013*** (.002)	1.012*** (.002)	1.012*** (.002)	1.012*** (.002)
Female	1.084 (.061)	1.036 (.060)	1.032 (.059)	1.035 (.060)	1.033 (.059)	1.033 (.059)
Months in Home	1.035*** (.001)	1.025*** (.001)	1.025*** (.001)	1.025*** (.001)	1.025*** (.001)	1.025*** (.001)
Makes Daily Decisions:						
Modified Independently	1.370*** (.101)	1.272** (.097)	1.274** (.097)	1.270** (.097)	1.276** (.097)	1.276** (.097)
Impaired	1.734*** (.120)	1.541*** (.110)	1.544*** (.110)	1.540*** (.110)	1.556*** (.111)	1.555*** (.111)
Highly Impaired	1.784*** (.152)	1.610*** (.141)	1.613*** (.141)	1.608*** (.141)	1.621*** (.142)	1.621*** (.142)
Payment Source First Month:						
Medicare and/or Medicaid		1.013 (.075)	1.002 (.074)	1.010 (.075)	1.017 (.075)	1.017 (.075)
Out-of-Pocket & Other		1.269** (.115)	1.250* (.114)	1.237* (.113)	1.232* (.112)	1.232* (.112)
Unknown Payment Source		1.488*** (.163)	1.488*** (.163)	1.506*** (.166)	1.516*** (.167)	1.516*** (.167)
Payment Source Most Recent Month:						
Medicare and/or Medicaid		.326*** (.032)	.327*** (.032)	.338*** (.034)	.337*** (.034)	.337*** (.034)
Out-of-Pocket & Other		.692*** (.057)	.686*** (.056)	.666*** (.056)	.666*** (.056)	.666*** (.056)
Unknown Payment Source		.193*** (.019)	.193*** (.019)	.198*** (.020)	.198*** (.020)	.198*** (.020)
Home-Level Control Variables						
% Home Medicaid (no Medicare)				1.002 (.003)	1.002 (.003)	1.002 (.003)
% Home Medicare and/or Medicaid				.997 (.004)	.998 (.004)	.998 (.004)
% Home Out-of-Pocket & Other				1.007* (.003)	1.006* (.003)	1.006* (.003)
Home Bedsize:						
50-99 Beds					.814 (.124)	.814 (.124)

	(1)	(2)	(3)	(4)	(5)	(6)
100-199 Beds					.743 (.115)	.743 (.115)
200+ Beds					.874 (.207)	.873 (.207)
Home Location:						
Micropolitan					1.235 (.149)	1.235 (.149)
Neither Micropolitan nor Metropolitan					1.434** (.185)	1.434** (.185)
Home for Profit					.848 (.087)	.848 (.087)
Constant	.361*** (.064)	.569** (.103)	.672* (.125)	.529* (.154)	.627 (.192)	.626 (.192)
Random Intercept (Variance)	3.806*** (.183)	3.881*** (.191)	3.832*** (.187)	3.818*** (.186)	3.744*** (.181)	3.744*** (.181)
			Predicted Outcome (Model 6) [$Pr(Y_{ij}=1\|x_{ij},\varsigma_j)$]:		% Black=0 % Black=41-42	.722 .644
# Individuals= 12,501 [# Homes= 1,140]						

*a** p<.05;

** p<.01;

*** p<.001

Table 3

Coefficients from Linear Regression Models Predicting Home Influenza Vaccination Rates[a]

	(1)	(2)	(3)
% Home Black	−.173*** (.043)	−.158*** (.041)	−.163*** (.041)
Home-Level Control Variables			
% Home Medicaid (no Medicare)		.360*** (.046)	.370*** (.043)
% Home Medicare and/or Medicaid		−.055 (.071)	−.024 (.069)
% Home Out-of-Pocket & Other		.371*** (.050)	.377*** (.048)
Home Bedsize:			
50-99 Beds	2.079 (2.400)	−1.684 (1.986)	−1.872 (1.945)
100-199 Beds	−.005 (2.504)	−3.694 (2.049)	−3.539 (2.012)
200+ Beds	6.604 (3.442)	2.459 (3.053)	1.736 (2.976)
Home Location:			
Micropolitan	11.479*** (1.634)	7.499*** (1.592)	7.261*** (1.565)
Neither Micropolitan nor Metropolitan	5.809** (1.787)	4.671** (1.668)	4.604** (1.655)
Home for Profit	−2.891* (1.424)	−3.123* (1.359)	−3.233* (1.348)
Resident-Level Control Variables			
Resident Race			
Black			.565 (.416)
Other			2.195 (2.474)
Age			.046 (.025)
Female			−.170 (.531)
Months in Home			.029*** (.007)
Makes Daily Decisions:			
Modified Independently			1.321 (.846)
Impaired			3.038*** (.839)
Highly Impaired			1.276 (.985)
Payment Source First Month:			
Medicare and/or Medicaid			−2.522** (.905)
Out-of-Pocket & Other			.230 (.875)

	(1)	(2)	(3)
Unknown Payment Source			3.332* (1.488)
Payment Source Most Recent Month:			
Medicare and/or Medicaid			2.402*** (.565)
Out-of-Pocket & Other			.154 (.460)
Unknown Payment Source			1.351* (.561)
Constant	65.366*** (2.627)	41.559*** (4.483)	34.489*** (4.708)
	Predicted Outcome (Model 3) [$Pr(Y_j \mid x_{ij})$]:	% Black=0 % Black=41–42	70.070 62.455
# Individuals= 12,501 [# Homes= 1,140]			

a* p<.05;

** p<.01;

*** p<.001

Table 4

Analysis of Vaccine Refusal among Non-Vaccinated Individuals[a]

Mean Level of Vaccine Refusal among Non-Vaccinated, by Resident Race

Total	Black	Non-Black	Difference
.181	.142	.188	−.046*

Odds Ratios from Logistic Regression Models Predicting Vaccine Refusal among Non-Vaccinated Individuals

	(1)	(2)
Resident Race:		
Black	.808 (.186)	.715 (.303)
Other Race	.338 (.220)	.327 (.214)
% Home Black		.982* (.007)
% Home Black * Resident Black		1.011 (.011)
Resident-Level Control Variables		
Age	1.004 (.005)	1.003 (.005)
Female	.947 (.135)	.929 (.133)
Months in Home	1.029*** (.003)	1.028*** (.003)
Makes Daily Decisions:		
Modified Independently	.857 (.153)	.853 (.152)
Impaired	.643* (.112)	.633** (.110)
Highly Impaired	.402*** (.092)	.402*** (.092)
Payment Source First Month:		
Medicare and/or Medicaid	1.293 (.231)	1.293 (.232)
Out-of-Pocket & Other	1.116 (.269)	1.108 (.266)
Unknown Payment Source	1.951* (.529)	1.972* (.536)
Payment Source Most Recent Month		
Medicare and/or Medicaid	.253*** (.060)	.327*** (.081)
Out-of-Pocket & Other	.385*** (.084)	.417*** (.094)
Unknown Payment Source	.145*** (.035)	.141*** (.037)
Home-Level Control Variables		
% Home Medicaid (no Medicare)		1.003 (.006)
% Home Medicare and/or Medicaid		.975** (.009)
% Home Out-of-Pocket & Other		.992 (.007)
Home Bedsize:		
50-99 Beds		.815 (.269)
100-199 Beds		.938 (.310)
200+ Beds		.702 (.347)
Home Location		
Micropolitan		.992 (.266)
Neither Micropolitan nor Metropolitan		.904 (.228)
Home for Profit		.733 (.157)

Odds Ratios from Logistic Regression Models Predicting Vaccine Refusal among Non-Vaccinated Individuals

	(1)	**(2)**
Constant	.103 *** (.044)	.234 * (.155)
Random Intercept (Variance)	8.507 *** (1.334)	8.072 *** (1.246)
# Individuals= 3,826 [# Homes= 970]		

*p<.05;

**p<.01;

***p<.001