Changes in Childhood Immunization Disparities between Central Cities and Their Respective States, 2000 versus 2006

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ABSTRACT *Central cities have lower childhood immunization coverage rates than states in which they are located. We conducted a secondary analysis of the National Immunization Survey (NIS) 2000 and 2006 of children 19–35 months old for 26 NIS-defined central cities and the rest of their respective states in order to examine patterns in early childhood immunization disparities between central cities and their respective states and the contextual factors associated with these disparities. We examined three measures of immunization disparities (absolute, difference, and ratio of change) and the patterns of disparity change with regard to selected contextual factors derived from the census. In 2000, immunization coverage in central cities was 68.3% and 74.7% in the rest of their states, a 6.4% disparity ($t=3.82$, $p<0.000$). Between 2000 and 2006, the overall city/state disparity narrowed to 3.5%, with the central city coverage up to 78.7% vs. 82.5% for the rest of state ($t=2.48$, $p=0.017$). However, changes in immunization disparities were not uniform: six cities narrowed, 14 had minimal change, and six widened. Central cities with a larger share of Hispanics experienced less reduction in disparities than other cities ($\beta=-4.2$, $t=-2.11$, $p=0.047$). Despite overall progress in childhood immunization coverage, most central cities still show significant disparities with respect to the rest of their states. Cities with larger Hispanic populations may need extra help in narrowing their disparities.*

KEYWORDS *Inner city, Immunization disparities, Childhood immunization*

INTRODUCTION

Central cities, the core areas of metropolitan regions, typically have lower childhood immunization coverage rates than the rest of the states in which they are located.^{1,2} Relatively little is known about the magnitude and trends of these disparities or the contextual factors associated with them. A first step in countering childhood immunization disparities is to identify which cities have reduced or widened their disparities and then map the differences in the characteristics of these cities and their changes in disparity.

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Nationwide, poverty and ethnicity are determinants of immunization status at the individual level. For example, in urban areas, children whose parents are poor, minority, and have lower educational level are less likely to be immunized on time.^{2–11} Yet, it is not known if these same risk factors operate in a contextual manner, affecting low-income communities as a whole, rather than only low-income families within the community. The few studies including contextual factors have shown inconsistent results. An elevated risk of underimmunization has been observed for children living in underserved areas, where insurance or clinic access was limited.^{6,12,13} Factors associated with immunization disparities varied by city and included insurance, number of children in the household, marital status of the parent, and enrollment in the supplemental feeding program for women, infants, and children (WIC).¹⁴ Yet, a few urban areas with high concentration of poor children achieved significant gains in immunization coverage. This was attributed to heightened awareness of the need for immunization by local providers and the positive impact of public health programs, such as WIC-based interventions. The variation in childhood immunization coverage rates among inner city areas needs to be more closely examined to identify the most appropriate strategies for reducing national childhood immunization disparities.

The objective of this study was to assess patterns and trends in early childhood immunization disparities in central cities, in 2000 and 2006. First, we examined disparities in childhood immunization levels for children 19–35 months old between central cities and the rest of their respective states and the change in the central city/state disparity from 2000 to 2006. Next, we assessed the central city/state immunization disparities in relation to the sociodemographics of the population, contrasting central cities with narrowing vs. widening immunization disparities.

METHODS

Study Design

This study is a secondary, comparative analysis of the National Immunization Survey (NIS), contrasting immunization rates for central city areas with those of the rest of the state, in 2000 and 2006. The NIS, conducted annually by the National Immunization Program and the National Center for Health Statistics of the Centers for Disease Control and Prevention, measures vaccination coverage estimates for children ages 19–35 months. It is a random-digit-dialed telephone survey followed by a provider record check. Data are weighted both to account for sample design as well as to reduce nonresponse and noncoverage biases. The NIS provides separate immunization data for 26 central counties or cities which have their own immunization action plans. This central county or city (“metropolitan statistical area”, MSA) is defined by the United States Office of Management and Budget as the city or central county or counties of the metropolitan core, plus adjacent counties with a “high degree of social and economic integration with the central county as measured by commuting.”¹⁵ By convention, these central counties are generally considered to be central cities, and we therefore use the terminology “central city” in referring to these central counties.¹⁵ Where these central city areas were defined, the other areas of the state were defined as “rest of state”.^{16,17} The rest of state is representative of all other areas of the state, including smaller urban, suburban, and rural areas.

Data Sources

We used the published NIS tables reporting on aggregate immunization rates by state and selected urban areas for children aged 19–35 months. We contrasted 2000 and 2006, using the central cities and rest of state areas as defined in 2000.^{18,19} Four of the cities included in 2000 were not included in the 2006 survey due to financial reasons (Birmingham, AL; New Orleans, LA; Columbus, OH; and Nashville, TN), and for these cities, we used 2005 NIS data for both the central city and rest of state, with the exception of New Orleans.²⁰ The 2005 data were used, as opposed to excluding those states, because the purpose of the study was to document change moving forward from 2000. New Orleans did not have data for 2005 or 2006; therefore, it was excluded. Demographic and other socioeconomic data were obtained from the 2000 census to assess the possible compositional effects of central city populations on immunization, using characteristics corresponding to the individual characteristics often found to be associated with incomplete immunization status: African American, Hispanic, age 18 and over who have not completed high school education, and families with incomes below the federal poverty level. All data are displayed as the percent of population with the specified characteristic.²¹

Inclusion Criteria

We included the 26 MSA central cities for which the NIS reported separate coverage rates in 2000, with the exception of New Orleans. Fourteen states had coverage for one central city; five states had two or more. The 26 central cities were: Birmingham, AL; Phoenix, AZ; Los Angeles, San Diego, and Santa Clara, CA; Miami and Jacksonville, FL; Atlanta, GA; Chicago, IL; Indianapolis, IN; Baltimore, MD; Boston, MA; Detroit, MI; Newark, NJ; New York, NY; Cleveland and Columbus, OH; Philadelphia, PA; Nashville and Memphis, TN; San Antonio, Houston, Dallas, and El Paso, TX; Seattle, WA; and Milwaukee, WI. Each central city was considered an independent unit of observation, making it possible for a state to have two or more central cities.

Outcome Measures

We used probability estimates of the annual immunization coverage rate for 19 to 35 months olds living in the designated area for the 4:3:1:3:3 series: four diphtheria–tetanus–acellular pertussis, three polio, one measles–mumps–rubella, three *Haemophilus influenza* b, and three hepatitis B. The 4:3:1:3:3 series was used because it is the most complete series studied in both the 2000 and 2006 NIS. It also reflects completion of the primary immunization series. We did not include varicella and pneumococcal vaccines since those vaccines were more recently introduced.

These coverage rates were used to calculate the following disparity measures: (1) *immunization coverage*, as the reported aggregate estimate of immunization coverage in 2000 and 2006 for the central city and the rest of state. (2) *Central city immunization disparity*: This was the difference between the immunization coverage rates of the central city and the respective rest of state, 2000 and 2006. A negative difference indicated that the coverage in the central city was lower than in the rest of state, while a positive difference indicated the opposite pattern. (3) *Central city disparity change*: This ratio was calculated by dividing the change in immunization rates between 2000 and 2006 for the central city by the change in immunization rates between 2000 and 2006 for the rest of the state. For example, Birmingham had a change of +7.9 points between 2000 and 2006, while the rest of state had a change of +7.1; therefore, the ratio is 1.1, meaning Birmingham had a

ten percent greater reduction in disparities in comparison to the rest of Alabama. Conversely, Jacksonville had a change of +2.8 points while the rest of Florida had a change of +12.2 points, making its ratio 0.23; therefore, Jacksonville had a widening of disparities in comparison to the rest of Florida.

Statistical Analysis

Analysis of variance was used to assess city compositional differences in race/ethnicity, female householder, families below the poverty line, and adult education less than high school. Then, we described the central city disparities using graphic presentations. Next, we analyzed the central city disparity change. The central cities were split into three categories of *central city disparity change*: (1) Widening disparities (less than 1.0 disparity change ratio), (2) little or no change in disparities (1:2 disparity change ratio), and (3) reduction in disparities (2.0 or more disparity change ratio). We assessed intergroup differences in these groups of cities using *t* tests. Finally, we used multiple linear regression analyses to assess the significance of the relation of city sociodemographic composition on the *central city disparity change*. SPSS 14.0 for Windows was used for these tests.

RESULTS

The central city areas differed from the rest of their states in sociodemographic characteristics. The analysis of variance showed that there were significant differences in the proportions of black ($F=10.02$, $p=0.003$), minority ($F=22.0$, $p<0.001$), female householder ($F=16.0$, $p<0.001$), and families below the poverty line ($F=6.3$, $p=0.016$) in the central cities compared to the rest of state. The proportions of Latino and with education less than high school did not differ significantly between the central cities and the rest of the state.

Central City Immunization Disparity

In 2000, the average immunization coverage in central cities was 68.3%, compared with 74.7% in the rest of state, a difference of 6.4% ($t=3.82$, $p=0.000$; Table 1). Fourteen out of the 26 central cities had immunization rates outside the 95% confidence interval of the average for the rest of the state. By 2006, the average central city vs. rest of state gap had narrowed to 3.5%, with the central city coverage up to 78.7%, still significantly lower than the 82.5% for the rest of state ($t=2.48$, $p=0.017$). This convergence is also seen in the reduction from 14 to seven central cities with immunization rates outside the 95% confidence interval of the average for the rest of state. In 2000, nine central cities had immunization rates equal to or exceeding the rate for their respective rest of state (range 0 to 6.7). There were five central cities with a greater than 0–4.9% immunization disparity (range –0.7 to –3.9), five with a 5–9.9% disparity (range –6.5 to –9.8), and seven with disparities of 10% or more (range –10.0 to –19.8).

As shown in Figure 1, in 2006, eight cities had immunization rates equal to or exceeding the rates in the rest of the state (range 0.1 to 4.3), ten cities had a greater than 0–4.9% gap (range –0.8 to –4.7), six had a 5–9.9% gap (range –5.4 to –8.1), and only two had a disparity of 10% or more (range –13.7 to –15.4). Central city immunization coverage exceeded that found in the rest of the state in Cleveland, San Diego, Birmingham, Nashville, Columbus, Los Angeles, Indianapolis, and Santa Clara. In the remainder of the central cities, immunization coverage lagged behind the rest of the state, with two cities, New York and Detroit, having immunization

TABLE 1 Immunization coverage rates and disparities for central cities and states, 2000 and 2006 (%)

State and central city	2000		2006	
	Coverage total	Central city disparity	Coverage total	Central city disparity
Alabama				
AL—City of Birmingham ^a	77.6±5.2	1.8	85.5±5.9	2.6
AL—rest of state	75.8±5.5		82.9±6.1	
Arizona				
AZ—City of Phoenix	64.8±6.1	−6.5	72.9±6.0	−5.4
AZ—rest of state	71.3±6.4		78.3±6.5	
California				
CA—City of Los Angeles	72.6±5.4	0.4	81.3±5.7	1.5
CA—City of San Diego	72.2±5.5	0.0	82.8±5.1	3.0
CA—City of Santa Clara	72.2±6.0	0.0	79.9±5.7	0.1
CA—rest of state	72.2±5.6		79.8±7.1	
Florida				
FL—City of Jacksonville	76.7±5.3	6.4	79.5±5.1	−3.0
FL—City of Miami	77.0±6.6	6.7	81.7±5.8	−0.8
FL—rest of state	70.3±5.8		82.5±5.1	
Georgia				
GA—City of Atlanta	77.1±5.5	−0.7	82.6±6.3	−0.8
GA—rest of state	77.8±5.5		83.4±5.3	
Illinois				
IL—City of Chicago	60.7±6.4	−14.6	79.0±5.7	−1.0
IL—rest of state	75.3±6.1		80.0±7.6	
Indiana				
IN—City of Indianapolis	61.9±7.1	−12.1	79.7±5.7	0.2
IN—rest of state	74.0±5.7		79.5±6.5	
Maryland				
MD—City of Baltimore	66.8±5.8	−10.0	76.0±7.1	−4.7
MD—rest of state	76.8±5.4		80.7±6.2	
Massachusetts				
MA—City of Boston	74.6±5.6	−7.6	85.3±4.7	−1.8
MA—rest of state	82.2±4.8		87.1±5.0	
Michigan				
MI—City of Detroit	56.4±7.3	−19.8	66.3±7.1	−15.4
MI—rest of state	76.2±5.5		81.7±5.4	
New Jersey				
NJ—City of Newark	61.8±6.7	−9.8	71.2±6.7	−8.0
NJ—rest of state	71.6±5.5		79.2±6.4	
New York				
NY—City of New York	66.2±6.2	−11.5	76.4±6.2	−13.7
NY—rest of state	77.7±5.1		90.1±4.3	
Ohio				
OH—City of Cleveland	66.8±6.1	−2.1	85.1±5.5	4.3
OH—City of Columbus ^a	71.1±5.9	2.2	85.9±6.2	2.1
OH—rest of state	68.9±6.4		2005: 83.8±5.7 2006: 80.8±5.6	
Pennsylvania				
PA—City of Philadelphia	70.8±5.3	−8.2	78.8±6.7	−7.4
PA—rest of state	79.0±5.3		86.2±5.7	

TABLE 1 *Continued*

State and central city	2000		2006	
	Coverage total	Central city disparity	Coverage total	Central city disparity
Tennessee				
TN—City of Nashville ^a	68.5±6.1	−10.0	86.6±6.1	2.5
TN—City of Memphis	75.6±5.6	−2.9	76.1±6.7	−6.9
TN—rest of state	78.5±5.6		2005: 84.1±5.6 2006: 83.0±6.4	
Texas				
TX—City of San Antonio	65.6±5.8	1.6	76.8±6.6	−0.8
TX—City of Houston	60.1±6.6	−3.9	73.8±5.9	−3.8
TX—City of Dallas	62.0±6.0	−2.0	76.6±6/7	−1.0
TX—City of El Paso	67.1±5.5	3.1	71.4±5.8	−6.2
TX—rest of state	64.0±6.0		77.6±5.2	
Washington				
WA—City of Seattle	66.9±6.1	−7.7	75.7±8.7	−3.1
WA—Rest of State	74.6±5.3		78.8±6.3	
Wisconsin				
WI—City of Milwaukee	62.9±6.7	−14.7	80.4±6.7	−8.1
WI—rest of state	77.6±5.3		88.5±4.5	
Central cities (averaged)	68.3		78.7	
Rest of state (averaged)	74.7		82.5	

Source: National Immunization Survey,^{18,19} coverage for 4:3:1:3:3 series
^a2005 National Immunization Survey²⁰ data used

rates 10% or more below that observed in the rest of the state. Four central cities that had higher immunization rates than the rest of the state in 2000 reversed course and had rates lower than the rest of state in 2006 (Miami, Jacksonville, San Antonio, El Paso). For example, El Paso had an immunization rate in 2000 that was over 3 percentage points higher than the rate for the rest of Texas, but in 2006, its rate was over 6 percentage points lower than that for the rest of the state.

Central City Disparity Change

Between 2000 and 2006, all central cities and the rest of their respective states had improved their childhood immunization rates. While on average central cities increased their immunization rates 1.4 times more than the rest of state, this average is brought up by five central cities whose immunization rates went up by 17.5 or more percentage points: Cleveland, Chicago, Nashville, Indianapolis, and Milwaukee. The average increase was 10.4%.

In Figure 2, we ranked and plotted the central city disparity change for 2000 to 2006. The 26 central cities are grouped into the three categories. Six central cities had widening immunization disparities relative to the rest of the state: Memphis, Jacksonville, El Paso, Miami, San Antonio, and New York. Fourteen central cities kept even with immunization rate gains of the rest of the state: Atlanta, Columbus, Santa Clara, Houston, Dallas, Birmingham, Philadelphia, Los Angeles, Phoenix, Cleveland, Newark, San Diego, Milwaukee, and Detroit. Six central cities outpaced the rest of state in their improvement to immunization coverage: Seattle, Boston, Baltimore, Indianapolis, Nashville, and Chicago.

*2005 National Immunization Survey data used

FIGURE 1. Disparities between central city and rest of state immunization coverage rates, 2006.

When the central city disparity change was linked to the proportions of the population individually at risk for underimmunization, the patterns of immunization coverage change correlated with the composition of their populations. Analysis of variance showed that two of the individual risk factors generally associated with underimmunization, ethnicity and poverty, are associated with the observed pattern

FIGURE 2. Change in the immunization disparity ratio 2000 to 2006 (central city vs. rest of state).

of reductions (Table 2). However, when we used multiple linear regression to control for the simultaneous influences of these compositional factors on the immunization disparity change ratio, the only compositional factor associated with the reduction in immunization disparity was Hispanic ethnicity (Table 3). Central cities which had a larger proportion Hispanic in 2000 were significantly less likely to reduce their immunization disparity by 2006 ($\beta = -4.2$, $t = -2.11$, $p = 0.047$).

DISCUSSION

While all central cities improved their immunization coverage rates between 2000 and 2006, not all improved their coverage at the same pace as the rest of the state. Only six of the 26 central cities “beat the odds”, with immunization coverage rate improvements exceeding those of the rest of their state. The remaining cities, the large majority, only kept pace with or fell behind the immunization rate gains experienced in the rest of the state during this time period.

These differences in immunization rate gains relative to the rest of their state were not associated with the compositional differences of race or poverty, two individual risk factors associated with underimmunization. When we controlled for ethnicity and education, poverty was no longer a significant predictor of immunization disparities. This suggests that poverty alone is not a barrier to success in raising city immunization coverage rates. Similarly, we showed that the disadvantages often shown at an individual level, namely being African American, low levels of education, or single parent families, do not play a role in determining the citywide progression toward elimination of immunization disparities. This finding is important, because it underscores the importance of distinguishing between individual and community risk. While we continue to reach out to low-income, minority families wherever they live, there is no evidence to suggest that communities that are impoverished or have high concentrations of African American

TABLE 2 Population characteristics of central cities in 2000 by change in the immunization disparity ratio, 2000–2006

Change in immunization disparity ratio	Percent African American	Percent Hispanic	Percent of adults with less than high school education	Percent of families with incomes below poverty
Widening disparity, ratio <1	21%	37%	25%	15%
None or minimum change, ratio 1–1.99	25%	17%	21%	11%
Narrowing disparity, ratio ≥2	21%	9%	18%	9%
Total	23%	20%	21%	12%
F (p)	0.27 (0.766)	4.2 (0.028)	2.3 (0.121)	4.5 (0.022)

TABLE 3 Central city characteristics predicting immunization disparity reduction

Characteristics of central cities, 2000	Disparity reduction (2006 vs. 2000)		
	Beta	<i>t</i>	Significance
% African American in city population	−2.78	−1.44	0.164
% Hispanic in city population	−4.18	−2.11	0.047
% Persons >15 without HS education	11.14	1.48	0.153
% Families w. income ≤ poverty level	−8.67	−1.05	0.308
Constant	1.52	1.89	0.073

$R^2=0.281$

families cannot attain national immunization goals. The huge gains demonstrated by the cities of Baltimore and Chicago, both with large African American and poor populations, attest to the power of cities to help their families overcome barriers to timely immunizations.

Although nationwide Hispanic children have made gains in their immunization coverage,²² our analysis shows that Hispanic ethnicity plays a different role as a contextual or community-level factor. Central cities with higher concentrations of Hispanics made slower progress in eliminating the central city-state disparity. Few if any studies have documented the citywide disadvantage associated with large Latino populations. Many factors could explain this contextual relation. The cities with high proportions of Hispanic families could have more medically underserved neighborhoods; they might have health systems which, perhaps unintentionally, impose additional barriers on the delivery of immunizations. Cities with large Hispanic populations are likely to have more recent immigrants, for whom access and use of primary care is problematic.²³ Children of immigrant parents have been shown to be less likely to have routine primary care.^{24,25} Finally, these cities might have health care systems which reflect hidden ethnic biases such as language barriers or cultural patterning of health care delivery, as documented in the Institute of Medicine report, whereby minorities receive a lower quality of care than nonminorities.²⁶

The findings from our study indicate that central cities do differ in how effective they are at mobilizing their central cities for childhood immunizations. Some cities clearly were better able to do this than others. These analyses can be used to guide future investigations into the programmatic and other contextual factors which enabled the cities which “beat the odds” to mobilize to ensure that all children are immunized on time. A better understanding of how Cleveland, Chicago, Nashville, Indianapolis, and Milwaukee mobilized to increase their immunization rates by 17.5 percentage points or more, above the average of 10.4% gains in the rest of state areas may help identify better practices for others to emulate. At the same time, we also need to examine the difficulties experienced in Memphis, Jacksonville, El Paso, and Miami in order to identify the community-level barriers that kept immunization coverage gains at such a low level compared to the rest of the state. For example, examining whether expansion of Vaccines for Children coverage might have played a role or the impact of other early childhood programs such as WIC or Head Start may be helpful.

This study has several limitations. This is a contextual study, where individual differences were not controlled. The compositional analysis used in our study may not fully reflect the sociodemographic heterogeneity in central cities, which could further influence immunization coverage. Not all central cities were included in our

study, which was limited to the 26 cities for which NIS reports separate immunization data as a subsample of the rest of the state. Likewise, immunization data were not available in 2006 for all cities surveyed in 2000. Because of the nature of the NIS sampling, we could not distinguish inner city areas within the NIS central city designation, although our analysis of variance did confirm that the areas we designated as central cities were in fact significantly more disadvantaged in terms of concentrations of poverty and low-income populations. The sample sizes of some of these central cities were small due to the design of the NIS, which increases the variance of the immunization coverage estimate for the central cities.^{16,27} Another limitation is the overlapping of confidence intervals when looking at absolute differences between central cities and the rest of states; this makes less of a difference in looking at the change ratio since the confidence intervals in 2000 and 2006 are for the most part the same. Caution is needed for interpreting the rankings of central city immunization differentials, because these rankings do not explicitly control for possible differences in sampling variability for the central city vs. rest of state areas.²⁸ By nature of the NIS methodology, there is potential for lower response rates in the central city areas, such as is often found in household and telephone surveys in urban areas. A related problem is the possible exclusion of families who only rely on cell phones, who were not eligible for inclusion because the sampling frame did not include cellular telephones.¹⁶ Another factor which might affect response rate might be the proportion of undocumented families which is higher among Latino communities; they may be less likely to have landline phones and, if sampled, may be hesitant to take part in a national survey.²⁹ Finally, we cannot account for potential confounders such as regional vaccine shortages, nor the impact of changes in Advisory Committee on Immunization Practices recommendations between 2000 and 2006. Although the 4:3:1:3:3 series itself did not change, the addition of new vaccines could have caused providers to postpone some vaccines if parents were concerned by the number.

Our findings suggest that community context plays a role in influencing the pace of immunization disparity reduction. The dynamics of immunization disparity reduction appear to differ for central cities and states, and what happens at the state level may not penetrate to the central city and vice versa. Concepts of social epidemiology and urban health have been used to explain contextual influences on a wide range of health behavior outcomes, and they could be useful for exploring the city-state dynamics of immunization delivery and disparity reduction.³⁰ Our study included only very general contextual features, such as ethnicity and poverty distribution, but future studies could include a more diverse set of contextual variables that would better model the hypothesized dynamics of community influence on immunization rates. These analyses need to be informed by qualitative studies of the processes by which certain cities narrowed their immunization disparities while others were hampered in achieving immunization coverage gains. Did these two groups of cities differ in perceived access to care or ease of obtaining immunizations? Do minorities in these cities have a different quality of access whereby they feel “entitled” to be users? Answers to these and related questions could inform city and state-specific policies to level the playing field and make it possible for all children to receive their immunizations on time, regardless of where they may live. As is evidenced by some of the limitations we have encountered in our study, efforts also are needed to improve the systems for tracking immunization coverage among the communities with children at high risk for underimmunization, namely the poor and minority populations of the central cities.

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