Title: Recent Trends in Influenza Vaccination Disparities Among Texas Children.

Authors: Lloyd Potter[1], Corey S. Sparks, Ph.D.[1, 2], Bradley Pollock[2,]

[1]Department of Demography, the University of Texas at San Antonio
[2]Department of Epidemiology and Biostatistics, the University of Texas Health Science Center at San Antonio

Keywords: Influenza, vaccination, disparities, low income, minority populations

Abstract: Adequate immunization of children protects them common infections and may serve as an indicator of access to health care. Racial and ethnic differentials in immunization of children may suggest differentials in access to health care.
Objectives: This research describes racial and ethnic differences in childhood influenza immunization coverage and identifies social and economic characteristics associated with these immunization differentials in Texas.
Methods: Using data from the National Immunization Survey racial and ethnic differences in seasonal influenza immunization among children is examined as related to social and economic characteristics of children in Texas over the period of 2004 to 2009.
Results: Findings suggest the presence of expected differences in childhood seasonal influenza immunization for Hispanic and non-Hispanic black children compared to non-Hispanic white children. Education and marital status of the mother are predictors of influenza immunization as is participation in WIC.
Conclusions: Implications of findings suggest the need for qualitative research to better understand barriers to immunization that differentially affect minority children in Texas. Addressing racial and ethnic immunization differentials among children may potentially result in reductions in other racial and ethnic health disparities as they age.

Introduction

Immunizations have been a keystone of pediatric preventive care for years, especially for infectious disease prevention in infants and young children. Adequate immunization of young children according to the required recommendations has been identified to help protect the children from many common infections. In recent years the U.S. has sustained high and relatively stable levels of childhood immunization in its quest to achieved one of the overarching goals of the *Healthy People 2010* to increase immunization coverage among all children [1]. As immunization begins at such young ages and because it relies on access to health care, differentials in immunization coverage by race and ethnicity may be an indicator of other health related differentials as children age.

Recent work has detailed the differences in overall vaccination coverage of US children[1, 2]. Other studies [3] show high rates of immunization coverage in US children, when using the 4:3:1:3:3:1 vaccine series. Despite high levels of total coverage, Zhao and colleagues still found significant disparities by race/ethnicity and poverty level. Hispanic children have been shown to have lower vaccination rates than non-Hispanic white children (Darling et al. 2005) Despite our knowledge of these disparities in the 4:3:1:3:3:1 vaccination series, less work has been devoted to understanding disparities in seasonal influenza vaccination in children [4, 5]. Bhat and colleagues [6] document that influenza death rates are highest among children under age 1, and they highlight the importance of influenza vaccinations in young children. In addition the CDC recommends children as young as six months be vaccinated against seasonal influenza.

Between 2000 and 2010, Texas had the sixth fastest population growth rate and the highest total numerical gain[7]. In addition, Texas has the second largest Hispanic population, behind only California[7]. Approximately 65% of the population growth in Texas between 2000 and 2010 can be attributed to growth of the Hispanic population and among persons aged 19 years and less, almost

97% of the growth is the result of population increases among Hispanics (Citation). Texas ranks seventh in the nation in terms of child poverty, and twelfth in the nation in terms of poverty among Hispanics (citation). Both of these factors put children at risk of lower vaccination coverage for the 4:3:1:3:3:1 vaccination series[2, 8].

The rapid population growth in Texas and in particular in the young Hispanic population of Texas combined with the lack of published work detailing disparities within the state in seasonal influenza vaccination coverage provides is the motivation for this study. Thus we examine the disparities in Texas in seasonal influenza vaccination coverage among children of various racial and ethnic and income groups between 2004 and 2009.

Data

We use data from the public use data files of the National Immunization Survey (NIS) from 2004 to 2011 for this study. This NIS is conducted annually by the Centers for Disease Control and Prevention to estimate vaccination coverage rates among children between the ages of 19 and 35 months. The survey relies on a random digit dialing telephone survey to screen households with children, and a follow-up mail survey of the child's immunization provider. Further details of the NIS survey protocol and sampling methods can be found elsewhere[9].

The outcome variable we examine is whether the respondent's child had received a seasonal influenza in during the year when the survey was conducted. Children who were not age-eligible for the vaccination were eliminated from the analytical dataset. Our focus is upon understanding patterns of disparities in Texas; therefore only children residing in Texas at the time of the survey were included in the analysis.

We consider three race/ethnic groups and two income groups. The race/ethnic categories are measured in the NIS by a respondent self-report. These groups

are Non-Hispanic White (NHW), Non-Hispanic Black (NHB) and Hispanic. The "Other" racial group has too few cases for meaningful analysis and are not included in this analysis. To construct income groups, the NIS poverty status variable is used and dichotomized into those below poverty and those above poverty. Other maternal and household characteristics considered include maternal education, maternal age and family WIC participation. Maternal education is operationalized as two dummy variables indicating whether the child's mother had less than or greater than a High School education, with a High School education being the reference group. Maternal age is likewise operationalized as two dummy variables indicating if a child's mother was less than 19 years old, 20 to 29 years old or older than 30 (the reference group). Finally, previous research on vaccination in low income children has pointed to the use of the Supplemental Nutrition Program for Women, Infants and Children (WIC) as one mechanism to increase vaccination coverage[10, 11]. This is included in the analysis using WIC usage in the past year as a predictor.

Methods

To examine vaccination disparities by race/ethnicity and poverty status, two analytical approaches are used. First, a stratified rate comparison between racial/ethnic and income groups in each of the years in the study period is conducted. This analysis is designed to highlight the population trends in influenza vaccination across the study period. To do this, yearly vaccination rates for each race/ethnicity and poverty status group are calculated using the survey library [12] in R[13]. This is used to estimate the proportions of each ethnic and income group that had a seasonal influenza vaccination, taking into account the stratified nature of the NIS sampling design, and appropriate population sampling weights. Once these yearly rates are calculated, temporal trend analysis using a robust linear regression model is used to visualize the observed trend in these state-level rates across the time period.

The second analytical method is a survey design corrected logistic regression model. This model is constructed to test for the effects of race/ethnicity, net of maternal characteristics and poverty status. The model is specified in three stages, the first considering only the effects of race/ethnicity on the log-odds of having been vaccinated, the second model adds the effects of maternal characteristics to the model, and the third specification adds the effects of household socioeconomic conditions to the model. Again, the survey library in R is used to estimate all model coefficients once survey design effects and sampling weights have been included.

Results

Table 1 provides the seasonal influenza rates for each racial/ethnic and socioeconomic group. The rates for some groups were not able to be estimated due to lack of cases in the data. On average, the influenza vaccination rates in Texas have increased over the study period. Figures 1 and 2 demonstrate the temporal trend analysis of the rates from Table 1.

Table 1. Seasonal Influenza immunization rates for the race/ethnic groups and poverty levels described in the text.

Year	Non-Hispanic White, Not in Poverty, % (95% CI)	Non-Hispanic White, In Poverty % (95% CI)	Hispanic, Not in Poverty, % (95% CI)	Hispanic, In Poverty % (95% CI)	Non-Hispanic Black, Not in Poverty, % (95% CI)	Non-Hispanic Black, In Poverty % (95% CI)
2004	16.8 (10.4 – 23.1)	31.2 (5.9 – 32.8)	14.8 (8.1 – 21.5)	17.4 (2.0 – 32.7)	5.6 (0.1 – 11.0)	NA (NA)
2005	51.2 (41.8 – 60.6)	8.9 (0 – 23.9)	25.9 (18.0 – 33.9)	17.9 (9.9 – 26.1)	6.4 (0.5 – 12.2)	44.1 (12.1 – 76.0)
2006	46.2 (36.9 – 55.6)	NA (NA)	28.4 (16.9 – 39.9)	18.9 (12.4 – 25.3)	24.4 (6.7 – 42.0)	9.5 (0 – 20.3)
2007	41.8 (30.7 – 52.9)	4.1 (0 – 9.5)	36.7 (23.9 – 49.5)	20.4 (10.4 – 30.3)	18.2 (1.2 – 35.1)	24.1 (4.1 – 43.9)
2008	47.3 (35.6 – 59.1)	23.2 (0 – 49.6)	36.4 (24.2 – 48.7)	23.8 (14.6 – 33.0)	31.3 (12.6 – 50.1)	34.9 (4.2 58.1)
2009	56.5 (43.7 – 69.4)	7.1 (0 – 18.5)	41.7 (28.6 – 54.9)	24.1 (16.1 – 32.1)	34.9 (14.1 – 55.8)	20.2 (5.9 – 34.5)
2010	50.0 (38.6 –61.4)	28.5 (0 –57.5)	41.4 (30.9 –51.9)	32.4 (23.6 –41.3)	31.9 (13.7 –50.1)	28.7 (9.5 –48.0)
2011	61.8 (51.0 –72.5)	30.7 (9.4 –52.1)	32.3 (20.5 –44.1)	30.3(22.1 –38.4)	47.1 (26.8 –67.4)	34.1 (13.5 –54.6)

Figure 1a-1d. Trend in Influenza Vaccination Rates for Non-Hispanic Whites, Non-Hispanic Blacks and Hispanics by Poverty Status, 2004-2011. 1a Difference Between NHW and NHB, Not in Poverty; 1b Difference Between NHW and NHB, in Poverty; 1c Difference Between NHW and Hispanics, Not in Poverty, and 1d Difference Between NHW and Hispanics, in Poverty. Intervals Represent 90% Confidence Intervals for the Regression Lines.

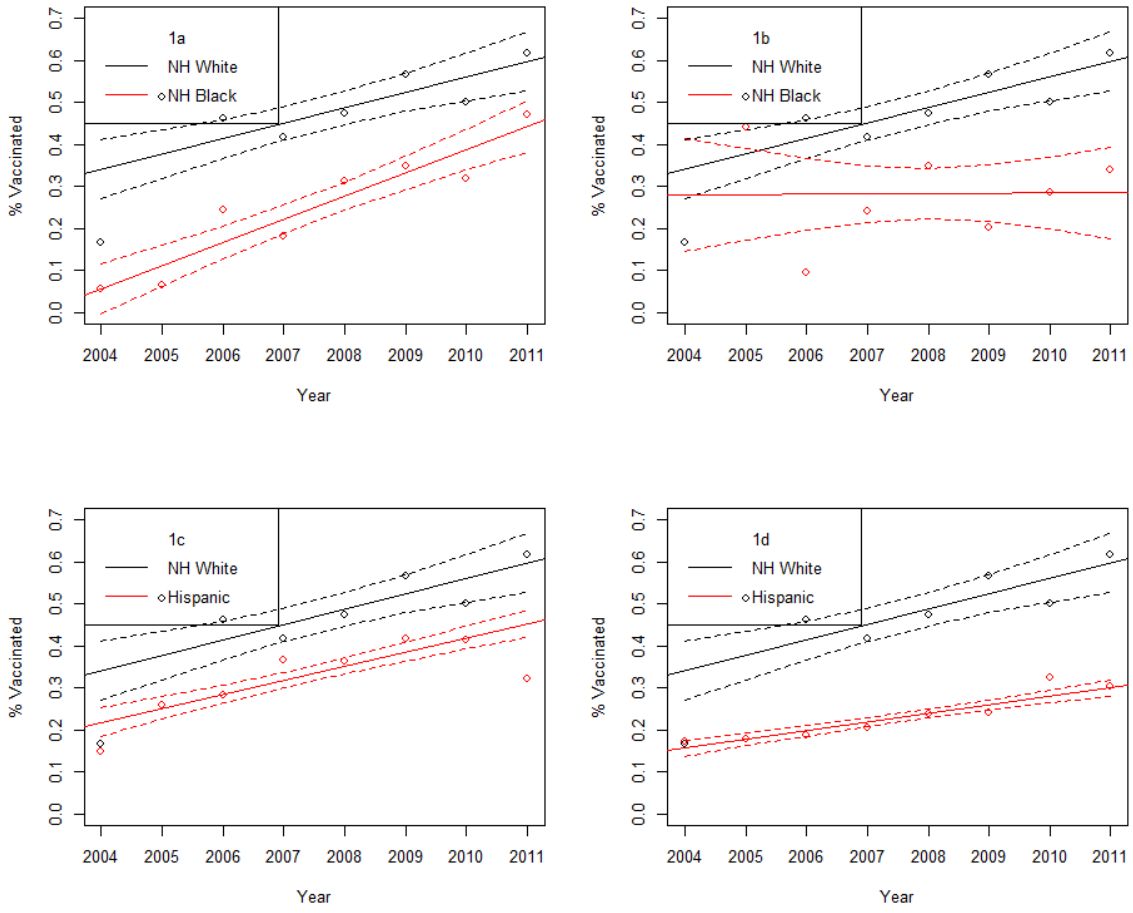


Figure 1a illustrates the gap between NHW and NHB children, not in poverty, in immunization coverage over the period. There is a significant gap in coverage rates between NHW and NHB children, and this gap persists over the period, with little change. When NHB children in poverty are compared to NHW children living above the poverty line in Figure 1b, we see that the disparity between these two groups widens over the period.

Figure 1c illustrates the comparison between NHW and Hispanic children both living above and below (1d) the poverty line. Figure 1c shows again, that both

groups living above the poverty line have increasing vaccination coverage over the period, but there is a divergence between the NHW and Hispanic children. Figure 1d illustrates a substantial divergence when NHW children above poverty are compared to Hispanic children living below poverty. Indeed the latter group shows little to no increase in their vaccination coverage over the period.

Table 2 presents the results of the individual-level analysis of influenza vaccination.

Table 2. Results of Logistic Regression Analysis of Seasonal Influenza Vaccination Outcome

	Base Model Odds Ratio (95% CI)	Base + Mother Odds Ratio (95% CI)	Base + Mother + SES Odds Ratio (95% CI)
Year	1.17(1.13 – 1.22)	1.16 (1.11 – 1.20)	1.16 (1.12 – 1.21)
Race/Ethnicity			
NH White (ref)	1.00	1.00	1.00
Hispanic	0.47 (0.38 – 0.58)	0.63 (0.50 – 0.80)	0.78 (0.61 – 1.18)
NH Black	0.43 (0.31 – 0.59)	0.57 (0.41 – 0.79)	0.68 (0.48 – 1.03)
Mother's Characteristics			
Age <19	-	0.64 (0.36 – 1.12)	0.67 (0.38 – 1.19)
Age 20-29	-	0.72 (0.59 – 0.89)	0.80 (0.64 – 1.00)
Age 30 +	-	1.00	1.00
< HS Edu	-	1.29 (0.96 – 1.75)	1.39 (1.03 – 1.88)
HS Edu (ref)	-	1.00	1.00
> HS Edu	-	1.65 (1.25 – 2.10)	1.33 (1.01 – 1.77)
Unmarried (Ref)	-	1.00	1.00
Married	-	1.62 (1.30 – 2.09)	1.46 (1.14 – 1.86)
Household Economic situation			
Below Poverty Line	-	-	0.85 (0.66 – 1.10)
Ever used WIC	-	-	0.58 (0.45 – 0.76)
Model Deviance	5,765	5,585	5,537
χ^2-test (vs. previous model)		χ^2 = 35.8, 5 df	χ^2 = 47.7, 2 df

Three models are presented: a base model with only time and race/ethnicity, a second model which adds the effects of mother's characteristics, and a final full model which controls for poverty level of the household and WIC usage.

Likelihood ratio tests are shown to examine model improvement across the three models. Similar to the results from the aggregate, data, there is an average increase in the odds of a child having received the influenza vaccine over time (16% higher odds in each year after 2004), and significant disparities between Hispanic and NHB children, when compared to whites. Hispanic children had 53% (95% CI 62%-42%) lower odds of receiving the vaccine, and NHB children had 59% (95% CI 69%-41%) lower odds than NHW children. When mother's characteristics are controlled, the disparities still persist, but diminish with Hispanic children having 37% lower (95% CI 50%-20%) and NHB children having 43% lower (95% CI 59%-21%) odds than NHW children of having received the vaccine. The largest impact of the maternal control variables is mother's education, where children with a mother with more than a high school education had a 65% higher (95% CI 25%-110%) odds of receiving the vaccine compared to a child whose mother only had a high school education. The final model shows that after controlling for household poverty status and WIC usage, the disparities between the race/ethnic groups become insignificant, despite the effect of WIC reducing the odds of being vaccinated. This relationship is problematic, however, since WIC is a means-based program, and there is a high correlation between using WIC and being below the poverty line. To tease this collinearity apart and to examine how WIC affects the odds of immunization in the racial/ethnic minority groups, two subsequent models are fit, one considering just the impacts of poverty and WIC separately, and the other considering the interaction between WIC use and race/ethnicity.

Table 3. Results of Logistic Regression Analysis of Seasonal Influenza Vaccination Outcome Highlighting Effects of Poverty Status and WIC usage.

	Base* + Poverty Odds Ratio (95% CI)	Base* + WIC Odds Ratio (95% CI)	Base* + WIC*race Odds Ratio (95% CI)
Year	1.17 (1.12 – 1.22)	1.16 (1.11 – 1.20)	1.16 (1.11 – 1.21)
Race/Ethnicity			
NH White (ref)	1.00	1.00	1.00
Hispanic	0.67 (0.53 – 0.85)	0.76 (0.59 – 1.00)	0.63 (0.45 – 0.87)
NH Black	0.59 (0.43 – 0.82)	0.67 (0.48 – 0.94)	0.41 (0.24 – 0.69)
Household Economic situation			
Below Poverty Line	0.76 (0.60 – 0.97)	-	-
Ever used WIC	-	0.56 (0.43 – 0.73)	0.40 (0.26 – 0.61)
Interaction term			
WIC* Hispanic	-	-	1.63 (0.96 – 2.76)
WIC*NH Black	-	-	2.64 (1.28 - 5.43)

* Controlling for maternal characteristics.

When each term is considered separately, as seen in Table 3, it is evident that the two predictors have different impacts on the racial/ethnic disparities. The poverty variable has the expected impact of lowering the odds of vaccination when taken by itself, and the disparities between NHW and Hispanics and NHB are maintained but reduced. When WIC is considered by itself, the disparities between both Hispanics and NHW become insignificant, although the effect of WIC itself is still to lower the odds of immunization. The interaction term between WIC and race/ethnicity shows that the when Hispanic and NHB children participate in WIC, the odds of receiving seasonal influenza vaccine are increased (while only marginally for Hispanic children) relative to NHW children, and for NHB children the effect is particularly significant.

Discussion

Results from other authors have described how vaccination coverage in the US has increased over the last decade [1, 2], and how for some groups, disparities in general vaccination rates have been maintained, while others have decreased. Little work has been done describing how these disparities function in terms of seasonal influenza vaccination in children, although some work has described

these effects in adults and the elderly [4, 10, 14, 15]. Still, these results are generally presented for the entirety of the US, and little has been done focusing on regional or state-specific analyses, despite the fact that local and state policies toward vaccination are often key determinants of their use.

Using data from the National Immunization Survey we examined the temporal trend in seasonal influenza vaccination disparities between the main race/ethnic groups in Texas. Results point to how NHB and Hispanic children continue to have lower vaccination rates than their NHW peers, and that children in these racial/ethnic groups who live below the poverty face additional disadvantages when compared to NHW children not living in poverty. The explanation of the mechanism by which these disparities are maintained in Texas, as in many areas of the country, is likely multifaceted. As described in the national setting[3], accessibility to adequate healthcare for poor populations is often an issue that is difficult to overcome, likewise discrimination based on race/ethnicity[16] or language [17, 18] may also play a role in many circumstances[19]. Conceptual models of health disparities, highlight that factors influencing such disparities are often multi-level in nature. The effects of being a minority, or living below the poverty are only compounded by the physical surrounding and residential location [20, 21]. Without data that would allow for these issues to be operationalized, we will lack clarity about the primary mechanisms for development and maintenance of such disparities.

Our finding that participating in certain programs, notably WIC, may suggest one mechanism by which minority racial/ethnic groups can overcome the disparity in immunization coverage[10, 11]. This effect is particularly significant in Texas, when compared to the rest of the US (results not shown, but available from the authors), where the effects of WIC participation significantly reduces the odds of vaccination, the same interactive effects are not found, and the disparities between NHW, Hispanics and NHB are still observed.

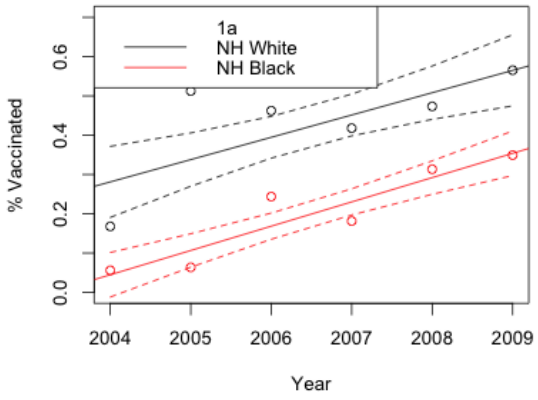
A better understanding of the racial and ethnic disparities in childhood seasonal childhood influenza vaccination may be needed to develop efforts to increase coverage among minority children in Texas. Conducting qualitative research among parents may lead provide insight regarding the racial and ethnic differences we see in vaccination coverage. Knowing more about the barriers that parents experience when it comes to vaccination of their children that differ by race and ethnicity may lead to the development and implementation of efforts to reduce vaccination disparities. Additionally, such knowledge may also lead to better insight into strategies to reduce other race and ethnic health disparities.

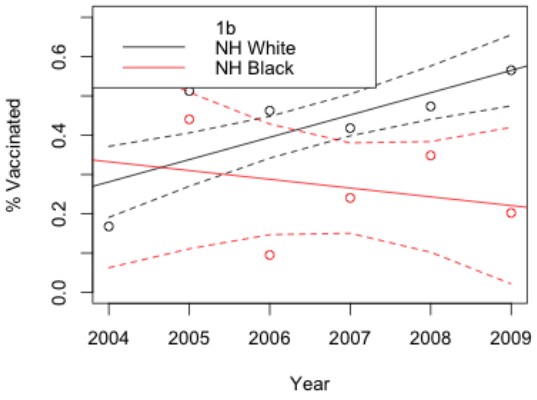
References

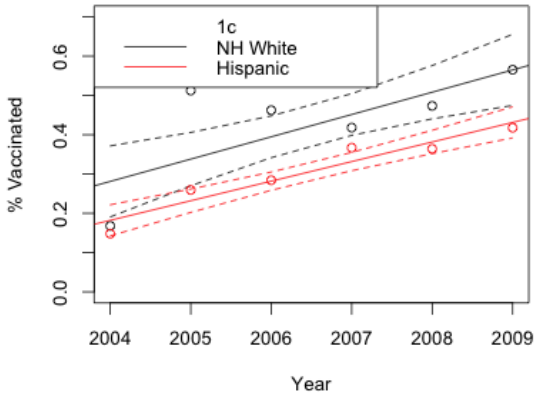
1. Zhao, Z. and E.T. Luman, *Progress Toward Eliminating Disparities in Vaccination Coverage Among US Children, 2000-2008.* American Journal of Preventive Medicine, 2010. **38**(2): p. 127-137.
2. Zhao, Z., P.J. Smith, and E.T. Luman, *Trends in early childhood vaccination coverage: Progress towards US Healthy People 2010 goals.* Vaccine, 2009. **27**(36): p. 5008-5012.
3. Chu, S.Y., L.E. Barker, and P.J. Smith, *Racial/ethnic disparities in preschool immunizations: United States. 1996-2001.* American Journal of Public Health, 2004. **94**(6): p. 973-977.
4. Schneider, E.C., et al., *Racial disparity in influenza vaccination - Does managed care narrow the gap between African Americans and whites?* Jama-Journal of the American Medical Association, 2001. **286**(12): p. 1455-1460.
5. Verani, J.R., et al., *Influenza vaccine coverage and missed opportunities among inner-city children aged 6 to 23 months: 2000-2005.* Pediatrics, 2007. **119**(3): p. E580-E586.
6. Bhat, N., et al., *Influenza-associated deaths among children in the United States, 2003-2004.* New England Journal of Medicine, 2005. **353**(24): p. 2559-2567.
7. Makun, P. and S. Wilson, *Population Distribution and Change: 2000 to 2010*, 2011, U.S. Department of Commerce: Washington D.C.
8. Fiscella, K., *Commentary - Anatomy of racial disparity in influenza vaccination.* Health Services Research, 2005. **40**(2): p. 539-549.
9. NORC, *A User's Guide for the 2009 Public-Use Data File*, 2010, National Center for Health Statistics: Washington, D.C.

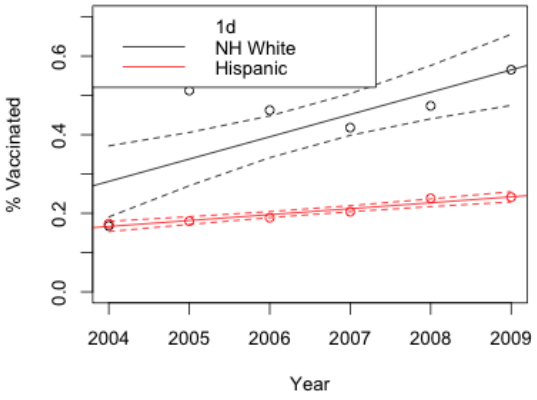
10. Shefer, A. and P.J. Smith, *Improving the immunization and health status of children in the Women, Infants, and Children (WIC) Program.* J Health Care Poor Underserved, 2004. **15**(1): p. 127-40.
11. Bardenheier, B.H., et al., *Factors associated with underimmunization at 3 months of age in four medically underserved areas.* Public Health Rep, 2004. **119**(5): p. 479-85.
12. Lumley, T., *Analysis of complex survey samples.* Journal of Statistical Software, 2004. **9**(1): p. 1-19.
13. R Development Core Team, *R: A language and environment for statistical computing*, 2011, R Foundation for Statistical Computing: Vienna, Austria.
14. Winston, C.A., P.M. Wortley, and K.A. Lees, *Factors associated with vaccination of medicare beneficiaries in five U.S. communities: Results from the racial and ethnic adult disparities in immunization initiative survey, 2003.* J Am Geriatr Soc, 2006. **54**(2): p. 303-10.
15. Link, M.W., et al., *Racial and ethnic disparities in influenza vaccination coverage among adults during the 2004-2005 season.* Am J Epidemiol, 2006. **163**(6): p. 571-8.
16. May, T. and R.D. Silverman, *Free-riding, fairness and the rights of minority groups in exemption from mandatory childhood vaccination.* Hum Vaccin, 2005. **1**(1): p. 12-5.
17. Logan, J.L., *Disparities in influenza immunization among US adults.* J Natl Med Assoc, 2009. **101**(2): p. 161-6.
18. Flores, G. and L.R. Vega, *Barriers to health care access for Latino children: a review.* Fam Med, 1998. **30**(3): p. 196-205.
19. Herrera, G.A., Z. Zhao, and R.M. Klevens, *Variation in vaccination coverage among children of Hispanic ancestry.* American Journal of Preventive Medicine, 2001. **20**(4): p. 69-74.
20. Aday, L.A., *Establishment of a conceptual base for health services research.* J Health Serv Res Policy, 2001. **6**(3): p. 183-5.
21. Aday, L.A., *Health status of vulnerable populations.* Annu Rev Public Health, 1994. **15**: p. 487-509.

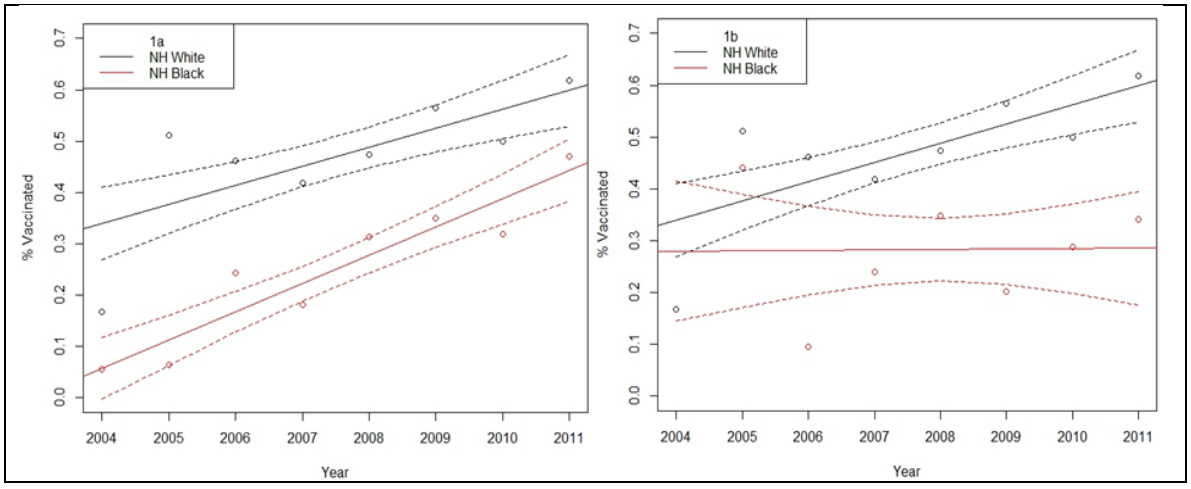
Figure 1a-1d. Trend in influenza vaccination rates for Non-Hispanic Whites, Non-Hispanic Blacks and Hispanics by poverty status, 2004-2009. 1a difference between NHW and NHB, not in poverty; 1b difference between NHW and NHB, in poverty; 1c difference between NHW and Hispanics, not in poverty, and 1d difference between NHW and Hispanics, in poverty. Intervals represent 90% confidence intervals for the regression line.

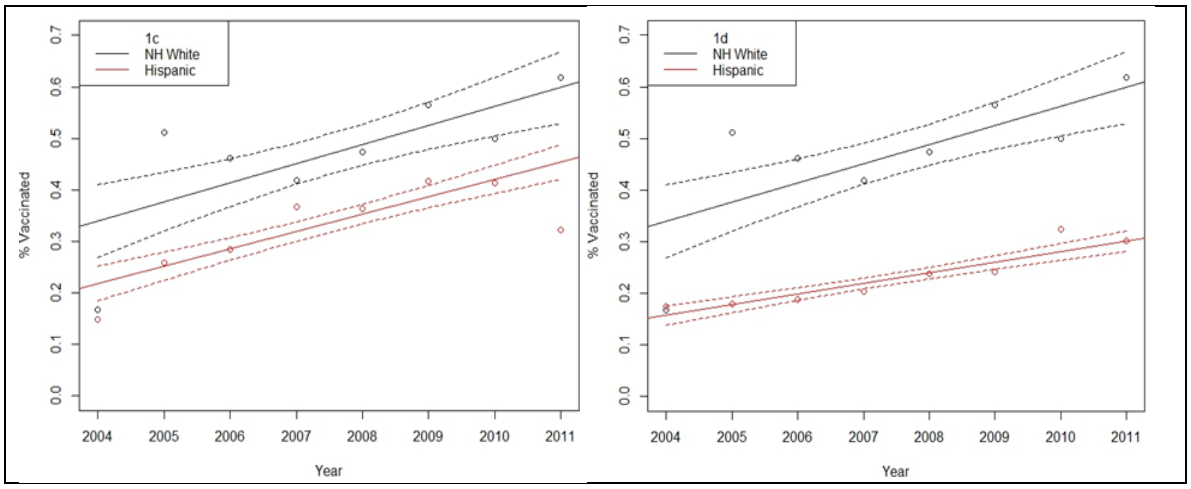

1a
NH White
NH Black
% Vaccinated
0.0
0.2
0.4
0.6
2004
2005
2006
2007
2008
2009
Year


1b
NH White
NH Black
% Vaccinated
0.0
0.2
0.4
0.6
2004
2005
2006
2007
2008
2009
Year


1c
NH White
Hispanic
% Vaccinated
0.0
0.2
0.4
0.6
2004
2005
2006
2007
2008
2009
Year


1d
NH White
Hispanic
% Vaccinated
0.0
0.2
0.4
0.6
2004
2005
2006
2007
2008
2009
Year


1a
NH White
NH Black
% Vaccinated
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
2004
2005
2006
2007
2008
2009
2010
2011
Year
1b
NH White
NH Black
% Vaccinated
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
2004
2005
2006
2007
2008
2009
2010
2011
Year


1c
NH White
Hispanic
% Vaccinated
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
2004
2005
2006
2007
2008
2009
2010
2011
Year
1d
NH White
Hispanic
% Vaccinated
Year