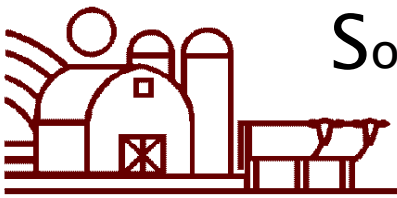
Rural Minority Children's Access to and Timeliness of Immunizations: 1993-2001



South Carolina Rural Health Research Center

UNIVERSITY OF SOUTH CAROLINA

Arnold School of Public Health
Department of Health Services Policy & Management

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Authors:
Arch G. Mainous III, PhD
Terrence E. Steyer, MD
Mark E. Geesey, MS

South Carolina Rural Health Research Center

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Joan Van Nostrand, DPA, Project Officer

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Executive Summary

Evidence indicates that rural individuals are more vulnerable to poor health outcomes. Limited access to health care services results in fewer medical visits and may make rural and minority populations particularly vulnerable to the consequences of lower access to care. This may be especially true for children who live in rural areas. Many health plans and national advisory committees currently use immunization rates as a marker for the quality of health care provided to children. The purpose of this study is to assess the quality of pediatric health care provided to rural minorities using timeliness of immunization receipt as a marker for quality.

Study Design and Definitions

For this study, a secondary analysis of nine years of data from the National Health Interview Survey (NHIS) was conducted. The NHIS is an annual survey conducted by the Centers for Disease Control and Prevention (CDC) to assess current health status in the United States. As part of this interview, data regarding childhood immunizations are collected from vaccine records supplied by the parents of children included in the interview sample. For this project, survey data from 1993 – 2001 was analyzed in annual increments.

National population estimates were made regarding the up to date immunization status of children under the age of six. The percentages of children up to date with their immunizations were calculated differently for this study than the calculations often reported by the Centers for Disease Control and Prevention (CDC). The CDC defines a child as being fully immunized when they have all of the recommended immunizations by the age of 2 years. However, certain vaccination series, such as Hepatitis B and Measles/Mumps/Rubella, may completed after 24 months. The definition used here includes all children from 3 to 71 months of age and accounts for the timeliness of the immunizations. For the purposes of this study, a child was considered up to date with immunizations if that child had received all of the vaccinations recommended by the Advisory Committee on Immunization Practice as appropriate for the age of the child and the year of the survey. Immunizations were counted as deficient if not given by one month after the child was eligible. A child is defined as up to date if he/she has received all immunizations recommended for his/her current age. We used population estimates for the up to date status for all childhood vaccines recommended each year, including newly introduced vaccinations in the years they were introduced.

Findings

- Children living in rural areas are less likely to receive newly recommended vaccines within the first two years after introduction of the recommendation. After 2 years, there are few significant differences in the percentage of children who are up to date with their childhood immunizations based on whether they live in urban or in rural areas.
- There are no significant differences in the percentages of children up to date with their immunizations between Whites, Blacks, and Hispanics living in urban and rural areas.

- By 2001 lack of health insurance was the strongest predictor for children not receiving their immunizations in a timely manner.
- When using national surveys, there is significant year-to-year variation in the percentage of children who are up to date with their immunizations.

Implications

- Ensuring that more children have insurance coverage may lead to a greater percentage of children being up to date with their immunizations. Mechanisms that address insurance coverage for childhood vaccinations, such as mandatory coverage requirements, should be explored.
- The delay of receiving immunizations by rural children, while unlikely to have caused any harm in the current environment, may become critical in the event of an infectious disease outbreak or bioterrorism incident. To address the time lag in immunization, additional research is needed regarding knowledge transfer mechanisms linking rural health care providers to current medical standards and systems barriers, perhaps associated with smaller rural public health infrastructures, that may delay the translation of knowledge into practice
- Assessments of quality of care and immunizations, in particular, can benefit from multiple years of data because of year-to-year variations.

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Introduction

Childhood Immunizations

The immunization of children against common preventable diseases has been of great interest to public health advocates since the first vaccination campaign against polio in the 1960s. Childhood immunizations are accepted as a marker for the quality of health care that children receive and all states now have childhood immunization laws that affect children entering school (Ornstein, 1999). The U. S. Department of Health and Human Services had set the goal to have 90 percent of two-year old children up to date on their immunizations by the year 2000. This goal failed and was set again as part of "Healthy People 2010" (US HHS, 1990; CDC, 2002). While childhood immunization rates are already high in most parts of the country, there are still children who are at risk for not receiving timely immunizations (Anonymous, 1999; CDC, 1996).

Although some studies have shown that rural children receive immunizations at rates similar to urban children, these findings have generally followed interventions in the public sector (Mainous, 1995; Slifkin, 1997). However, immunization rates are still less than optimal with both areas having approximately one-third of all eligible children not up to date on their vaccinations (Lowery, 1998). Moreover, it has also been shown that being non-white and having parents with lower income increases a child's risk of missing immunizations (Schempf, 2003).

Several interventions have been put in place to try and increase immunization rates. For example, Congress passed the Vaccine for Children program in 1993 that provides publicly purchased vaccines to all eligible children born in the United States. It is unclear how these broad interventions affected immunizations rates in rural and urban areas, particularly for African Americans. One study conducted in the early 1990's showed that federal programs providing free vaccinations have differential effects on the provision of immunizations in rural and urban areas (Mainous, 1995).

Policy Relevance

The relevance of this study for rural health policy lies in its focus on three crucial factors: children's health services, access to care, and quality of care. Each of these factors is critical for workforce decisions and distribution of public funds. In addition, by examining the impact of national trends before and after the introduction of major publicly funded initiatives the impact of national initiatives on rural health can be assessed.

Objectives/Hypotheses

The primary objective of the project is to examine the impacts of race, insurance coverage, poverty, and having financial difficulty obtaining medical care on being up to date with childhood immunizations for rural and urban children during the years 1993 – 2001. We hypothesize that the effects of these factors will vary over the years corresponding to implementation of vaccination programs for children. We expect to see some factors being more important in the early years and becoming less (or non-) important in later years. We expect the converse trend to be evident for other factors.

Research Plan

We conducted an analysis of the National Health Interview Survey (NHIS) using data from the years 1993 – 2001. In the 1993-2001 NHIS interviews, all participants in the NHIS who were parents of children under the age of 18 were asked to complete a supplemental survey on immunization coverage. We calculated the percentage of children up to date with their immunizations for each of the different vaccines before and after the introduction of both the Vaccines for Children program and new immunization recommendations. Details are provided in the appendices at the end of this report.

The State of Childhood Immunizations (1993-2001)

Demographics of U.S. Children

The information for this study came from children ages 3 to 71 months who participated in the NHIS from 1993 to 2001. Using appropriate weighting values US population estimates were determined by residence area and race (Table 1). The Hispanic population (both urban and rural) grew markedly between 1993 and 2001, while the Black population decreased as a percentage of the total population and also in absolute numbers. The White population showed only minor changes. The population of the "Other" racial group in rural areas is generally too small for further statistical analyses.

Again using appropriate weighting values from the NHIS, the percentage of US children with vaccination shot records peaked in 1994 (54.7%) along with the introduction of the Vaccines for Children Program (Oct. 1994) (Table 2). This percentage declined over the next three years until 1997 when it neared the level of 1993 at about 37%. It continued to fall, reaching a low of 33.8% in 2000, and then increased slightly to 37.2% in 2001.

Access to Care for U.S. Children

The percentage of U.S. children with health insurance (public or private) increased slightly between 1993 and 2001 from 86.1% to 90.6% (Table 2). Likewise, the percentage of children living above the poverty level increased from 76.7% to 82.6%. The percentage of children who had a medical home remained steady during the study period at about 96%.

In the NHIS interviews during 1993-1996 a single question was asked regarding whether the child needed medical care but was unable to get it. When questioned further, over 50% of respondents unable to get care cited lack of money or insurance as the primary reason for not getting the needed care. Beginning in 1997 this question was modified to inquire specifically about whether lack of money was a reason for not getting needed medical care. Regardless of the question or year, less than 3% reported not receiving the medical care they needed because they couldn't afford it. Because this factor had little variation between the years or between participants in a given year, it was not used in the stratified analyses.

Calculating Up to Date Immunization Status

The percentages of children up to date with their immunizations were calculated differently for this study than the calculations often reported by the Centers for Disease Control and Prevention (CDC). The CDC defines a child as being fully immunized when they have all of the recommended immunizations by the age of 2 years. This definition does not take into account any child under the age of 2 years and does not factor in the timing of the immunization. The definition used in this study accounts for all children from 3 to 71 months of age and accounts for the timeliness of the immunizations. For the purposes of this study, a child was considered up to date with immunizations if that child had received all of the vaccinations

recommended by the Advisory Committee on Immunization Practice as appropriate for the age of the child and the year of the survey. In order to allow a parent to have a full month to obtain the immunization for their child, all immunizations were counted as deficient if not given by one month after the child was eligible. For example, a 4 month old child who had not received his or her second IPV would not be considered deficient for the IPV dose that usually is given at the age of 4 months. However, a 5 month old child who had not received his or her second IPV would be considered deficient for IPV. For immunizations that can be given within a window of time, a child was considered deficient one month after the end of the immunization window. Immunizations for children older than 19 months of age were adjusted so that immunization recommendations in place at the time of their births were followed.

The U.S. national estimates for percentages of children up to date on their vaccinations are calculated using the appropriate weighting factors. The authors' original hypothesis regarding shot records and percentage of children up to date with their immunizations was the belief that parents who maintained a shot record for their children would be more conscientious about their children's vaccinations. Therefore, their children would be more up to date than the children of parents who did not maintain a shot record. However, the calculations of up to date status for all children in the study (Fig. 1) yielded substantially greater percentages than for the subset of children who had shot records available (Fig. 2). For some groups (e.g. Urban Blacks in 1999-2001) the differences in calculated percentage of children up to date are as much as 20 points. This difference arose because of the ability of a parent to respond to questions regarding the number of immunizations the child had received by stating that the child had received all of his shots, even though the parent would not necessarily know how many shots the child had received nor how many were recommended. These responses inflated the calculations of up to date immunization percentages. While parents of children with shot records were also permitted this response when queried about shots received but not recorded on the shot record, the rate of this response was far less than among parents whose child did not have a shot record. For example, in 1993, among children without a shot record 52.4% of parents responded that their child had received all of the recommended DTP shots, while only 0.7% of parents who produced a shot record responded that their child had received all of the recommended DTP shots.

Other studies confirm that the use of parental memory only to assess immunization status is fraught with errors. A 1994 study by the HMO Health Net found that 88 percent of parents whose children were not fully immunized believed that their child had been fully immunized by the age of two (Keitel 1995). In the 1993 NHIS fully 89% of parents believed that their child had received all recommended shots even though 33% answered "Don't Know" to one or more queries into how many of a particular vaccine their child had received. The results of a series of studies conducted by the NCHS concluded that the accuracy of immunization reports that relied solely on parental memory is poor (either biased or unreliable) (Willis et al. 1999). They also mention that across a number of other studies that compare parental reports with provider records, considerable error, often in the direction of over-reporting, appears to be the rule.

As another measure of the inaccuracy of parental memory, parents of children without shot records had a very high percentage who did not know how many shots their child had received. This percentage for DTP in 1993 was 19.0% while only 0.7% of those parents with shot records did not know how many DTP shots their child had received (because the shot record was incomplete). If a parent did not know how many shots the child had received then the child was eliminated from the calculations.

Table 3 gives the raw number of children surveyed for each year of the NHIS and demonstrates the effects on the number of children remaining for our analyses of not having a shot record, not knowing how many shots the child has received, and being a member of the "Other" racial group . The statistical analyses generally include children of all races. However, the surveyed population number of the "Other" racial group was generally too small to provide valid statistical trends in racial comparisons so these children were excluded from analyses which included a racial component.

For children without shot records, due to the potential for inflated responses and the high percentage of parents who did not know how many shots their child had received, we decided to eliminate these children from our calculations of up to date immunization status. While this would also eliminate any children who truly had no immunizations, and therefore would not have a shot record, these children account for a small percentage of the total U.S. population of children. Based on parental memory in the NHIS, between 1993 and 1996 children with no immunizations accounted for less than 3% of the children surveyed (ages 3-71 months). In 1997 this percentage dropped to less than 1% where it has remained since. Therefore, the calculated percentages of children up to date with their immunizations, based on shot records only, should be slight overestimates of the true national immunization rates. In all further analyses only children with shot records are included. Using the appropriate weighting factors the demographics of this U.S. shot record group are presented in Table 4.

Between 1993 and 1996 the overall percentage of children up to date with their immunizations climbed from <6% to >30% (Table 5). In 1997, with the introduction of the Varicella vaccine, the Overall up to date percentage dropped to 20%, but steadily rose with time to reach 35% in 2001. The percentage up to date for DTP, MMR, and Polio rose from 1993 to maxima in 1996, but have declined since then. The percentage of children up to date with Hepatitis vaccination steadily increased from 13% in 1993 to 78.5% in 1998, and has since remained at about this level. The HIB percentage has been constant at 50-60% since 1993. In 1997, the first full year after the introduction of varicella vaccine in 1996, the percentage of children up to date with varicella was only 18%. The percentage has climbed steadily every year reaching 62% in 2001.

Percent of Children Up to Date by Residence Area and Race

In the comparison of populations divided by race (White, Black, or Hispanic) and residence area (Urban vs. Rural) some common trends in percent up to date can be observed. Blacks generally have lower percentage of being up to date with Overall immunizations than Whites, while Hispanic percentages are generally equal to Whites, especially in later years (Fig. 2). Rural populations generally have lower percentages than urban populations, but the trend is weak, at best. The high percentage of Rural Blacks in 1995 who are up to date is probably a spurious value resulting from the low sample number (n=35). A statistical analysis (χ^2) of the variations in up to date percentages for these populations was conducted for three years: 1993, 1997, and 2001 (Table 6). Statistical significance was defined as $p \leq 0.05$. In 1993, for the percentage of children up to date with their Overall vaccinations, Urban Whites were greater than other groups. In 1997 the variations in percent up to date by residence area and race were no longer significant, although Blacks tended to have lower percentages than Hispanics who in turn had lower percentages than Whites. By 2001 urban and rural Whites and Hispanics attained

parity in percent up to date, while urban and rural Blacks had significantly lower percentages (see also Fig. 2).

Few general trends in percent up to date with Diptheria-Tetanus-Pertussis (DTP) immunizations are apparent over the years of the survey (Fig. 3). In nearly every year, especially since 1999, urban Blacks are less up to date with DTP immunizations than any other group. This distribution is significant in 1993 and 2001, but not in 1997 (Table 6).

Before 1999 the distribution of percent up to date with Measles-Mumps-Rubella (MMR) immunizations shows no variations between residence area and race groups (Fig. 4). Since 1999, as with DTP immunizations, urban Blacks tend to be less up to date than other groups, but this trend was not significant in 2001 (Table 6).

Variations in percent up to date with Polio immunizations were similar to those seen with MMR (Fig. 5). Before 1999 no differences between groups were apparent. Since 1999 urban Blacks are less up to date than other groups. In 2001, unlike DTP, this distribution was statistically significant (Table 6).

The recommendations for Hepatitis vaccination were introduced in October, 1991. The initial low percentage of children up to date seen in 1993 is typical for a newly introduced vaccine (Fig. 6). The 1993 residence area and race distribution of percent up to date was statistically significant with urban Whites and urban Hispanics having higher percentages than other groups (Table 6). By 1997, while the percentage of children up to date in all groups had increased substantially, these two groups still had significantly greater percentages. After 1997 every group except one, urban Blacks, reached and maintained a level of parity in percent up to date. The percentage of up to date urban Black children actually declines between 1998 and 2000. The distribution of percent up to date is statistically significant in 2000 (χ^2 ρ=0.01), but not quite significant in 2001 (ρ=0.07).

Haemophilus Influenza B (HIB) vaccination recommendations were newly introduced in 1992. Children born before these recommendations were not included in our analyses for 1993 and 1994 since they would not have had time to receive all of their shots. Therefore, the calculations of percent up to date for these years only include children ages 3-18 months. As with other vaccinations, few trends are apparent over the years of the study (Fig. 7). In 1993 urban Blacks and rural Hispanics have significantly lower percentages of children up to date than other groups (Table 6). In 1997 the same pattern is observable. By 2001 parity between all groups has been attained, although urban Blacks tend to have a lower percentages, but not statistically significantly lower.

Recommendations for Varicella vaccinations were introduced in 1996. Initial percentages of children up to date were higher among urban Whites and urban Hispanics (Fig. 8), the same pattern that was seen after the introduction of the Hepatitis vaccination (Table 6). Any residence area or racial differences observed in 1997 were eliminated by 2001.

Percent of Children Up to Date by Socioeconomic Factors

The relationship between having health insurance and up to date immunizations was explored. In 1993 having medical insurance was not a factor in the percentage of children up to date with their immunizations (Table 7). In 1997 children with insurance had a significantly greater percentage up to date with their Overall immunizations and for four of the six individual

vaccinations (MMR, HIB, Hepatitis, Varicella). In 2001 the percentage of children up to date with their Overall immunizations was significantly lower for children without insurance, however this difference was probably due solely to the lower percent up to date with HIB in children without insurance.

In 1993 the type of health insurance a child had was generally not a significant factor in the percentage of children up to date with their immunizations (Table 8). Only for DTP was there a significant distribution: children with private insurance were more up to date. In stark contrast, in 1997 there were significant distributions in percent up to date for Overall immunizations and for four of the six individual vaccinations (DTP, MMR, HIB, Varicella). Children with private insurance were more up to date than children with public insurance, who in turn were more up to date than children with no insurance. This trend was also apparent for Polio and Hepatitis vaccinations, although non-significant ($\rho>0.05$). By 2001, for the Overall immunizations, the difference between private and public insurance had disappeared, but uninsured children still were less up to date Overall. For the individual vaccines, only HIB showed a significant distribution. This distribution alone may be responsible for the statistically significant distribution observed in the Overall up to date percentages.

Children living below the poverty level in 1993 were less up to date for DTP, Polio, MMR, and HIB vaccinations than children living above the poverty level (Table 9). However, they were not significantly less up to date for their Hepatitis and Overall immunizations. In 1997 the percentage of children up to date with their Overall immunizations was significantly lower for children living below the poverty level than for children living above the poverty level. Among the individual vaccinations only for MMR and Varicella were the percentages of children up to date significantly less for children living below the poverty level than for children living above the poverty level. By 2001, while children living below the poverty level tended to be less up to date, none of these differences were significant.

In every year about 96% of the population had a medical home (Table 2). Except for the MMR vaccine in 1993 and the Hepatitis vaccine in 1997, there were no significant differences in the up to date percentages between children with and without a medical home (Table 10).

Financial problems prevented less than 2.5% of the population from receiving the medical care they needed (Table 2). Financial problems were never a significant factor in the percent of children up to date with their vaccinations (Table 11).

Percent of Children Up to Date by Residence Area and Socioeconomic Factors

Among the socioeconomic factors, only the two with significant distributions, health insurance (Yes/No) and poverty status (Above/Below) were investigated further as to whether differences between rural and urban residence area existed. In the analysis of percent up to date by residence area and health insurance status (Table 12) no significant differences were found for 1993. In 1997 significant distributions were found for the Overall, MMR, HIB, Hepatitis, and Varicella up to date percentages. The lack of insurance is again an apparent factor in these distributions, but rural children without insurance are even less up to date (except for HIB vaccinations) than urban children without insurance. In 2001 rural children without insurance still are significantly less up to date with their Overall and HIB immunizations.

The distribution of the percentage of children up to date by residence area and poverty status during 1993 reveals that urban children living below the poverty level were less up to date for DTP, MMR, and HIB (Table 13). The percent of children up to date with Polio immunizations also show this same trend, but not significantly. The percent up to date Overall show no significant relationships probably due to the very low calculated percentages which make statistical comparisons difficult. In 1997 there were significant differences for Overall, MMR, and Varicella percent up to date. The distribution in percent up to date for Overall and MMR immunizations are due mostly to poverty status and not residence area or a combination of the two. For the newly introduced Varicella vaccine the percent up to date among rural children living below the poverty level is significantly less than for other groups. By 2001 there are no significant differences in percent up to date by residence area or poverty status.

Multivariate Analyses of Immunization Rates

For the years 1993, 1997, and 2001 logistic regression analyses were performed to identify factors that are significant predictors of not being up to date with recommended immunizations. These regression analyses calculate the odds of not being up to date on immunizations compared to a reference category. The following variables were included in the models: the combined residence area/race variable (Urban/Rural and White/Black/Hispanic), having health insurance (Yes/No), poverty status (above or below poverty level), having a medical home (Yes/No), or whether money problems caused the child to miss medical care (No/Yes). For the residence/race variable, the reference category for all comparisons is Urban White children.

In 1993 Rural White children had a 5.43 times greater likelihood of not being up to date on their Overall immunizations than Urban White children (Table 14). This was primarily due to missing Hepatitis vaccinations. Urban Black children also had a greater likelihood of not being up to date with their Hepatitis vaccinations. Children living below the poverty level, while not having a significantly greater risk of not being up to date with their Overall vaccinations, did have greater risks of not being up to date with DTP, MMR, and HIB vaccinations. Health insurance, having a medical home, and money problems were not significant predictors of missing vaccinations in 1993.

Children living below the poverty level in 1997 were more likely to not be up to date on their Overall, MMR, or Varicella vaccinations than children living above the poverty level (Table 15). Rural White children were more likely to be missing Varicella vaccinations. Although Rural Hispanic children were more likely to be missing HIB vaccinations, they were less likely to be missing MMR vaccinations. Children lacking health insurance were significantly more likely to have missed their MMR, HIB, or Varicella vaccinations. Lack of a medical home was a significant factor only for missing Hepatitis vaccinations. Money problems were still not an issue in 1997.

Rural Black children and children without health insurance in 2001 were more likely to not be up to date on their Overall vaccinations (Table 16). Rural Hispanic children were less likely to have missed DTP, Polio, or MMR vaccinations. Children without insurance were significantly more likely to be missing HIB vaccinations. Poverty status, having a medical home, and money problems were not significant issues in 2001.

In general, during 1993, children living below the poverty level were more likely to have missed vaccinations and not be up to date on their immunizations. Rural Whites and Urban Blacks were also at a greater risk of having missed vaccinations. In 1997, while Rural White children and children living below the poverty level were still less likely to be up to date on some or all of their vaccinations, lack of health insurance had also become an important factor in missing vaccinations. By 2001, however, poverty status was no longer an important factor as to whether children were missing vaccinations. While Rural White children no longer had an elevated risk of not being up to date on their immunizations, Rural Black were at greater risk. Lack of health insurance remained as a significant factor predicting greater risk of missing immunizations.

Conclusions

In general, similar percentages of rural and urban children were up to date with their vaccinations. Importantly, minority children who live in rural areas were similarly up to date with their immunizations as rural whites and urban minorities. Thus, the difference in up to date percentages between minority children and white children do not appear to be related to their area of residence.

Rural children were less likely to receive newly recommended vaccinations in the first two years that the recommendation exists, but this variation disappeared after two years. The lag was noted both for the hepatitis B vaccine, which was recommended for routine use beginning in October 1991, and for the varicella vaccine, which was recommended for routine use beginning in July 1996. For the first two years after each vaccine's introduction, children living in rural areas were less likely to receive this vaccine in a timely manner compared with urban children. There were no racial differences amongst the rural children. While this study was not able to quantify the effects of the time lag, it is possible that some rural children experienced vaccine-preventable diseases. The rural/urban difference disappeared about two years after the recommendation was made.

The time lag in up-to-date immunization rates between rural and urban children suggests that rural practitioners require more time to meet current quality standards, either because knowledge about standards diffuses more slowly to rural areas or because rural practitioners take longer to orient systems of care to emerging requirements than do urban practitioners. The presence of a catch-up period in a health care environment perceived to be suffused with rapid electronic communication merits further exploration. While the likelihood that any children were harmed by the vaccination time lag is extremely small, such a time lag might become more important in the event of a bioterrorism incident or in the face of an emerging infectious disease. Additional research is needed into knowledge transfer mechanisms linking rural practitioners to current medical standards. Further, research is needed into systems barriers, perhaps associated with smaller rural public health infrastructures, that may delay the translation of knowledge into practice.

The most important factor affecting the receipt of timely immunizations in 2001, for children living in both urban and rural areas, appears to be the presence or lack of health care insurance. Children who had health care insurance were more likely than children without insurance to receive their immunizations at the appropriate time. This may have effects on rural immunization rates as children in rural areas were less likely to have health insurance. (Comer, 1995; Frenzen, 1993; Hartley, 1994) Interestingly, this difference became more pronounced after 1997, by which time the Vaccines for Children program was well-established to attempt to eliminate this disparity.

The Vaccines for Children program led to a shift in delivery sites for childhood vaccinations. Prior to 1993 about half of all vaccinations were delivered in public health clinics, while at present private offices deliver 73% of childhood vaccinations (AAP 2003). While the wider availability of vaccines benefits most children, a switch to office-based vaccination does pose barriers for some children, most obviously those lacking health insurance. In addition to uninsured children, an estimated 16% of privately insured children have coverage that does not

include vaccinations (Late, 2003). Since these children are technically "insured," they cannot take advantage of governmental programs for uninsured children. In addition, many private insurance plans require co-pays or deductibles that can serve as a barrier to low income families, causing them to defer immunizations till they are required for school entry. Such subtle effects could not be detected through this study.

Actions are needed both at the policy and at the practice level to ensure that all children are immunized promptly. The Institute of Medicine, in a forthcoming report, recommends fairly sweeping changes in the way vaccines are selected for recommendation and subsequently financed (IOM, 2003). First, the IOM recommends that vaccine coverage for children become a Federally mandated element in all health insurance, both public and private. Some states already include such a mandate in state insurance licensing regulations. To cover uninsured populations, the IOM recommends a voucher system covering vaccine and administration costs. Additional research is needed to determine whether the broad changes suggested by the IOM might be feasible and, if so, whether these changes would address the problems of a rural-urban implementation lag noted above. In the interim, increased efforts are needed to enroll eligible rural children in state Medicaid and S-CHIP programs, and to ensure that all rural children have access to low cost providers such as federally qualified community health centers.

Regardless of long term financing strategies for vaccination, the American Academy of Pediatrics recently released recommendations on clinical activities practitioners can undertake to increase vaccination coverage (AAP, 2003). The recommendations, based on findings of the Clinical Preventive Activities Task Force of the Centers for Disease Control and Prevention, focus on parent reminders, prompts for parents and staff during all child visits, and standing orders regarding immunization. The AAP also recommends quality improvement activities, such as periodic examination of immunization rates within individual practices in order to identify and understand gaps in coverage. The AAP is not specific about how quality improvement should be conducted. However, the Centers for Disease Control and Prevention offer a free software product, CASA or clinic assessment software application, that is designed to assist practitioners track and improve immunization rates. Additional educational efforts are needed to ensure that information concerning the AAP recommendations and the availability of free software support is widely communicated to rural practitioners.

The estimates for percentage of children up to date with their immunizations in this study differ widely from those reported by the Centers for Disease Control as part of the Healthy People 2010 program. The reason for this difference is the definition used for up to date immunization status. The Centers for Disease Control defines up to date as a child who has received all required immunizations by the age of 2, regardless of when the immunizations were given. In our analysis, we defined children as up to date if they had received the recommended vaccination within 1 month of the recommended age. Thus, this study does not look only at the immunization rates of 2 year olds, but at the rates for all children 71 months and younger. This difference in definition led to the widely varying percentages of up to date immunization status reported in this study.

There are limitations to this study. First, this was a secondary data-analysis of data collected for the National Health Interview Survey. As with all secondary data sets, the data was limited to questions asked by the survey team and responses given by the participants. Second, this study limited the amount of participant bias that could influence the results by using only written shot records to determine a child's timeliness of immunization. Although this may have

limited the sample to those most involved in their child's health care, we felt that this strategy led to more accurate reporting of a child's immunization status.

Despite these limitations, this study is the first to assess timeliness of immunization among urban and rural children, specifically looking at racial differences. While there was no difference found in overall up to date immunization status, rural children were less likely to receive new vaccines when they are first recommended. Efforts should be made to increase the dissemination of the Advisory Committee on immunization Practices' recommendations to rural health care providers. Future efforts should also be placed on increasing the enrollment of children into publicly funded health care programs as a way to increase immunization rates.

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Appendix 1

Methods

Survey Data Source

This study is an analysis of the National Health Interview Survey (NHIS), a personal interview household survey using a nationwide sample of the civilian, noninstitutionalized population of the United States. The sample is chosen in such a way that each person included has a known non-zero probability of selection. It is based on a complex multistage design with over-sampling for some targeted subpopulations, particularly for minority populations. Sampling weights have been developed to account for the survey design and to provide an adjustment for survey non-response. . Because of the complex design and the ratio adjustments applied to the sample weights, the direct application of standard statistical analysis methods for variance estimation and hypothesis testing may yield misleading results (NHIS). We used SUDAAN analyses to incorporate the sample weights and account for the complex sampling design. The interviewed sample for each year (except 1996) was composed of about 40,000 households containing approximately 100,000 persons. The number of households in 1996 was 25,990 and the number of persons was 63,402. The number of children ages 3-71 months who had immunization data ranged from a low of 5262 (1999) to a high of 7461 (1994) with a mean of 5986 (Table 3).

Dependent Variables

Childhood Up to Date Immunization Status

All children were assessed according to whether they were up to date on their immunizations. Immunization status was determined for 6 vaccinations: Diptheria-Tetanus-Pertussis (DTP), Polio, Varicella, Hepatitis B, Measles-Mumps-Rubella (MMR), and Haemophilus Influenza B (HIB). Each record for these immunizations indicates not only whether the child had received these shots, but also how many. The parent was asked to remember whether immunizations were given as well as to present the immunization shot record.

To determine if an individual is “up to date” on immunizations, the Advisory Committee on Immunization Practice Recommendations were used for each age, with a one month lag after the recommended age to allow parents sufficient time to acquire the immunization. For example, the second Polio vaccination is due at age 4 months, but a child with only one Polio vaccination is not considered as having missed the vaccination unless the child is age 5 months or older. Complete immunization data in the National Health Interview Survey (NHIS) is available only for children less than 6 years of age at the time of the survey. For the years 1993 and 1994 the HIB immunization recommendation for children older than 18 months of age was deleted to follow the lack of HIB recommendation in place at the time of birth. This change is indicated by an asterisk in the schedule below, which was used to determine completeness of immunizations.

Years 1993 - 1994

Children aged	
3 – 4 months	1 or 2 Hepatitis B, 1 DTP, 1 Polio, 1 HIB
5 – 6 months	2 Hepatitis B, 2 DTP, 2 Polio, 2 HIB
7 – 15 months	2 or 3 Hepatitis B, 3 DTP, 3 Polio, 3 HIB
16 – 18 months	2 or 3 Hepatitis B, 4 DTP, 3 Polio, 4 HIB, 1 MMR
19 – 71 months*	3 Hepatitis B, 4 DTP, 3 Polio, 1 MMR

Years 1995 - 1996

Children aged	
3 – 4 months	1 or 2 Hepatitis B, 1 DTP, 1 Polio, 1 HIB
5 - 6 months	2 Hepatitis B, 2 DTP, 2 Polio, 2 HIB
7 – 15 months	2 or 3 Hepatitis B, 3 DTP, 2 or 3 Polio, 3 HIB
16 – 18 months	2 or 3 Hepatitis B, 3 or 4 DTP, 2 or 3 Polio, 4 HIB, 1 MMR
19 – 71 months	3 Hepatitis B, 4 DTP, 3 Polio, 4 HIB, 1 MMR

Years 1997 - 2001

Children aged	
3 – 4 months	1 or 2 Hepatitis B, 1 DTP, 1 Polio, 1 HIB
5 – 6 months	2 Hepatitis B, 2 DTP, 2 Polio, 2 HIB
7 - 15 months	2 or 3 Hepatitis B, 3 DTP, 2 or 3 Polio, 3 HIB
16-18 months	2 or 3 Hepatitis B, 3 or 4 DTP, 2 or 3 Polio, 4 HIB, 1 MMR,
19 – 71 months	3 Hepatitis B, 4 DTP, 3 Polio, 4 HIB, 1 MMR, 1 Varicella

Because of the potential for significant discrepancies between relying solely on parent memory versus the shot record information, a subgroup of participants with shot records was created for separate analyses. The subgroup with shot records also included children whose parents (when queried) provided information about additional shots which were not recorded on the shot record. Additional information could include the number and types of additional vaccinations, or merely that the child had received all of his shots for a particular type of vaccination.

Independent Variables

Health Insurance

The child's insurance status was determined by examining a variable created in the NHIS indicating whether the respondent had any health insurance. This variable is a recode of the different possible payers. In addition, type of insurance was also recorded, with the respondent being asked about receiving benefits from several different public programs (Medicaid, CHAMPUS, Indian Health Services, etc.) and up to four private insurance companies. Health

insurance was analyzed as either a Yes/No variable (does or does not have insurance) or by type of insurance (private, public, none).

Poverty

Poverty status was determined through a specific variable that is a ratio of the family's income to the previous year's federally defined poverty level, accounting for the number of household members. A dichotomous variable was created describing the subjects as either below or above the poverty level. Individuals with missing data for poverty index were excluded from the analyses. The percentage of individuals missing poverty index data ranged from 6.8% in 1993, to 15.7% in 1997, and 21.2% in 2001. Substituting family income data would not decrease the percentage of missing data because the poverty index is calculated from family income.

Medical Home

Having a medical home was determined by using questions asked in the NHIS focusing on whether the patient has a usual source of care. The items focused on having a usual place for care. From 1993-1996, the NHIS defined this concept using the question "Is there a particular person or place that (name) usually goes to when (he or she) is sick or needs advice about (his or her) health?", and, if there was more than one location identified, a follow-up question was asked: “Is there ONE of those places that (name) goes to most often when (he or she) is sick or needs advice about (his or her health).

In the 1997-2001 data sets the usual source of care question was replaced by the question: "Is there a place that (name) usually goes when (he or she) is sick or needs advice about health?" This item was used to determine a medical home.

For the entire study period (1993-2001) we could identify a second variation on having a medical home in order to compare the quality of care, particularly splitting care between routine/preventive care and acute care. If the respondent had a usual place, they were asked if there was a different place that they went for preventive/routine care from their “usual” place of care when they are sick. In theory, this distinction would allow us to look at the phenomenon of a medical home in terms of splitting care, which may be particularly important for childhood immunizations. However, once we divided the population into racial and rural/urban groups, the population sizes of people who split care between providers were too small to provide statistically meaningful results.

Access to Care (Monetary Problems)

To study access to care, especially in regard to financial limitations, a question was used to determine a person's ability to get care when needed. In the 1993-1996 data the question "At any time during the past twelve months did (name) need medical care but was not able to get it?" was used. More than 50% of respondents not able to receive care, when questioned further, cited a lack of money or insurance as the primary reason for not getting the care needed. Beginning in 1997 and following through to 2001, a slightly differently worded question inquiring specifically about financial problems was used: “During the past 12 months, was there any time when (person) needed medical care, but did not get it because (person) couldn't afford it?

Although questions were present in all survey years regarding delay of care, the population numbers of people who reported delayed care for any of a number of reasons were too small to warrant further analysis. In addition, it was unclear what effect a delay in care would have, if any, on receipt of immunizations.

Control Variables

Residence Area

Residence area (Urban or Rural) was assessed in this project according to residence in or out of a metropolitan statistical area (MSA). The NHIS contains data indicating whether a respondent resides in an MSA.

Race/Ethnicity

The race of the respondent was determined through standard self-report items used by the National Center for Health Statistics. For the present analysis we used a recoded variable with the categories of White, Black, and Other. An additional variable defined Hispanic ethnicity. These variables were combined into one variable for Race/Ethnicity with the categories White, Black, Hispanic, and Other, however, population numbers of Other race children was too small for meaningful analyses.

Analysis

Objective: To examine the impact of race, poverty status, insurance coverage, having a medical home, and monetary problems on receipt of childhood immunizations for rural and urban children during the years 1993 – 2001.

We performed a descriptive analysis for the years from 1993 – 2000. Statistics were computed for each year of the NHIS. Population estimates for rural and urban children by race were calculated using appropriate sampling weights. Sampling weights were also used to calculate the demographic parameters of percentages of children with shot records, having insurance, above poverty level, with a medical home, and without money problems. For each year, we calculated the number of children who are up to date on each of the immunizations following the immunization recommendations of the Advisory Committee on Immunization Practices of the Centers for Disease Control. Up to date percentages were also calculated for the Overall total of these vaccinations. Due to serious data quality problems involving parental recall of vaccinations received, information from children with shot records only was used in these calculations.

A subset of the study years was selected for further, more in-depth analyses. The first and last years of the period (1993 and 2001) were selected. The mid-point of the study period (1997) was also the first full year after the introduction of the Varicella vaccination recommendations. For these three years population estimates for being up to date in childhood immunizations for rural and urban children by race were calculated using appropriate sampling weights. To compare the differences between immunization rates calculated for each residence area/racial group Chi^2 analyses were used. Immunization rates were also calculated independently for several factors: whether the child had insurance, the type of insurance, poverty status, medical home, and financial problems. To examine the relationships between these factors and being up to date in childhood immunizations Chi^2 analyses were again used. The relationship between residence area and insurance status and the combined effect on the percentage of children up to date with their immunizations was further investigated through a series of Cochran-Mantel-Haenszel (CMH) tests of these combined factors. Another series of

CMH tests was conducted to explore the relationship between residence area and poverty status and the combined effect on the percentage of children up to date with their immunizations.

Logistic regression analyses were used to create models of the likelihood of not being up to date on immunizations for each year (1993, 1997, and 2001) based upon the variables of residence area, race, poverty, insurance coverage, having a medical home, and monetary problems.

Appendix 2
Supporting Tables and Figures

Table 1: Demographics of the U.S. population of children ages 3-71 months.

		Urban (%)				Rural (%)			
Year	**Population**	**White**	**Black**	**Hispanic**	**Other**	**White**	**Black**	**Hispanic**	**Other**
1993	22,322,219	48.49	13.71	13.62	3.63	16.40	2.24	1.23	0.68
1994	22,292,980	48.99	13.36	14.49	3.49	15.42	2.13	1.52	0.61
1995	22,551,356	50.14	13.01	14.63	3.95	14.03	2.11	1.48	0.66
1996	23,026,666	48.78	12.69	15.22	3.02	15.50	2.75	1.50	0.52
1997	23,024,534	49.53	12.90	15.73	4.40	13.35	1.97	1.50	0.62
1998	22,972,309	47.18	12.20	16.29	4.12	15.44	2.47	1.61	0.68
1999	22,724,810	47.02	12.87	16.50	3.82	15.80	1.53	1.75	0.70
2000	22,700,345	47.46	12.39	17.23	4.70	13.94	1.96	1.49	0.83
2001	22,766,601	47.18	12.46	17.34	4.46	14.47	1.99	1.66	0.44

Table 2: Demographics of the U.S. population of children ages 3-71 months.

Year	Have Shot Record (%)	Have Insurance (%)	Above Poverty Level (%)	Have Medical Home (%)	No Money Problems (%)
1993	36.93	86.07	76.65	95.89	98.26
1994	54.68	85.67	77.40	95.73	98.73
1995	49.22	88.02	78.34	96.21	98.83
1996	45.92	87.28	78.63	96.35	98.88
1997	37.61	89.00	77.07	95.83	98.26
1998	37.33	89.79	79.30	96.39	98.54
1999	35.52	90.22	81.46	95.74	97.66
2000	33.79	88.28	82.15	96.00	97.70
2001	37.15	90.62	82.58	96.15	98.25

Table 3. Sample numbers from the surveyed population (U.S. children ages 3-71 months). Each column is a subset of the previous column.

Year	Total number	Have shot record	No missing data	White, Black, or Hispanic	Rural
1993	6908	2493	2453	2355	538
1994	7461	4012	3957	3797	861
1995	6742	3348	3309	3193	586
1996	4249	2024	1994	1944	428
1997	6025	2288	2282	2192	374
1998	5803	2268	2262	2182	457
1999	5262	1899	1884	1807	370
2000	5718	2023	2008	1922	330
2001	5706	2133	2120	2037	387

Table 4: Demographics of U.S. children with shot records ages 3-71 months (the U.S. Shot Record Group).

		Urban (%)				Rural (%)			
Year	**Population**	**White**	**Black**	**Hispanic**	**Other**	**White**	**Black**	**Hispanic**	**Other**
1993	8,243,442	48.09	10.43	15.82	2.98	19.08	1.10	1.51	0.99
1994	12,188,832	49.38	10.28	16.53	3.30	16.61	1.29	1.99	0.62
1995	11,100,550	50.79	16.08	15.71	3.99	15.71	1.25	1.91	0.77
1996	10,573,380	46.56	10.05	17.13	2.89	18.11	2.18	2.50	0.59
1997	8,659,320	50.21	9.87	17.40	4.34	14.27	1.29	2.15	0.47
1998	8,575,910	45.27	9.68	17.67	3.64	19.52	1.53	2.30	0.40
1999	8,071,207	45.19	11.15	17.74	3.95	17.39	0.93	2.78	0.87
2000	7,671,145	44.44	10.45	20.67	4.93	15.10	1.05	2.29	1.07
2001	8,457,640	45.56	10.87	18.93	3.98	16.59	1.23	2.49	0.35

Table 5: Percentage of the U.S. shot record group up to date with immunizations.

Year	**Overall[1]**	**DTP**	**MMR[2]**	**Polio**	**Hepatitis**	**HIB[3]**	**Varicella[4]**
1993	5.8	76.7	92.5	73.8	13.0	58.9	
1994	14.3	79.3	92.9	78.9	26.5	60.9	
1995	27.6	82.7	92.5	89.7	45.6	49.8	
1996	33.9	83.6	93.7	91.6	57.5	56.9	
1997	20.0	82.4	91.7	91.1	71.7	58.9	18.1
1998	23.2	75.5	90.9	86.8	78.5	56.2	30.4
1999	29.3	76.7	91.0	84.2	78.8	56.2	42.1
2000	31.7	73.9	86.6	79.2	75.8	53.9	57.3
2001	35.0	76.1	88.1	78.7	78.7	53.5	62.1

Notes: [1]Includes Varicella after 1996. [2]MMR for age >15 months only
[3]HIB for 1993-94 age <19 months only. [4]Varicella not recommended before 1997.

Table 6: Percentage of the U.S. shot record group up to date with immunizations by residence area and race, and statistical significance (X^2) of the variations.

1993	Overall	DTP	MMR	Polio	Hepatitis	HIB	Varicella
Urban Whites	7.5	79.4	93.6	73.8	15.7	63.3	
Urban Blacks	3.9	68.5	89.2	67.2	7.7	36.3	
Urban Hispanics	3.7	71.0	92.0	74.6	10.1	53.0	
Rural Whites	2.7	81.3	93.2	77.8	8.3	67.1	
Rural Blacks	4.1	83.3	83.4	71.4	8.8	64.3	
Rural Hispanics	5.2	72.3	88.5	80.5	8.3	34.7	
X^2 p=	0.02	0.01	0.53	0.24	<0.01	0.01	
1997	**Overall**	**DTP**	**MMR**	**Polio**	**Hepatitis**	**HIB**	**Varicella**
Urban Whites	22.7	81.7	91.3	91.7	73.8	63.0	22.3
Urban Blacks	16.1	77.5	93.2	89.8	67.2	50.5	11.7
Urban Hispanics	17.8	83.0	92.6	91.6	76.0	56.3	16.6
Rural Whites	18.7	81.8	92.3	90.6	65.8	58.5	11.0
Rural Blacks	14.7	92.1	88.4	91.2	63.1	69.5	6.1
Rural Hispanics	17.0	81.7	96.9	93.1	68.0	47.7	4.6
X^2 p=	0.21	0.32	0.42	0.95	0.05	0.01	<0.01
2001	**Overall**	**DTP**	**MMR**	**Polio**	**Hepatitis**	**HIB**	**Varicella**
Urban Whites	37.0	78.9	88.7	80.0	78.4	54.7	64.2
Urban Blacks	23.7	63.0	79.5	64.3	68.9	44.2	53.4
Urban Hispanics	36.4	72.5	89.1	79.4	80.2	53.0	66.3
Rural Whites	37.1	79.8	88.0	80.0	83.4	55.4	59.4
Rural Blacks	23.6	75.5	92.0	88.4	86.4	61.1	52.6
Rural Hispanics	36.9	82.2	95.0	89.3	83.2	58.1	56.7
X^2 p=	0.03	0.02	0.16	0.03	0.07	0.34	0.29

Table 7. Percentage of the U.S. shot record group up to date with immunizations by whether the child had health insurance, and statistical significance (X^2) of the difference.

1993	Overall	DTP	Polio	MMR	HIB	Hepatitis	Varicella
Total	7.22	76.78	72.44	93.26	62.50	17.70	
Yes	7.35	77.45	72.85	93.62	62.46	17.94	
No	6.35	72.43	69.78	91.15	62.79	16.15	
X^2 p=	0.69	0.22	0.43	0.41	0.97	0.61	
1997	**Overall**	**DTP**	**Polio**	**MMR**	**HIB**	**Hepatitis**	**Varicella**
Total	19.97	81.28	91.13	91.65	58.91	71.68	18.06
Yes	20.60	81.86	91.50	92.47	60.30	72.59	19.47
No	14.80	76.52	88.02	85.31	47.37	64.08	7.23
X^2 p=	0.04	0.12	0.20	0.03	<0.01	0.02	<0.01
2001	**Overall**	**DTP**	**Polio**	**MMR**	**HIB**	**Hepatitis**	**Varicella**
Total	35.04	76.11	78.61	88.11	53.57	78.70	62.17
Yes	36.01	76.69	79.02	88.00	54.81	79.33	62.66
No	25.33	70.21	74.49	89.13	41.06	72.38	57.84
χX^2 p=	0.01	0.13	0.34	0.68	0.01	0.18	0.40

Table 8. Percentage of the U.S. shot record group up to date with immunizations by the type of health insurance, and statistical significance (χ^X) of the distribution.

1993	Overall	DTP	Polio	MMR	HIB	Hepatitis	Varicella
Total	7.22	76.78	72.44	93.26	62.50	17.70	
Private	8.35	80.20	75.93	94.84	64.26	19.00	
Public	5.55	72.45	67.25	91.29	59.63	16.02	
None	6.35	72.43	69.78	91.15	62.79	16.15	
X^2 p=	0.31	0.05	0.07	0.13	0.82	0.51	
1997	**Overall**	**DTP**	**Polio**	**MMR**	**HIB**	**Hepatitis**	**Varicella**
Total	19.97	81.28	91.13	91.65	58.91	71.68	18.06
Private	22.59	83.37	91.95	93.20	62.27	72.75	22.83
Public	16.70	78.90	90.62	91.05	56.41	72.28	12.85
None	14.80	76.52	88.02	85.31	47.37	64.08	7.23
X^2 p=	<0.01	0.05	0.38	0.05	<0.01	0.08	<0.01
2001	**Overall**	**DTP**	**Polio**	**MMR**	**HIB**	**Hepatitis**	**Varicella**
Total	35.04	76.11	78.61	88.11	53.57	78.70	62.17
Private	35.70	77.61	78.57	87.39	54.70	78.25	62.31
Public	36.63	74.81	79.94	89.37	55.02	81.54	63.44
None	25.33	70.21	74.49	89.13	41.06	72.38	57.84
Xx^2 p=	0.04	0.17	0.55	0.62	0.03	0.15	0.66

Table 9. Percentage of the U.S. shot record group up to date with immunizations by poverty level, and statistical significance (X^2) of the distribution.

1993	Overall	DTP	Polio	MMR	HIB	Hepatitis	Varicella
Total	5.78	77.06	74.07	92.57	59.04	13.12	
Above	5.93	79.10	75.11	94.07	62.21	13.27	
Below	5.32	70.69	70.82	87.88	50.16	12.65	
X^2 p=	0.65	<0.01	0.10	<0.01	0.03	0.76	
1997	**Overall**	**DTP**	**Polio**	**MMR**	**HIB**	**Hepatitis**	**Varicella**
Total	19.61	81.37	90.98	91.78	58.95	71.89	18.33
Above	21.63	81.92	91.28	92.81	59.97	71.99	20.96
Below	12.76	79.53	89.99	88.43	55.50	71.56	9.83
X^2 p=	<0.01	0.32	0.54	0.04	0.17	0.88	<0.01
2001	**Overall**	**DTP**	**Polio**	**MMR**	**HIB**	**Hepatitis**	**Varicella**
Total	34.80	77.09	80.02	89.39	54.28	79.57	62.80
Above	35.51	78.11	80.81	90.01	55.40	80.02	63.14
Below	31.42	72.17	76.24	86.32	48.92	77.39	61.08
χX^2 p=	0.21	0.05	0.21	0.28	0.08	0.46	0.66

Table 10. Percentage of the U.S. shot record group up to date with immunizations by whether the child had a Medical Home, and statistical significance (X^2) of the distribution.

1993	Overall	DTP	Polio	MMR	HIB	Hepatitis	Varicella
Total	7.26	76.93	72.52	93.19	63.29	17.72	
Home	7.24	77.33	72.58	93.81	64.06	17.97	
None	7.76	67.38	71.16	79.73	42.44	11.65	
X^2 p=	0.92	0.28	0.87	0.05	0.34	0.27	
1997	**Overall**	**DTP**	**Polio**	**MMR**	**HIB**	**Hepatitis**	**Varicella**
Total	20.22	82.46	91.41	92.65	60.05	70.84	17.73
Home	20.50	82.98	91.49	92.87	60.47	71.66	18.03
None	12.27	67.76	89.21	87.59	48.37	47.57	10.94
X^2 p=	0.09	0.06	0.57	0.35	0.13	0.01	0.18
2001	**Overall**	**DTP**	**Polio**	**MMR**	**HIB**	**Hepatitis**	**Varicella**
Total	35.09	77.00	79.22	88.77	53.92	79.04	61.19
Home	35.23	76.74	79.34	88.57	54.01	79.32	61.40
None	31.58	83.75	76.25	93.42	51.75	71.94	56.42
XX^2 p=	0.62	0.25	0.71	0.19	0.77	0.40	0.57

Table 11. Percentage of the U.S. shot record group up to date with immunizations by whether financial problems prevented the child from receiving needed medical care, and statistical significance (X^2) of the distribution.

1993	Overall	DTP	Polio	MMR	HIB	Hepatitis	Varicella
Total	7.25	76.69	72.46	93.24	62.45	17.77	
Problem	3.72	76.27	63.41	93.07	62.32	23.79	
None	7.32	76.70	72.64	93.25	65.96	17.64	
X^2 p=	0.33	0.95	0.32	0.97	0.75	0.48	
1997	**Overall**	**DTP**	**Polio**	**MMR**	**HIB**	**Hepatitis**	**Varicella**
Total	19.97	81.28	91.13	91.65	58.91	71.68	18.06
Problem	16.11	77.19	90.35	93.35	57.14	76.80	15.20
None	20.46	81.80	91.22	91.43	59.13	71.03	18.44
X^2 p=	0.16	0.17	0.73	0.35	0.62	0.06	0.29
2001	**Overall**	**DTP**	**Polio**	**MMR**	**HIB**	**Hepatitis**	**Varicella**
Total	34.99	76.10	78.65	88.12	53.49	78.69	62.13
Problem	32.10	78.37	77.69	89.14	53.78	78.74	56.58
None	35.46	75.73	78.81	87.95	53.44	78.68	63.13
X^2 p=	0.37	0.46	0.77	0.69	0.94	0.99	0.18

Table 12. Percentage of the U.S. shot record group up to date with immunizations by residence area and health insurance status. Cochran-Mantel-Haenszel (CMH) tests of the statistical significance of the distributions.

1993	Overall		DTP		Polio		MMR		HIB		Hepatitis		Varicella	
Insurance	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Urban	8.19	7.46	76.07	68.30	71.71	62.68	92.80	89.23	59.00	59.05	19.89	18.93		
Rural	4.57	2.93	82.04	85.35	76.63	92.20	96.36	96.80	72.53	87.20	11.48	7.35		
CMH p=	0.70		0.21		0.41		0.39		0.82		0.62			
1997														
Urban	20.83	16.98	81.43	77.74	91.77	86.89	92.21	86.52	60.68	46.27	73.86	65.89	21.28	8.15
Rural	19.50	7.79	83.85	72.61	90.20	91.67	93.63	81.65	58.51	50.92	66.62	58.28	11.22	4.56
CMH p=	0.05		0.12		0.21		0.03		<0.01		0.03		<0.01	
2001														
Urban	35.27	27.34	75.35	71.88	77.93	76.54	87.48	90.78	53.58	44.41	78.05	70.38	63.58	58.04
Rural	38.92	19.00	81.94	64.99	83.3	68.06	89.93	84.47	59.63	30.54	84.35	78.67	59.32	57.27
CMH p=	0.01		0.12		0.32		0.69		0.01		0.16		0.42	

Table 13. Percentage of the U.S. shot record group up to date with immunizations by residence area and poverty status. CMH tests of the statistical significance of the distributions.

1993	Overall		DTP		Polio		MMR		HIB		Hepatitis		Varicella	
Poverty	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below	Above	Below
Urban	6.88	5.18	78.94	67.70	74.96	68.11	94.55	86.84	61.30	47.96	14.61	13.60		
Rural	2.75	5.86	79.62	81.19	75.60	80.36	92.52	91.32	65.43	59.83	8.74	9.31		
CMH p=	0.64		<0.01		0.10		<0.01		0.03		0.75			
1997														
Urban	22.18	12.53	81.03	80.53	91.08	91.02	92.21	89.70	60.56	55.80	72.89	74.65	22.55	11.67
Rural	18.94	13.60	86.33	75.86	92.26	86.25	95.54	83.52	57.04	54.41	67.48	60.31	13.65	3.10
CMH p=	<0.01		0.30		0.54		0.04		0.19		0.98		<0.01	
2001														
Urban	34.95	31.33	76.69	70.52	79.66	73.99	89.01	86.14	54.75	46.41	78.47	75.21	64.59	60.58
Rural	37.73	31.71	83.74	77.61	85.36	83.65	93.58	86.91	57.96	57.21	86.19	84.6	58.04	62.83
CMH p=	0.20		0.04		0.19		0.28		0.07		0.42		0.67	

Table 14. Results of the logistic regressions for the U.S. shot record group in 1993. Odds Ratio (OR) of not being up to date on immunizations relative to the reference level with 95% confidence intervals (95%CI).

	Overall		DTP		Polio		MMR		HIB		Hepatitis	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Residence/Race												
Urban White	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Urban Black	1.40	0.65-3.05	1.12	0.62-2.01	0.98	0.56-1.70	1.17	0.49-2.80	1.69	0.68-4.17	**1.78**	**1.01-3.17**
Urban Hispanic	1.64	0.77-3.51	1.04	0.65-1.67	0.88	0.55-1.39	0.86	0.35-2.16	1.18	0.45-3.07	1.31	0.75-2.30
Rural White	**5.43**	**2.10-14.05**	0.76	0.48-1.20	0.75	0.52-1.10	0.38	0.12-1.20	0.75	0.38-1.48	**2.79**	**1.56-4.99**
Rural Black	1.13	0.24-5.30	0.66	0.11-3.94	0.51	0.09-2.92	2.11	0.26-17.36	2.05	0.31-13.62	3.39	0.75-15.37
Rural Hispanic	0.77	0.09-6.92	0.81	0.15-4.34	0.33	0.07-1.48	ND	ND	ND	ND	2.46	0.29-21.28
Health Insurance												
Yes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
No	0.81	0.35-1.87	1.33	0.86-2.07	1.18	0.77-1.82	1.05	0.38-2.91	0.76	0.35-1.65	1.00	0.57-1.75
Poverty Level												
Above	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Below	1.74	0.96-3.13	**1.53**	**1.08-2.16**	1.37	0.96-1.96	**2.28**	**1.15-4.51**	**1.95**	**1.03-3.70**	1.15	0.73-1.80
Medical Home												
Yes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
No	0.71	0.18-2.71	1.56	0.70-3.47	0.86	0.32-2.31	1.43	0.35-5.91	2.13	0.52-8.76	1.44	0.49-4.23
Money Problems												
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Yes	4.87	0.59-40.54	0.70	0.33-1.48	0.94	0.45-1.93	2.07	0.61-7.00	1.14	0.47-2.76	0.94	0.38-2.34

Table 15. Results of the logistic regressions for the U.S. shot record group in 1997. Odds Ratio (OR) of not being up to date on immunizations relative to the reference level with 95% confidence intervals (95%CI).

	Overall		DTP		Polio		MMR		HIB		Hepatitis		Varicella	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Residence Area														
Urban White	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uban Black	1.38	0.80-2.40	1.23	0.77-1.99	1.22	0.61-2.47	0.59	0.24-1.46	1.47	0.99-2.18	1.29	0.80-2.06	1.65	0.89-3.05
Urban Hispanic	1.19	0.84-1.67	0.84	0.56-1.27	1.00	0.51-1.96	0.68	0.30-1.54	1.31	0.97-1.76	0.85	0.62-1.18	1.05	0.68-1.63
Rural White	1.23	0.76-2.00	0.78	0.49-1.26	1.03	0.54-1.98	0.66	0.32-1.35	1.20	0.83-1.73	1.40	0.92-2.14	**1.78**	**1.02-3.10**
Rural Black	1.65	0.38-7.13	0.29	0.07-1.17	0.83	0.21-3.24	0.83	0.22-3.10	0.66	0.28-1.53	1.81	0.85-3.85	3.53	0.60-20.69
Rural Hispanic	0.97	0.45-2.06	0.77	0.40-1.47	0.62	0.15-2.58	**0.12**	**0.02-0.95**	**1.86**	**1.01-3.45**	1.59	0.64-3.95	2.94	0.59-14.70
Health Insurance														
Yes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
No	1.20	0.73-2.00	1.36	0.85-2.17	1.78	0.96-3.31	**2.23**	**1.08-4.59**	**1.53**	**1.03-2.28**	1.43	0.95-2.16	**2.33**	**1.30-4.19**
Poverty Level														
Above	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Below	**1.68**	**1.20-2.37**	1.22	0.82-1.82	0.98	0.50-1.94	**2.14**	**1.15-3.98**	1.04	0.76-1.43	0.97	0.70-1.35	**2.07**	**1.13-3.78**
Medical Home														
Yes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
No	1.28	0.53-3.08	1.53	0.72-3.23	1.25	0.56-2.80	1.68	0.51-5.57	1.42	0.73-2.76	**2.77**	**1.46-5.28**	1.02	0.35-2.94
Money Problems														
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Yes	1.22	0.33-4.46	0.75	0.28-1.99	0.92	0.25-3.43	5.43	0.74-40.03	1.24	0.51-3.00	1.34	0.55-3.25	1.36	0.33-5.70

Table 16. Results of the logistic regressions for the U.S. shot record group in 2001. Odds Ratio (OR) of not being up to date on immunizations relative to the reference level with 95% confidence intervals (95%CI).

	Overall		DTP		Polio		MMR		HIB		Hepatitis		Varicella	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Residence Area														
Urban White	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Uban Black	1.71	0.98-2.97	1.60	0.93-2.74	1.56	0.95-2.56	1.64	0.89-3.04	1.26	0.77-2.06	1.51	0.94-2.43	1.38	0.74-2.57
Urban Hispanic	0.98	0.69-1.40	1.42	0.99-2.04	0.93	0.58-1.48	0.85	0.43-1.68	0.99	0.68-1.45	0.82	0.53-1.27	0.88	0.58-1.34
Rural White	1.03	0.70-1.52	0.89	0.56-1.42	0.94	0.54-1.62	0.69	0.34-1.40	0.96	0.67-1.37	0.62	0.36-1.05	1.20	0.75-1.93
Rural Black	**3.10**	**1.26-7.65**	1.57	0.37-6.72	0.45	0.12-1.62	0.63	0.12-3.29	0.81	0.26-2.54	0.58	0.21-1.60	2.56	0.90-7.27
Rural Hispanic	1.14	0.46-2.83	**0.44**	**0.24-0.80**	**0.13**	**0.06-0.28**	**0.14**	**0.04-0.48**	0.79	0.33-1.90	0.80	0.32-2.00	1.27	0.41-3.95
Health Insurance														
Yes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
No	**1.83**	**1.13-2.96**	1.52	0.86-2.66	1.34	0.74-2.44	0.87	0.39-1.97	**1.94**	**1.18-3.21**	1.68	0.89-3.17	1.14	0.61-2.16
Poverty Level														
Above	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Below	1.10	0.79-1.52	1.19	0.82-1.72	1.29	0.83-1.99	1.66	0.88-3.13	1.19	0.84-1.67	1.13	0.74-1.74	1.03	0.66-1.61
Medical Home														
Yes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
No	1.34	0.67-2.70	0.65	0.22-1.97	1.77	0.67-4.65	0.43	0.08-2.24	0.87	0.42-1.81	1.60	0.63-4.09	1.67	0.66-4.19
Money Problems														
No	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Yes	0.81	0.25-2.55	0.72	0.27-1.93	1.01	0.34-3.03	1.16	0.28-4.89	0.89	0.32-2.46	0.78	0.28-2.19	0.83	0.29-2.68

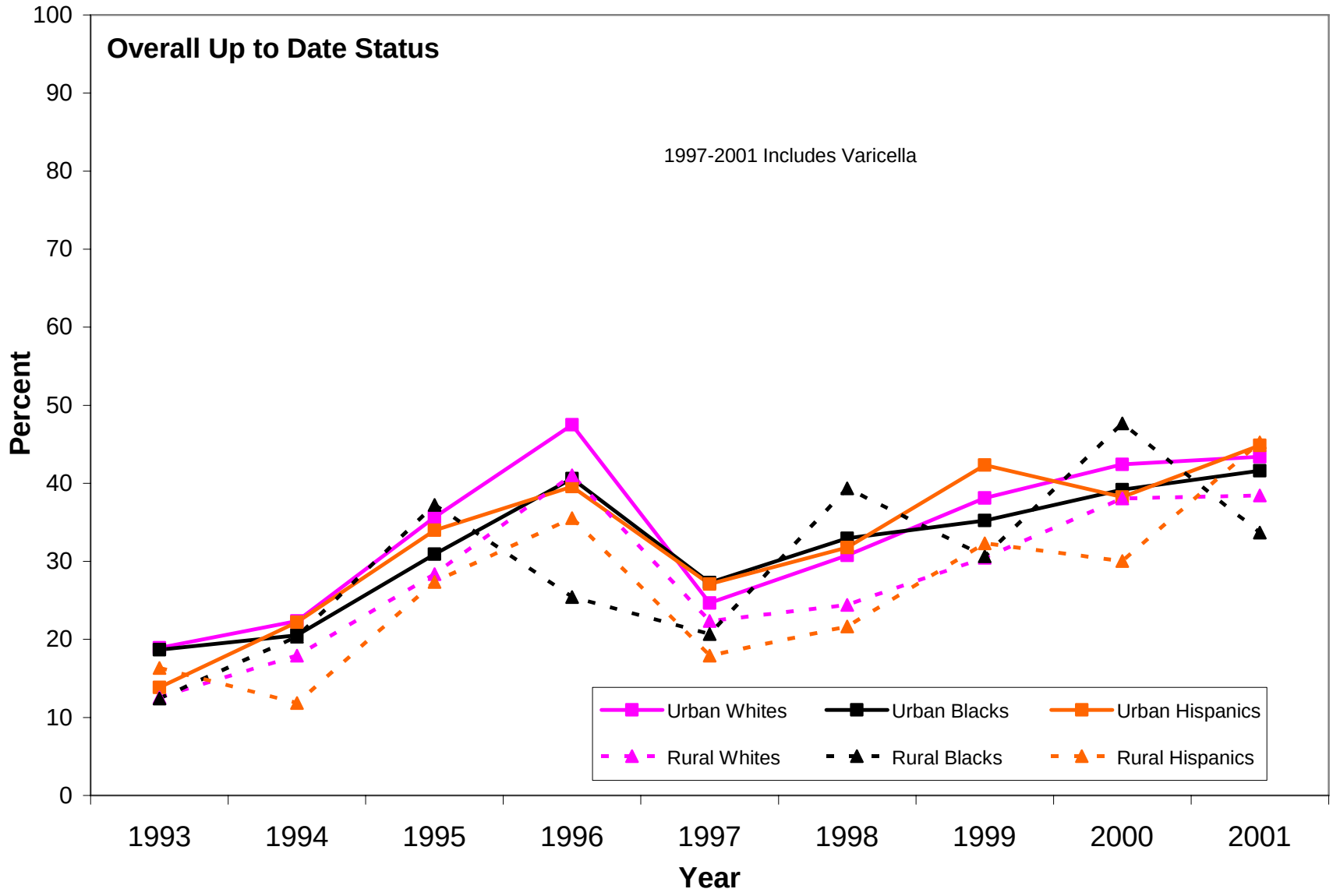

Figure 1. Percent of children up to date with their Overall immunizations by year, residence area, and race. Population includes all children regardless of whether they had a shot record.

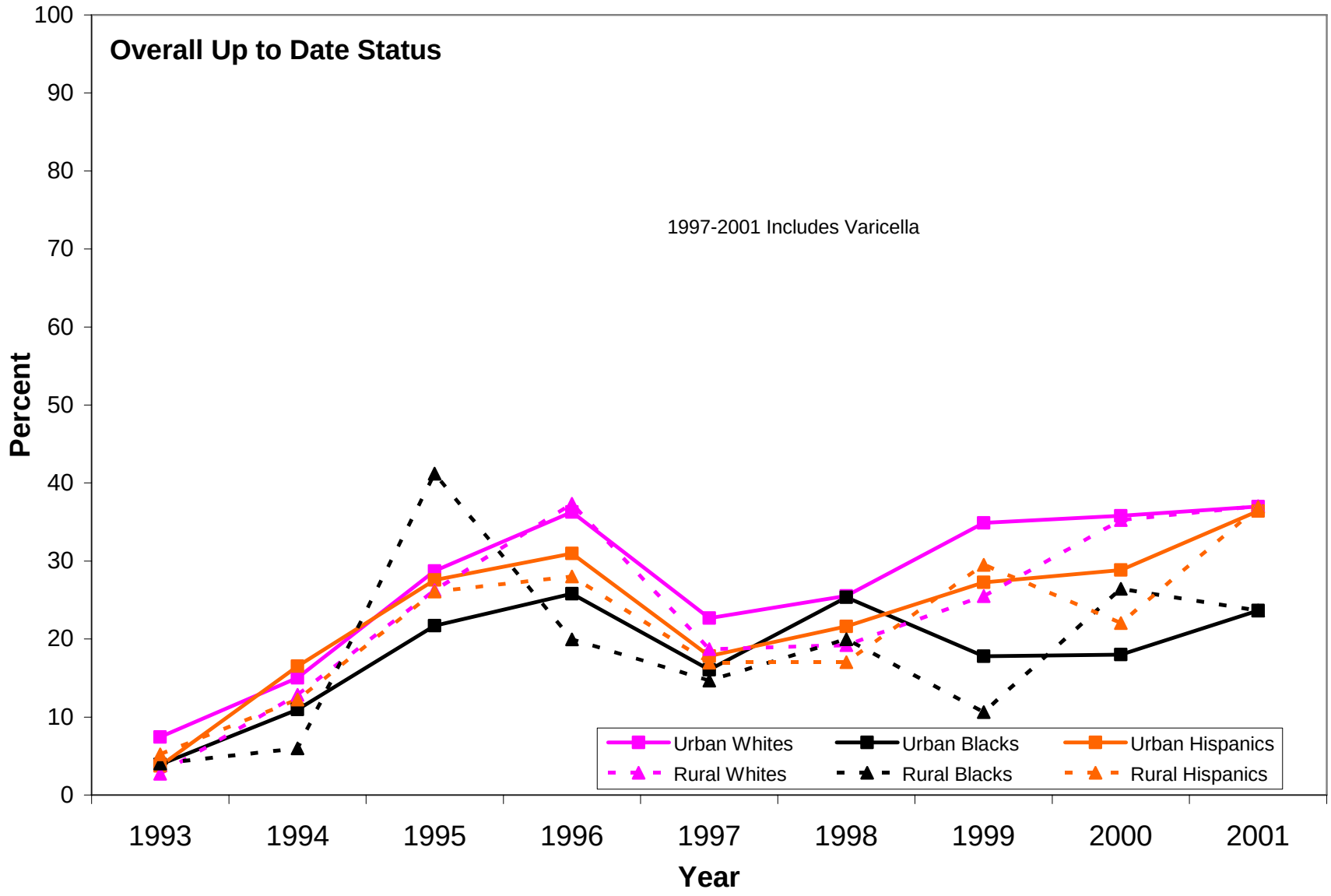

Figure 2. Percent of children up to date with their Overall immunizations by year, residence area, and race. Population includes children with shot records only.

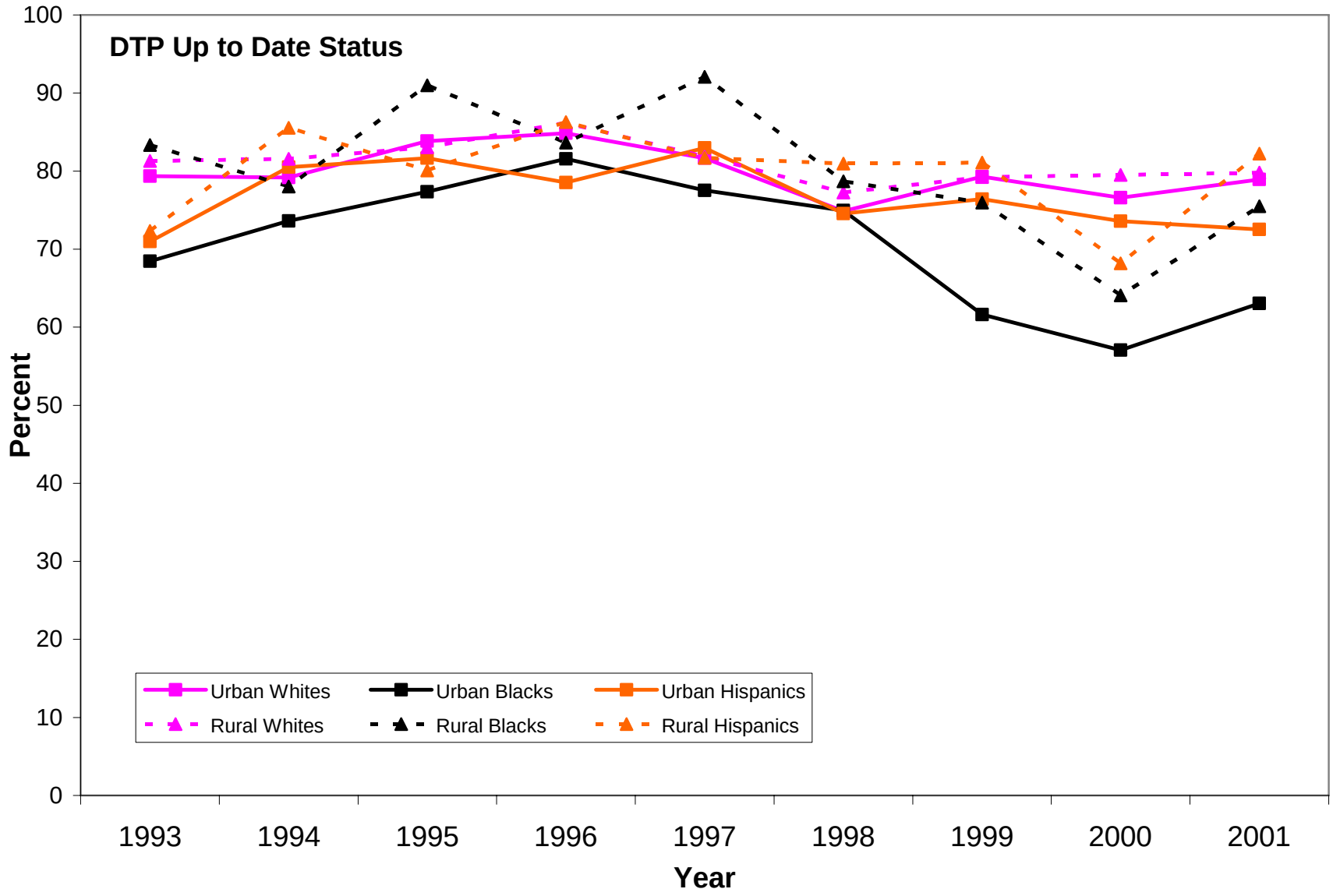

Figure 3. Percent up to date with DTP immunizations by year, residence area, and race. Population includes children with shot records only.

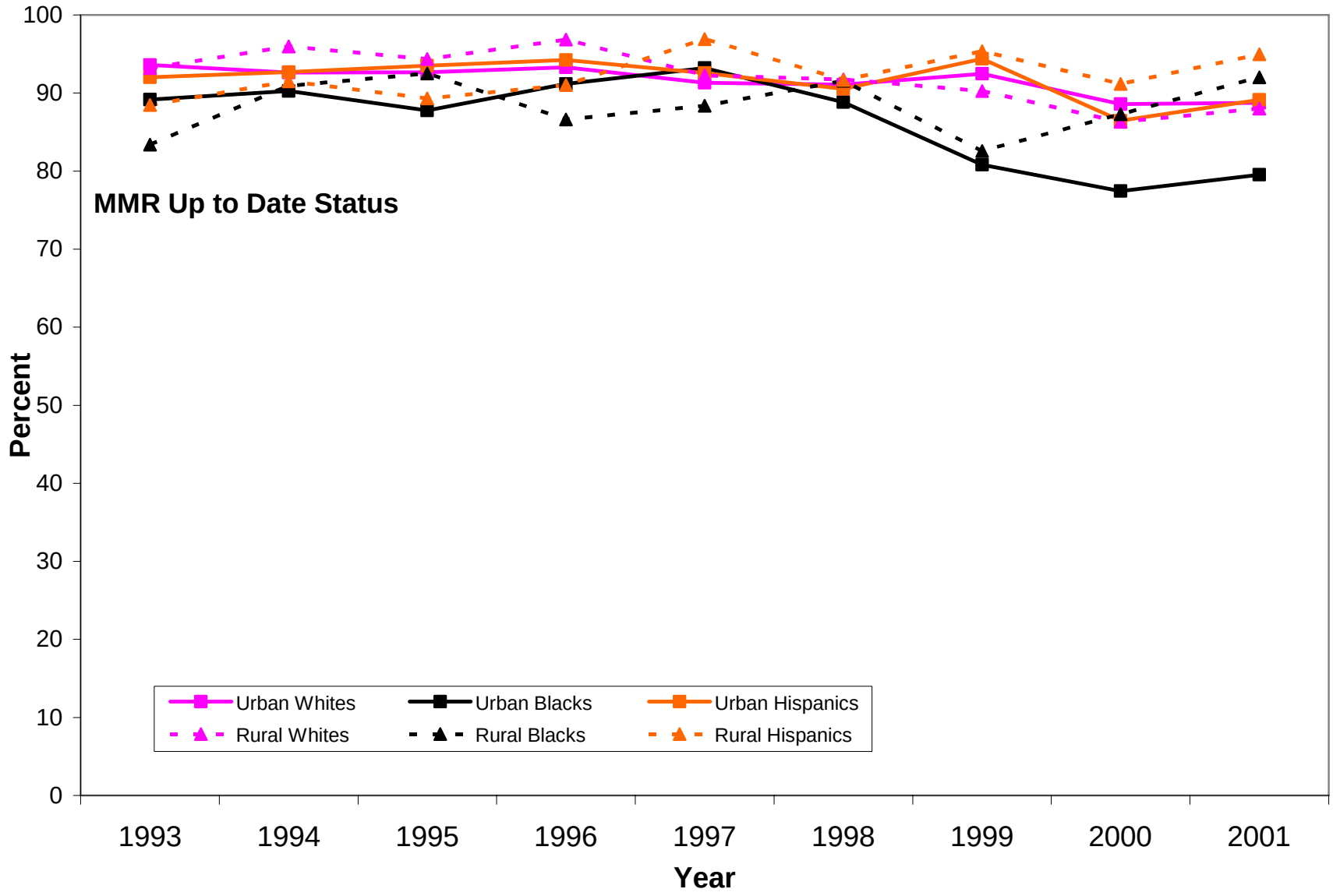

Figure 4. Percent of children up to date with MMR immunizations by year, residence area, and race. Population includes children with shot records only.

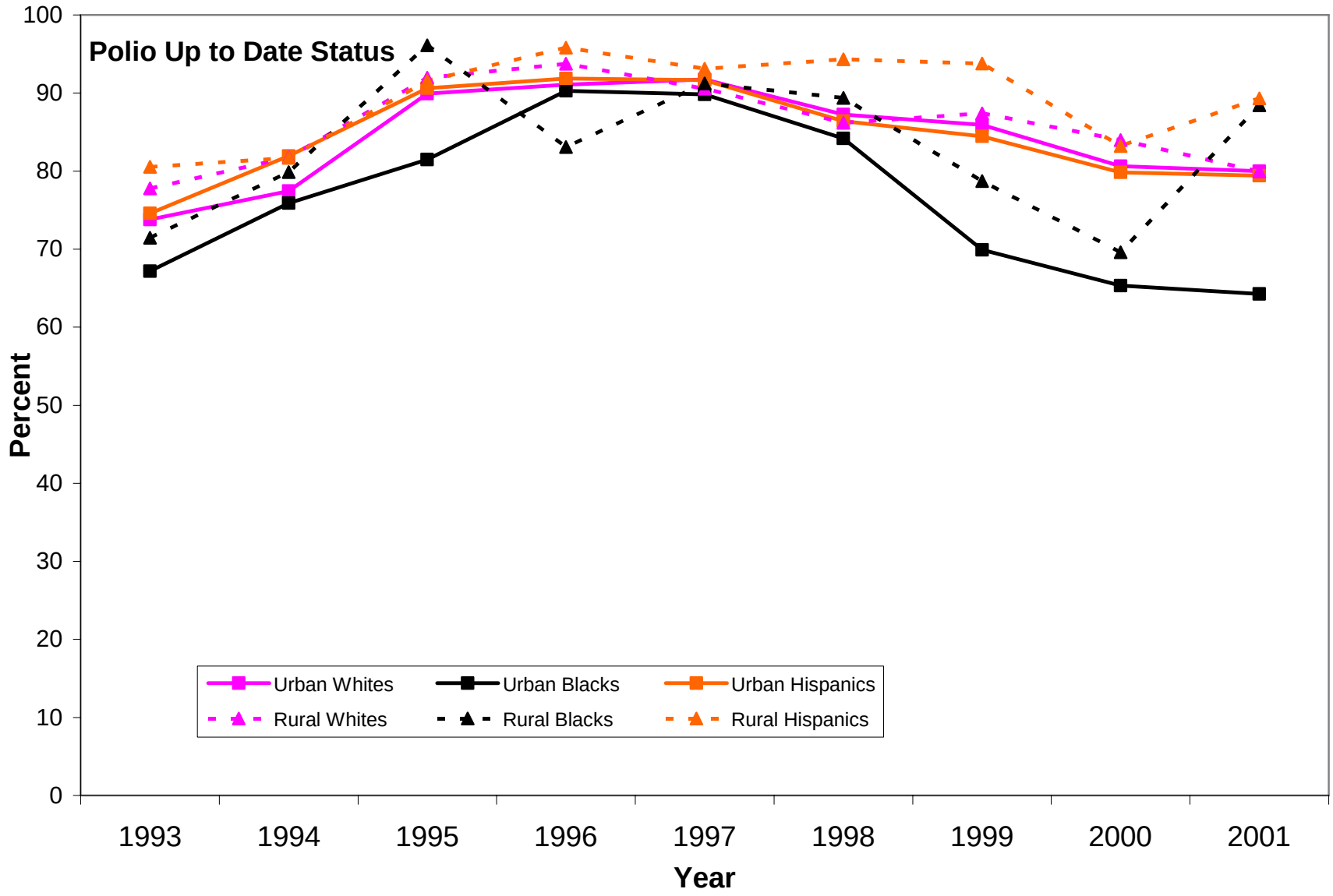

Figure 5. Percent up to date with Polio immunizations by year, residence area, and race. Population includes children with shot records only.

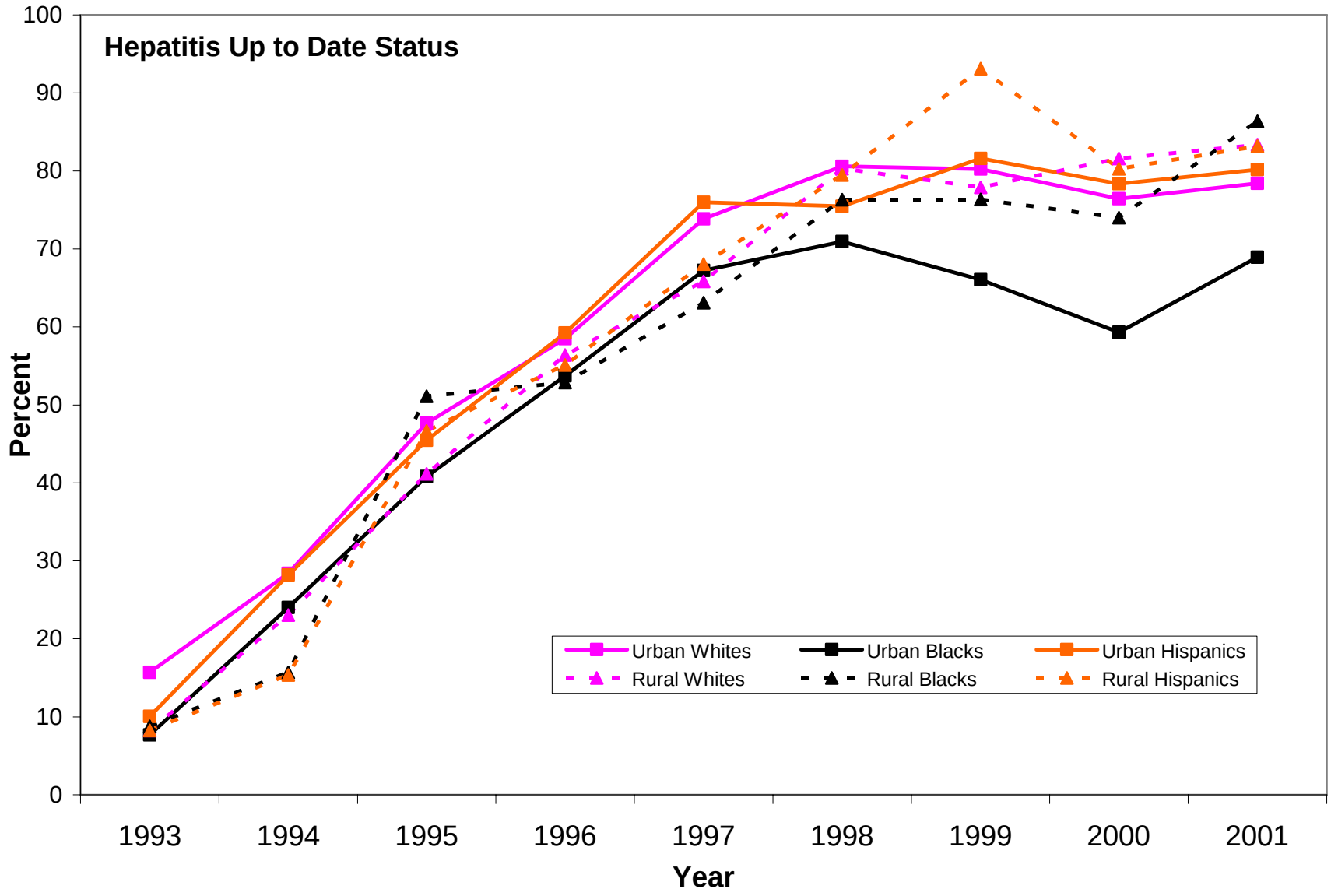

Figure 6. Percent up to date with Hepatitis immunizations by year, residence area, and race. Population includes children with shot records only.

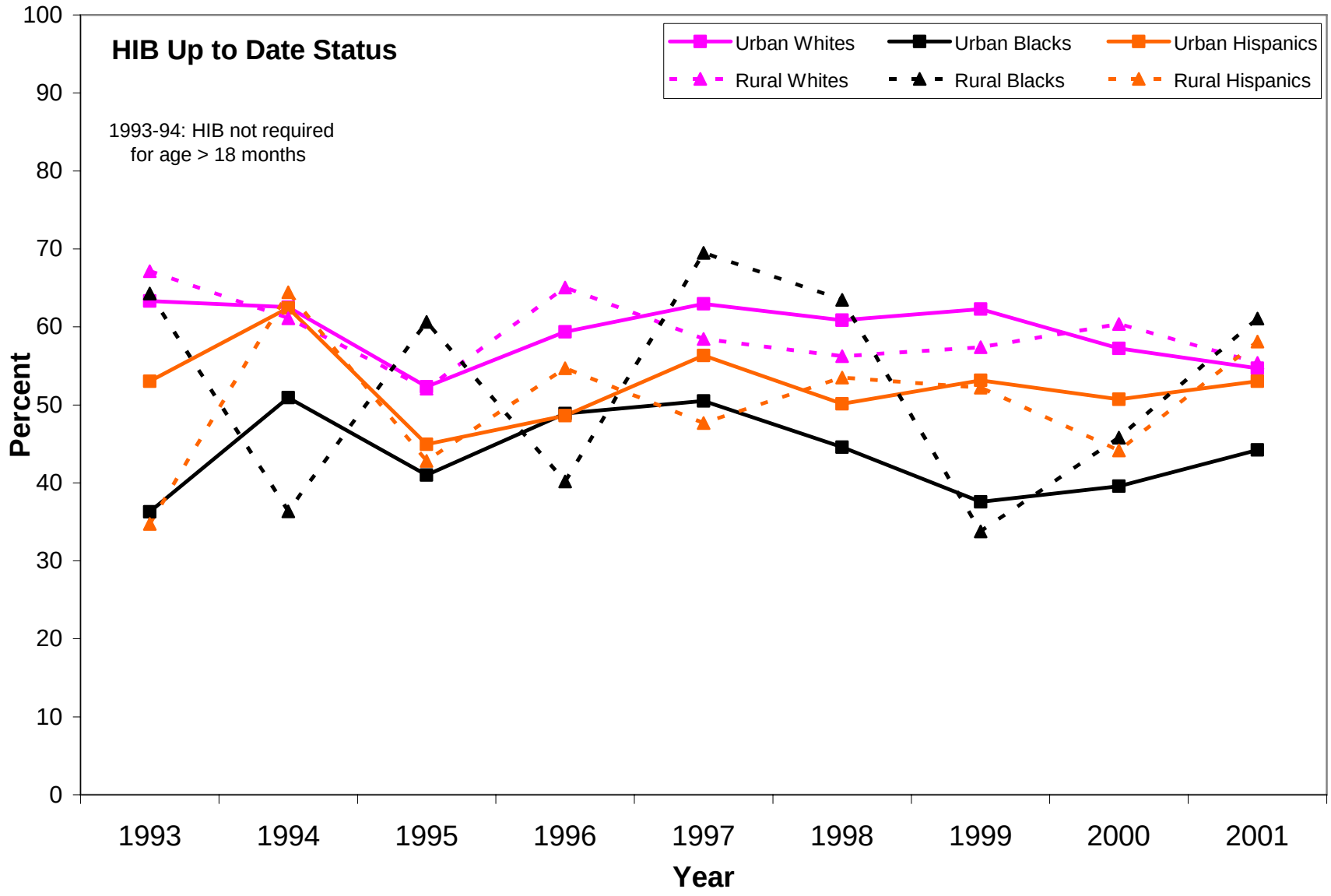

Figure 7. Percent up to date with HIB immunizations by year, residence area, and race. Population includes children with shot records only.

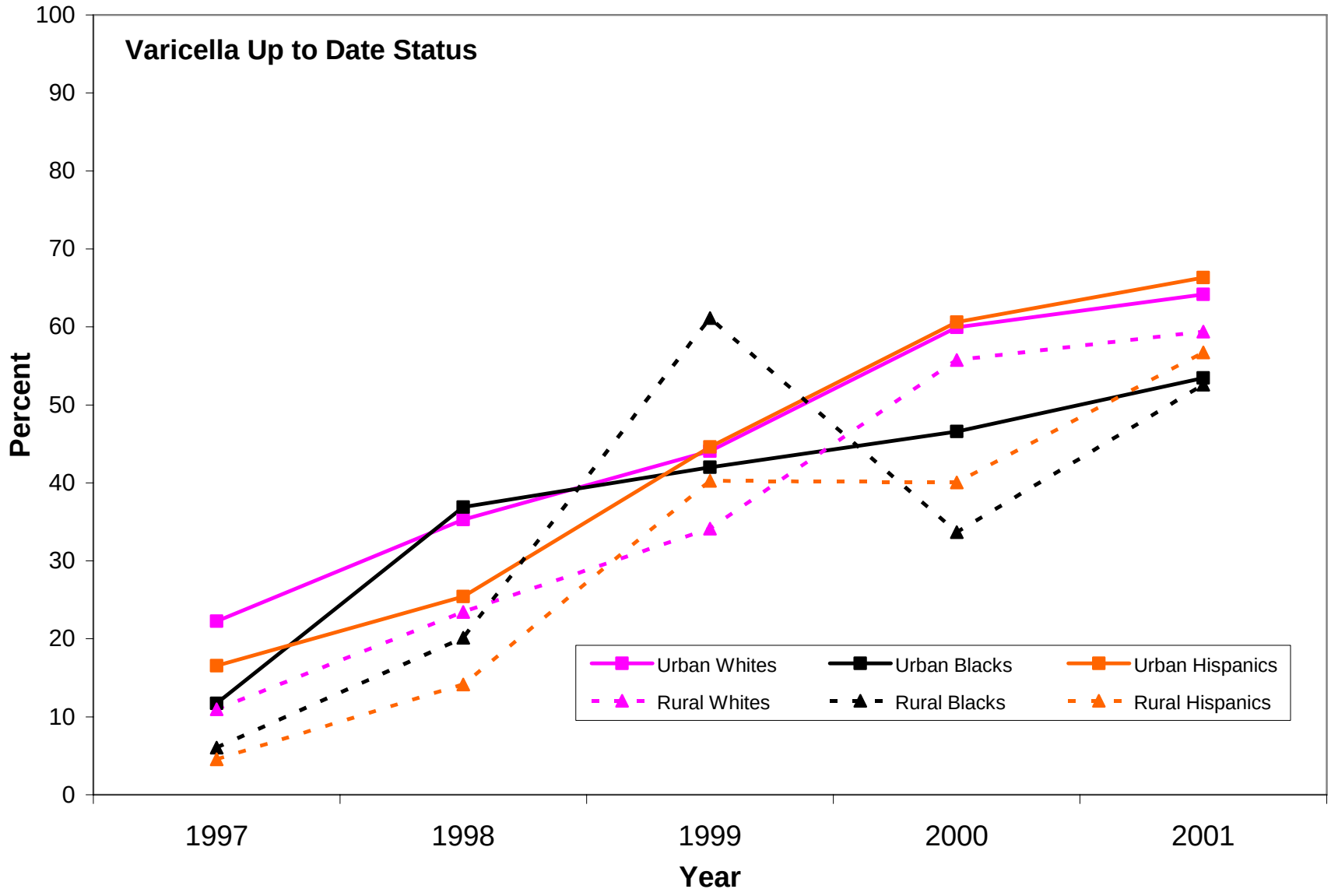

Figure 8. Percent up to date with Varicella immunizations by year, residence area, and race. Population includes children with shot records only.