



**Colorado childhood
immunization rates:
Policy and practice**

CHILDREN
white paper

Colorado Health Institute
Denver, Colorado

Colorado childhood
immunization rates:
Policy and practice

Three things to know ...

- Colorado enjoys 2-year old immunization rates that approach Healthy People 2010 objectives for all recommended vaccines except the fourth dose of diphtheria, tetanus and pertussis (DTaP).
- To the extent that under-immunized children reside in geographic, cultural or economic pockets of need, the risk associated with a vaccine-preventable outbreak is heightened.
- Childhood poverty is the most frequently cited risk factor for under-immunization.

A NOTE TO THE READER

I am pleased to release this white paper on childhood immunization rates in Colorado. A grant from The Colorado Trust and Caring for Colorado, allowed CHI to undertake this study to illuminate the U.S. Centers for Disease Control and Prevention statistic that placed Colorado 50th in the country in 2002 and 2003 for child immunizations.

In this paper we examine data from the National Immunization Survey over a nine-year period to better understand what it means to be 50th. As with many data driven exercises, there is a much more fascinating story to be told once we scratch beneath the surface of a global statistic. The Colorado story further unfolds through the thoughtful insights of a group of Colorado and national immunization experts.

The paper has been a rich learning experience, particularly as CHI staff and consultants have ferreted out the meanings associated with state rankings and their application to state policy decision-making and the subsequent program development activities that follow.

We extend a special thanks to The Colorado Trust and Caring for Colorado for supporting this research, it has made a significant, and hopefully enduring, contribution to our understanding of immunization policy and practice in Colorado.



Pamela P. Hanes, Ph.D.
President and Chief Executive Officer



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The Colorado Health Institute (CHI) was established in 2002 as a nonprofit corporation to serve as an independent source of objective, non-partisan health information for Colorado decision-makers in the public and private sectors. CHI was established and funded through a memorandum of understanding between The Colorado Trust, Caring for Colorado, and the Rose Community Foundation.

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Table of Contents

Executive Summary	6
Project Objectives	7
Background	8
Immunization Rates: What do they tell us?	10
Colorado and National Immunization Rate Trends	16
Demographic Determinants of Immunization Rates	25
Provider Characteristics of Immunization Rates	31
Other Factors Influencing Immunization Rates	32
Immunization Policies and Programs in Colorado	33
Successful Programs and Policies to Improve Immunization Rates	41
Options for Improving Colorado Childhood Immunization Coverage	47
Appendices	53
Appendix A: Vaccine Safety	
Appendix B: DTaP Vaccine Shortage	
Appendix C: Summary of CDC Task Force Recommendations	
Endnotes.....	58

Executive Summary

Ranking last among states in its overall vaccination rate in 2002 and 2003 brought Colorado some notoriety, media coverage, and legislative attention. While immunization stakeholders welcomed attention to the chronic issue of un- and under-immunized children, a side effect has been increasingly polarized rhetoric and politicization of the data.

This white paper aims to scratch beneath the surface of aggregate statistics. It argues that the statistic that ranks Colorado 50th in immunization rates is not an adequate problem statement and that greater specificity is needed. The state rankings are based on an index measure that indicates a problem is likely present – much like a smoke detector – but they provide less-than-adequate information on the specific nature of the problem. A more nuanced analysis reveals three inter-related coverage issues that deserve focused policy attention. In each case, improvements are warranted in:

- 2-year old immunization rates for under-immunized populations;
- The timeliness of all immunizations, especially for infants under the age of 12 months; and,
- Timing the administration of the fourth dose of Diphtheria, Tetanus and Pertussis (DTaP) by 18 months of age.

Colorado enjoys 2-year old immunization rates that approach Healthy People 2010 objectives for all recommended vaccines except the fourth dose of DTaP. The recent drop in Colorado's overall immunization rate was driven by a time-limited vaccine shortage that led the state to temporarily suspend its requirement that the fourth dose of DTaP be administered by 18 months of age. The otherwise commendable rates by vaccine mask the fact that administration of the recommended vaccine series is often not provided at the recommended age; and further, that certain population groups have coverage rates that are lower than statewide averages. To the extent that these under-vaccinated population groups are geographically concentrated, it creates an outbreak risk. High vaccination rates for 2-year olds can create a false sense of security that dissipates when one examines the lower coverage rates for infants under the age of twelve months, especially since infants are most susceptible to adverse outcomes resulting from infectious disease. In these cases, the outbreak risk is not merely hypothetical; 40 percent of the hospitalizations for vaccine-preventable diseases for Colorado children in 2002-03 were for children under the age of twelve months.

Childhood poverty is the most commonly cited risk factor for under-immunization. Several public programs, such as Medicaid, CHP+, the Vaccines for Children Program, and the Section 317 program exist to ensure that low-income children receive timely immunizations. These programs have contributed to the overall trend toward greater vaccination coverage over the last decade. However, this white paper has identified several areas for improvement in these and other immunization initiatives. Best practices

from the literature and from Colorado are identified to guide the policy development process.

The paper concludes with options for improving Colorado childhood immunization rates for foundations and other policy makers to consider in light of presented scientific evidence, Colorado's current childhood vaccination status, population risk factors, the state's current immunization infrastructure, and insights from expert informants. The options that derive from our research and analysis include:

- Create a state-level vision and plan that strengthens coordination between the programs currently administered by the Department of Health Care Policy and Financing (HCPF) and the Department of Public Health and the Environment (CDPHE) and builds on the active involvement of the private sector;
- Invest in information systems to improve data for planning, evaluation and immunization monitoring; and,
- Make strategic investments that improve access to immunizations and address Colorado immunization priorities.

Project Objectives

The Colorado Trust and Caring for Colorado invited the Colorado Health Institute (CHI) to develop a white paper on childhood immunization policy and practice in Colorado. CHI submitted a proposal in October 2004 that outlined the following objectives:

- Analyze and describe Colorado vaccination trends and their correlates;
- Identify gaps in existing programs and policies that contribute to low immunization rates; and,
- Provide options for public and private sector initiatives to improve childhood immunization rates.

The primary information sources for this white paper include: the research literature on vaccination coverage, key interviews with 18 state and national immunization experts, and secondary data analysis of the National Immunization Survey (NIS).

The project was guided by the following research questions:

- What "should" immunization rates be and why?
- What are Colorado immunization rate trends for key immunization series, and how do these compare to national trends?
- What are the demographic determinants of immunization rates in Colorado and nationally?
- What provider characteristics are associated with immunization rates in Colorado and nationally?

- What other factors influence immunization rates based on the literature and expert opinion?
- What are Colorado's major public immunization programs and policies?
- What strategies, programs, or policies have been demonstrated to improve immunization rates?

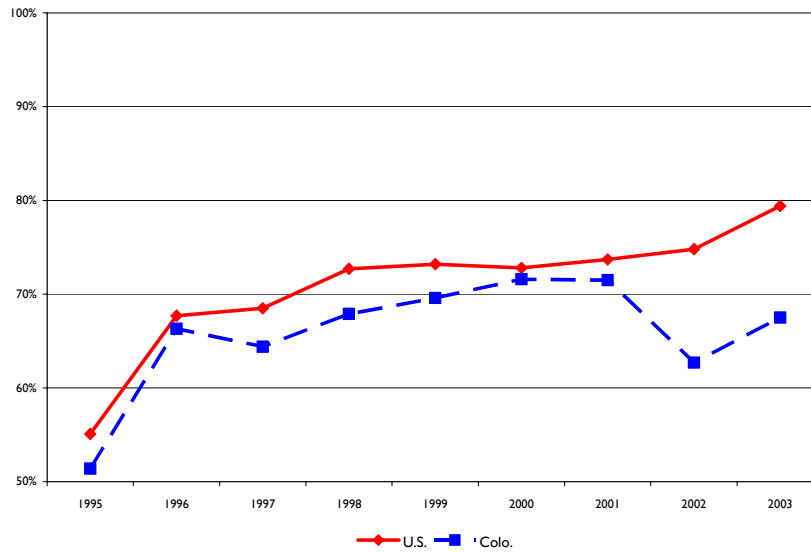
Background

The Centers for Disease Control and Prevention (CDC) have identified universally recommended childhood vaccinations as one of 10 great public health achievements of the 20th century. To make their case, CDC recalls that in the early 1900s cases of small pox numbered in the tens of thousands. Hundreds of thousands of measles and diphtheria cases were reported annually and killed thousands, mostly children. In 1922 alone, more than 5,000 patients died of pertussis. By the year 2000, smallpox and polio had been virtually eradicated, and childhood cases of measles and Haemophilus influenzae type b (Hib) had dwindled to record low numbers. The universally recommended vaccines for children have dramatically reduced childhood morbidity and mortality in the U.S.¹

Nationally, 2-year old immunization rates have reached all-time highs. Graph 1 compares national and Colorado immunization rates over a nine-year period for the recommended vaccination series known as the 4:3:1:3:3 series. This series consists of four doses of diphtheria, tetanus and pertussis (DTaP) vaccine, three doses of polio vaccine, one dose of Measles Mumps Rubella (MMR) vaccine, three doses of Haemophilus influenzae type b (Hib) vaccine and three doses of hepatitis (Hep B) vaccine. In 2003, U.S. immunization rates for the 4:3:1:3:3 series were within the margin of error for meeting the Healthy People 2010 objective of 80 percent for fully immunized 2-year olds (defined as infants and toddlers between 19-35 months of age).² However, the experience in Colorado was less robust.

Through 2001, Colorado's immunization rate for the 4:3:1:3:3 series tracked slightly lower than the national rate. Although lower, the rate was not significantly different from the national average. Colorado's coverage rate dropped sharply from national rates during the next two years (2002-03), ranking Colorado 50th among the states for the combined vaccination series (see Graph 1).

Graph 1: Combined vaccination series (4:3:1:3:3) for children 19-35 months of age, Colorado and U.S.



Source: National Immunization Survey (1995-2003)

Colorado's ranking of 50th among the states for the 4:3:1:3:3 combined series attracted both media coverage and legislative attention.^{3,4,5} While pediatric associations, children's organizations, hospitals, and public health departments welcomed attention to the issue of un- and under-immunized children, a side effect has been increasingly polarized rhetoric and politicization of the data. Both sides of the immunization debate cite the same CDC data to draw opposite conclusions. In 2002 the Colorado coverage rate was 62.7 percent; while in 2003 it was 67.5 percent. Even considering a confidence interval of +/- 6.5 percent, Colorado did not come close to the Healthy People 2010 benchmark of 80 percent for the series in either year.

Public health advocates claim that Colorado immunization rates signal a looming "public health crisis"; whereas mass immunization opponents maintain that current vaccination levels are sufficient to prevent the circulation of viruses.⁶ To the extent that conflicting interpretations of immunization data enter into the policy debate as they did in the 2004 Colorado legislative session, it has created confusion and inaction among legislators and other policymakers.⁷

This politicization of the data highlights the need to scratch beneath the surface of aggregate statistics to more fully describe the issue so that policymakers, funders, and program developers can determine whether intervention is necessary and if so, to craft appropriate and targeted strategies. Even the CDC National Immunization Program staff has raised concerns about uses of the NIS data, suggesting caution about the use of state ranking data in particular.⁸ CDC recognizes the need to educate the media and government officials about the appropriate uses of state rankings and their constituent measures.⁹ Colorado immunization experts who have worked with the NIS data underscored this message.¹⁰

We therefore begin this white paper on childhood immunization practices with a primer on vaccination estimates and measures with the goal of answering the question “what should immunization rates be and why?” This section also reviews what the summary measures do and do not tell us about the immunization status of Colorado children. Data limitations are highlighted. Later sections of the paper address alternative measures, risk factors for under-immunization, and interventions needed to boost coverage rates. The paper concludes with a set of options for improvement.

Immunization rates: What do they tell us?

Because the success of universally recommended childhood vaccines at reducing childhood infectious diseases and increasing human longevity is well-documented elsewhere, a summary of this literature will not be repeated here.^{11,12} However, it is important to understand why certain vaccines are universally recommended for children and how their very success has complicated infectious disease surveillance activities.

INDIVIDUAL AND HERD IMMUNITY

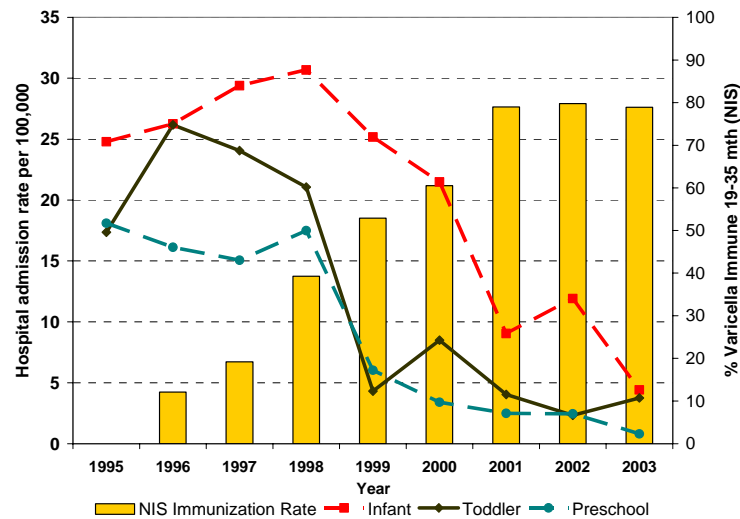
Vaccines “work” because they mobilize the body’s natural defenses against infectious disease.¹³ Vaccines are derived from components of infectious diseases that, when injected, induce an immune system response that prevents future infection. This definition of immunization considers individual-level effects. Population-based vaccination strategies produce a ‘safety in numbers’ effect known in the scientific community as herd immunity. Herd immunity occurs when a large proportion of the population is immune to an infectious agent, in this case, due to vaccination. Herd immunity creates a protective barrier to disease by reducing the chance of contact between those with an infectious disease and individuals susceptible to the disease.¹⁴ The Healthy People 2010 target for individual vaccines is set at 90 percent coverage under the assumption that coverage at this level is generally sufficient to produce herd immunity. However, the size of the herd necessary to prevent a disease epidemic varies by disease.¹⁵

The protective effect of mass immunization thus extends beyond specific individuals immunized, benefiting the un- and under-immunized in a population. This phenomenon is important because there are groups of children for whom immunizations are not yet or ever may be medically recommended. Infants, children with immunodeficiencies, and children who have had, or are at risk for, adverse vaccine reactions, all benefit from herd immunity.

Graph 2 illustrates the individual and herd immunity effects of immunization for chicken pox. Universally recommended varicella (chicken pox) vaccine dates to 1995. Plotting Colorado varicella immunization rates against hospital inpatient discharge data for varicella during a nine-year period demonstrates that as adherence to vaccination improved, hospitalizations for children under the age of five declined. Hospitalization

rates have steadily declined among infants less than twelve months of age, even though they are yet ineligible to receive the vaccine.¹⁶ This analysis illustrates how infants derive protection from chicken pox through herd immunity, particularly from older siblings who have been vaccinated.

Graph 2: Chicken pox (Varicella) hospitalizations in Colorado by age cohort and year



Data Sources: James Todd, M.D., Departments of Epidemiology, Clinical Microbiology, and Clinical Outcomes, The Children's Hospital, Denver, Colorado; CDC National Immunization Survey (1996-2003); and Colorado Hospital Association discharge data (1995-2003). Infant = 28 days to < 1 year; Toddler = 1 year to < 3 years; Preschool = 3 years to < 5 years

Infectious diseases spread through social networks and community contacts. However vaccination protection through herd immunity is often measured across a larger geographic area, usually at the state level. It is possible to have statewide coverage rates that mask pockets of need. In epidemiological terms,

No matter how large the proportion of immunes in the total population, if some pockets of the community, such as low-income neighborhoods, contain a large enough number of [un- and under-vaccinated individuals] ... the epidemic potential in these neighborhoods will remain high.¹⁷

IMMUNIZATION RECOMMENDATIONS AND REQUIREMENTS

Immunization recommendations and requirements derive from several sources. Typically each January, the American Academy of Pediatrics (AAP), the Advisory Committee on Immunization Practices (ACIP) of the Centers for Disease Control and Prevention (CDC), and the American Academy of Family Physicians (AAFP) jointly issue an annual Recommended Childhood Immunization Schedule. We reference the joint statement as either the ACIP recommendation or the ACIP vaccine schedule. CDC publishes updates to the annual ACIP recommendation in the Morbidity and Mortality Weekly Reports (MMWR).

In practice, states influence immunization schedules by passing laws that mandate vaccination compliance prior to entering childcare centers and public schools (K-12).

Current Colorado law requires that all parents or guardians document their child's immunization status before the child attends a childcare center, primary or secondary school.¹⁸ Parents are required to furnish a certificate of immunization or their child faces suspension or expulsion.¹⁹ The vast majority of states provide for a religious exemption. Colorado is one of 20 states that also allows for a philosophical exemption.²⁰ To obtain a philosophical exemption, the parent or guardian must state in writing that he or she has a personal belief that is opposed to immunizations.²¹ Vaccination exemption policies, particularly philosophical exemptions, were enacted in response to parental concerns about vaccine safety²² (see Appendix A - Vaccine Safety).

In Colorado, the State Board of Health is charged with specifying immunization policy with regard to childcare centers, pre-school and K-12 certification requirements. In setting policy, the Board of Health considers the ACIP recommendations and other factors including medical, religious, and philosophical exemptions as well as vaccine supply issues.

For the 2003-2004 academic year, up-to-date vaccination coverage for individual vaccines for Colorado kindergarteners was estimated at 84 percent, as opposed to the national average of approximately 94 percent.²³ The CDPHE tracks approved school exemptions, but it does not publish these rates due to concerns about the reliability of the data. CDPHE is currently conducting an audit on a random sample of Colorado public schools and childcare facilities, reviewing records and validating the immunization status of children. In this audit, CDPHE is investigating the extent to which reported rates reflect actual coverage rates. Regional rates and a statewide estimate resulting from the audit will be available in May 2005.

DISEASE SURVEILLANCE AND VACCINE COVERAGE

Graph 2 (previous page) illustrates the challenge of monitoring the control of infectious diseases in the context of universally recommended vaccines. Over time, tracking disease outbreaks becomes a less effective means for identifying pockets of need and populations at-risk of infectious disease. Bolton et al. have observed that, "disease surveillance was the more important [monitoring] strategy when these diseases were widely prevalent ...however, as the prevalence of vaccine-preventable diseases declined, the importance of vaccination coverage rates as indicators of the population's susceptibility gradually increased."²⁴

Early and Current Measures

The practice of estimating national immunization coverage rates using the up-to-date vaccination status of 2-year olds dates back to the 1970s. At that time, the primary concern of CDC was preventing measles outbreaks among school-aged children. The 'up-to-date at 24 months measure' served as a school readiness indicator. With an epidemiological focus on elementary school children, this school readiness indicator

allowed time to intervene if coverage rates were found to be low. More recent measles outbreaks (1989-1991) affected large numbers of pre-school children and shifted the epidemiological focus to younger population groups.²⁵ Concomitantly, the relevance of 2-year old vaccination rates as a direct measure of population risk increased.

Currently, 2-year old immunization rates represent one of ten leading health indicators identified by the U.S. Department of Health and Human Services' Healthy People 2010 Initiative. Leading health indicators are selected not only for their intrinsic value, but also for their relevance to broader public health issues.²⁶ For example, the use of preventive services, including immunizations, is predictive of access to health care, another Healthy People 2010 leading indicator.²⁷ In short, 2-year old immunization rates have been tracked for well over 30 years, but their epidemiological relevance and interpretation has changed over time.

Coverage Measures in the NIS and NHIS

Two federal surveys, the National Immunization Survey (NIS) and the National Health Interview Survey (NHIS), collect data on the immunization status of preschool children between the ages of 19 and 35 months. As Zell et al. explain, "this target age group was established because by the age of 19 months children should have received the complete series of vaccinations for DTaP, polio, MMR, Hib, and Hep B and because narrowing the age range to just 2-year olds, that is children ages 24-35 months, would be extremely costly given very small numbers."²⁸ Both surveys include index measures of combined series vaccination coverage as well as individual vaccine measures. Healthy People 2010 immunization measures are drawn from these two federal data sources.

Unless otherwise noted, all of the data reported herein were drawn from the NIS and have undergone statistical testing.²⁹ A list of published NIS tables for 2003 can be found at: <http://www.cdc.gov/nip/coverage/NIS/03/toc-03.htm>.

The NIS is an annual telephone survey that was implemented in 1994 as a national vaccination surveillance system for infants and young children. The NIS was specifically designed to provide reliable and valid annual estimates of vaccination coverage for 78 separate areas including all 50 states, the District of Columbia, and 27 large urban areas considered to be at high risk for under-vaccination.³⁰ Immunization providers verify immunization information obtained from parents; the NIS data reported herein use the provider-verified dataset. National and Colorado-specific studies validate NIS estimates of vaccination coverage.^{31,32} Zell et al. provide a thorough and thoughtful discussion of these validation studies and a review of the statistical methods used to evaluate and ensure the quality of national NIS estimates.³³

Like all surveys, the NIS is subject to data limitations and is not equally well suited for all analytical purposes. For example, the use of state rankings has been questioned.³⁴ Further, less populated states like Colorado have small sample sizes that preclude sub-state and multivariate analyses. Even the statewide estimates for Colorado have large margins of error (plus-or-minus 6.4 percent) for the 4:3:1:3:3 series.³⁵ As a result, the

Colorado rate on the 4:3:1:3:3 series could be as high as 73.9 percent or as low as 61.1 percent. In spite of the margin of error, Colorado remains well under Healthy People 2010 goal, even at the high end of the range. The current analysis compensates for the NIS data limitations by combining multiple years of data, when appropriate, to stabilize estimates.³⁶ We also attempted to validate findings by considering whether multiple data sources, e.g., vaccination rates, disease incidence, and key informant interviews converge to tell a consistent story about the Colorado rankings.

Index Measures

Index measures provide a snapshot of immunization status and represent a convenient means to track and communicate vaccination coverage. The vaccination literature uses the term *index* measure interchangeably with *combined series* measure. Combined series are constructed by counting all the doses per vaccine for each recommended vaccine for 2-year olds. Children receiving all recommended doses of all vaccines by the age of 2 years are considered fully vaccinated using a combined series measure.

The most commonly cited combined vaccination series is the 4:3:1:3:3, which is the benchmark used for the Healthy People 2010 objective. Because ACIP recommendations change over time, the combined series measure also changes. This explains why the combined series measure used in the immunization literature can vary from study to study. NIS reports four separate combined series measures: 4:3:1; 4:3:1:3; 4:3:1:3:3; and 4:3:1:3:3:1 (see Table 1). Five years after ACIP recommends the addition of a vaccine, the NIS creates a new series measure that incorporates the addition.³⁷

Table 1 summarizes current ACIP-recommended vaccines, the recommended doses, and the recommended age for completion of the individual vaccine series.³⁸ The row sequence corresponds to the order in which the individual vaccines are listed in the combined series measures.

Table 1: Immunization Series Defined

Recommended Doses	Vaccine	ACIP recommendation for maximum age of specified dose
4	DTaP (Diphtheria, Tetanus, Pertussis)	18 months
3	Poliovirus	18 months
1	MMR (Measles, Mumps Rubella)	15 months
3	Hib (Haemophilus influenzae type B+)	15 months
3	HepB (Hepatitis B)	18 months
1	Varicella (Chicken Pox)	18 months

This table abbreviates the official ACIP recommendation for children under the age of 2 years. The full schedule can be found at www.cdc.gov/nip. Current ACIP recommendations also include the pneumococcal vaccine; however, it has not yet been included in the summary measures. Hepatitis A and annual Influenza vaccinations are also recommended but for select populations only.³⁹

In summary, index or combined series measures can be useful as a communication tool, but they lack diagnostic precision. As overall population indicators, index measures can signal where a problem may be present but they are less useful at providing information on the specific nature of the problem.

The ACIP vaccination schedule provides recommended age ranges for each dose of each vaccine; these recommendations are based on studies of vaccine safety and efficacy. As a snapshot, index measures only partially capture the age-appropriateness for each immunization series. A general assessment of vaccination coverage for children up to 35 months of age could overlook children who are 20 months behind the ACIP-recommended schedule and yet still be counted as fully vaccinated.⁴⁰ To determine whether Colorado childhood vaccination rates are a problem, one must separately consider the individual vaccine rates.

Individual Vaccine Measures

Immunization experts typically do not rely on index measures to assess population risk. In the alternative, they prefer measures that disaggregate index measures and consider the timing of vaccinations on an individual vaccine basis. Further, these experts resist the temptation to rank the relative importance of individually recommended vaccines. As one Colorado expert explained,

Each part of the series is important for different reasons. It would not make sense to prioritize them. In general, ... there are three main categories of immunizations, those that protect children against diseases they are very likely to come in contact with (Hib, Pertussis, Varicella, and Pneumococcus), those that will protect children when they become older against diseases that they may or may not come in contact with (tetanus, Hepatitis B), and those that are necessary to protect both the child and the community in the unlikely event a [serious] disease was introduced (Polio, Measles, Mumps, Rubella, Diphtheria).⁴¹

It has been suggested that categorizing the relative risk of individual vaccine preventable diseases is a somewhat artificial exercise. The point made by most experts interviewed for this study was that although the risk of exposure varies, all of the diseases pose potentially serious health consequences.

Timeliness Measures

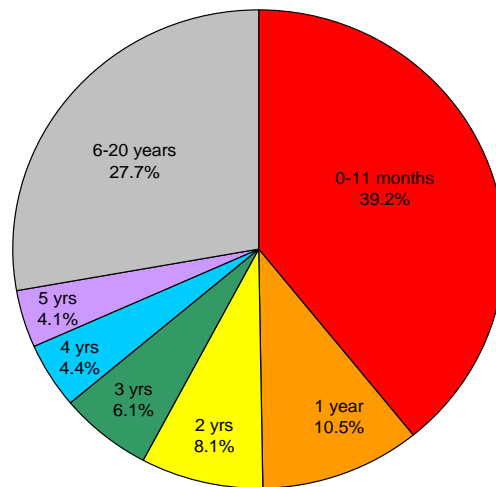
Late or inappropriately timed immunizations are another epidemiological concern that is not well captured by index measures. Several studies have documented that compliance with recommended age ranges in the ACIP schedule is low. For example, one study revealed that only 9 percent of children received all of the immunizations recommended by 24 months within the recommended age range for each vaccine. The authors concluded that a “high vaccination status at 24 months of age does not reflect the reality that many vaccinations are not given at the appropriate ages.”⁴² A Colorado study of immunization timeliness found that “poor families who move frequently, have older children, and are headed by younger parents” are at the highest risk for delayed

immunization. Inaccurate or lack of knowledge about the ACIP recommended schedule were also implicated in late immunizations.⁴³

Failure to adhere to the ACIP schedule can reduce vaccine efficacy and immunity. Again, herd immunity is especially important for infants who, due to their age, are not fully immunized. For example, vaccine efficacy for pertussis is just 44 percent for one dose of DTaP, suggesting that even infants who are current on their immunization schedule may be at risk of contracting the disease.⁴⁴

Graph 3 presents 2002-03 Colorado hospital data noting that 39.2 percent of children hospitalized with vaccine-preventable diseases were infants under the age of 12 months. Colorado immunization experts argue that missed and late immunizations, in combination with age-related susceptibility, play a role in the elevated risk of hospitalizations among infants.⁴⁵ However, they also note that this timeliness theory cannot be tested adequately due to the lack of available data with regard to a child's immunization status at the time of hospitalization.

Graph 3: Age distribution of children hospitalized in Colorado for common vaccine-preventable diseases (Pertussis, Varicella, *Haemophilus influenzae* type B, *Streptococcus pneumoniae*)



Data Sources: James Todd, M.D., Departments of Epidemiology, Clinical Microbiology, and Clinical Outcomes, Children's Hospital, Denver, Colorado; and Colorado Health and Hospital Association (2002-2003)

Colorado and national immunization rate trends

This section disaggregates the 4:3:1:3:3 immunization series into individual vaccination measures. This approach allows for an examination of the sensitivity of the index measure relative to its individual component parts. A brief overview of each vaccine and its associated disease is provided. Colorado performance on the individual

vaccine measures is compared to various benchmarks including national NIS rates, Healthy People 2010 objectives, and the coverage rate for the Colorado 4:3:1:3:3 combined series.

DTaP (DIPHTHERIA, TETANUS, PERTUSSIS) VACCINE

The DTaP vaccination is a combined vaccine administered as a single injection. It protects against diphtheria, tetanus, and pertussis. The introduction of the diphtheria vaccine has largely controlled exposure to the disease from sources internal to the United States.⁴⁶ However, imported cases of diphtheria have historically caused isolated outbreaks among unvaccinated children in Colorado.⁴⁷ Tetanus is an example of a childhood immunization that protects against exposure that is most likely to occur among older adults. A tetanus booster is required every ten years. Reported cases of tetanus in the United States generally occur among individuals over the age of 50 who were not vaccinated as children.⁴⁸ Unlike many of the other vaccine-preventable diseases, tetanus is not a contagious disease, so unvaccinated individuals do not benefit from herd immunity.⁴⁹

Pertussis (whooping cough) vaccination dates to the 1940s. In the case of pertussis we know that immunization confers less than ideal immunity. The incidence of pertussis has decreased 150 percent since the 1940s but periodic outbreaks persist, therefore the disease is not considered controlled. The DTaP vaccination is currently administered over a 4-6 year period, with doses four and five functioning as booster shots, conferring additional protection to toddlers and school-aged children. Because pertussis immunity wanes over time, an adolescent booster has been developed and is awaiting FDA approval.

True herd immunity cannot be achieved through immunization because the currently recommended DTaP series does not provide life-long immunity to pertussis. This may explain why the clinical literature estimates that a very high vaccination coverage rate of 92-94 percent would be required to prevent the circulation of pertussis in the population, especially in light of the highly contagious nature of the disease.⁵⁰ By contrast, herd immunity requirements for diphtheria are estimated at an 85 percent coverage rate.⁵¹

The incidence of pertussis in Colorado was three times the national average in 2002.⁵² In children under the age of 6 months, the disease is life threatening.⁵³ Colorado experienced hundreds of pertussis cases and seven deaths during the five-year period between 1997 and 2001.⁵⁴ As Table 2 illustrates, Colorado experienced a surge of pertussis cases in 2004, although some of this increase has been attributed to improved diagnostic procedures.⁵⁵ Among the cases reported, adolescents between the ages 10-19 years accounted for nearly half (46%) of all cases; yet infants under the age of twelve months had the highest rates of infection.

Table 2: Colorado pertussis cases by age group, 2003-2004

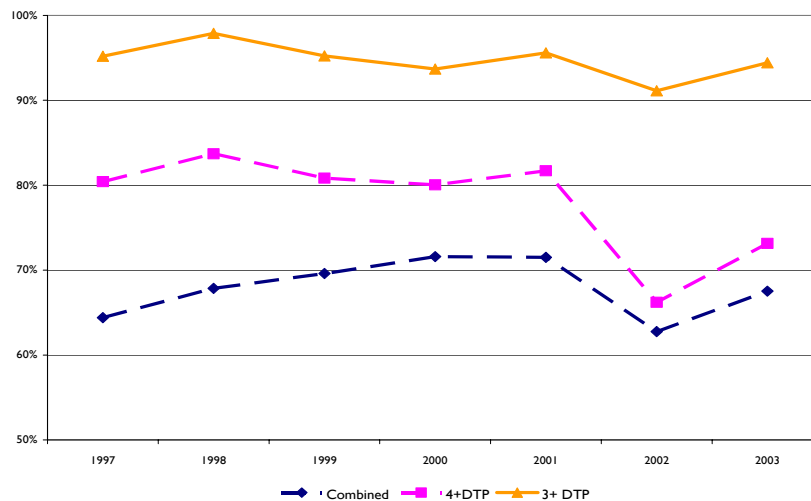
Age Group	Cases		Percent		Rate	
	2003	2004	2003	2004	2003	2004
< 1	46	100	12.5%	8.2%	66.8	145.2
1-4	42	123	11.4%	10.1%	16.1	47.0
5-9	42	99	11.4%	8.1%	13.5	31.7
10-14	94	310	26.1%	25.5%	13.0	95.8
15-19	57	249	15.2%	20.5%	16.4	72.9
≥ 20	87	336	23.4%	27.6%	2.6	10.3
Total	368	1217	100.0%	100.0%	8.0	26.5

Data Source: CDPHE (2003-2004). The 2004 data are provisional.

Just under three-quarters of Colorado toddlers between the ages of 19 and 35 months were up-to-date with all four doses of the DTaP vaccine. Colorado's 2003 rate of 73.1 percent was well below the Healthy People 2010 objective of 90 percent and was also low relative to the national average of 84.8 percent.

As Graph 4 illustrates, Colorado's low 4:3:1:3 combined vaccination series rate in recent years was being driven by low 4+DTaP vaccination rates. The graph also illustrates that it is the fourth dose, not earlier doses, that was most implicated in the recent dip in the combined series rate. The 3+DTaP rate was relatively stable over the entire time period. Colorado immunization experts attribute Colorado's 4+DTaP and combined series rates to a national DTaP vaccine shortage in 2001 and the corresponding policy decision in Colorado to temporarily suspend the state school vaccine certification requirements with respect to the fourth and fifth doses of DTaP⁵⁶ (see Appendix B for more on the DTaP vaccine shortage).

Graph 4: Combined 4:3:1:3 vaccination series vs. third and fourth doses of DTaP, 19-35 months of age, Colorado



Source: National Immunization Survey (1997-2003)

The fourth and fifth doses of DTaP are booster immunizations that aim to extend immunity into older age groups.⁵⁷ Although it has been reported that the fourth dose of DTaP is among the most frequently missed vaccines for under-immunized children in the U.S.,⁵⁸ key informants believe that missed boosters compound the risk of waning immunity to pertussis in adolescents. The health services research literature suggests that missing or late fourth DTaP doses are often due to the late administration of earlier doses.⁵⁹

Table 3 displays Colorado’s 3+ DTaP and 4+DTaP immunization rates, which signal a potential timeliness problem associated with the entire DTaP series. As shown in Table 3, nearly half of Colorado toddlers received the fourth DTaP dose late (after 19 months) or not at all. Further, one-third of children failed to receive the third dose as recommended by 7 months of age. The bolded percentages indicate the age and vaccine combinations for which age-appropriate coverage levels are well below the estimated herd immunity threshold.⁶⁰ This combination of factors indicates an increased risk for an outbreak of pertussis.

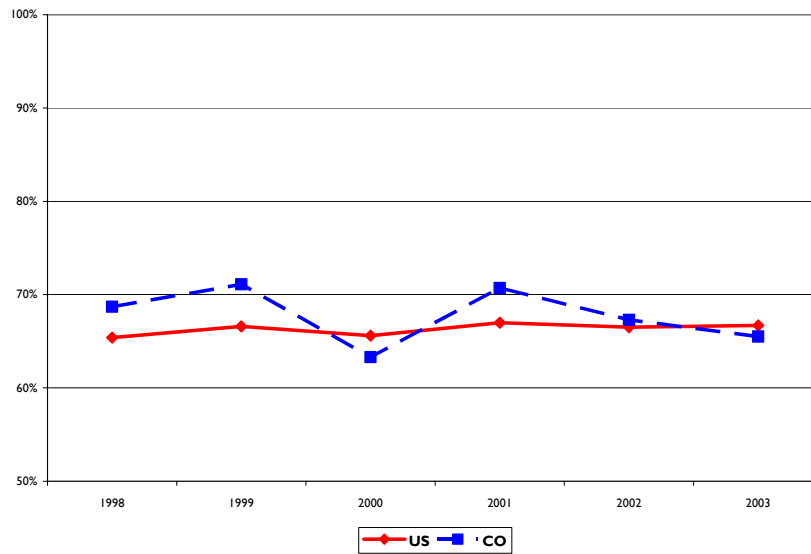
Table 3: Pertussis herd immunity thresholds and actual coverage rates by age

Age	Pertussis herd immunity threshold	3 rd DTaP U.S.	3 rd DTaP CO	4 th DTaP U.S.	4 th DTaP CO
At 7 mos. (ACIP rec. Dose 3 at 6 mos.)	92-94%	66.7%	65.5%	N/A	N/A
At 19 mos. (ACIP rec. Dose 4 at 18 mos.)	92-94%	94.5%	93.0%	67.5%	55.2%
Between 19-35 mos. (HP 2010)	92-94%	96.0%	94.4%	84.8%	73.1%

Source: NIS, 2003

To underscore the pertussis threat, Graph 5 plots vaccine coverage rates for 3+DTaP over time for infants at 7 months of age. Again, the ACIP schedule calls for three doses of DTaP by age 6 months. Although pertussis is potentially fatal to infants at this age, Colorado coverage rates have consistently hovered around 65 percent, or 25-30 percentage points below the herd immunity threshold. It should be noted though that Colorado’s 7-month rate for 3+DTaP is not significantly different from the national average.

Graph 5: Three doses of Diphtheria, Tetanus, and Pertussis (DTaP) by 7 months of age, Colorado and U.S.



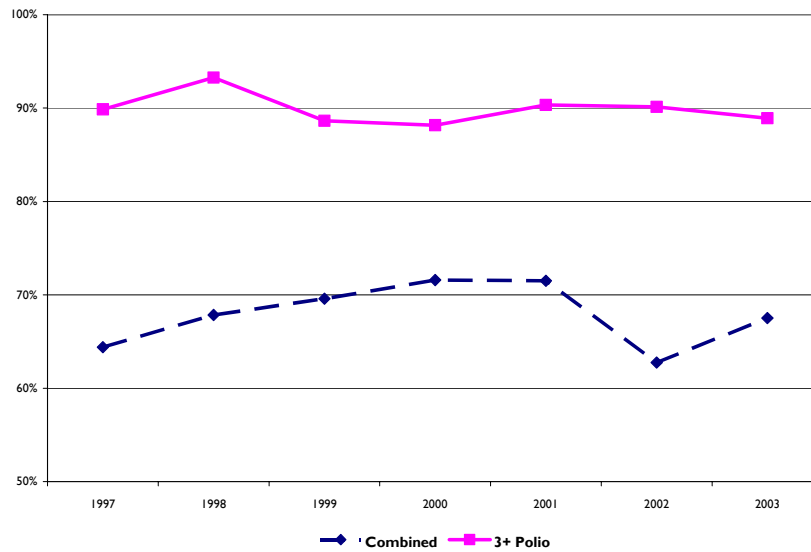
Source: National Immunization Survey (1997-2003)

POLIOVIRUS VACCINE

Like diphtheria, naturally occurring poliovirus has been eradicated from the Western Hemisphere since the widespread use of polio vaccines.⁶¹ However, polio persists in Africa and other countries so the possibility of imported infections continues.⁶² In 2003, 88.9 percent of toddlers between the ages of 19-35 months were vaccinated for polio in Colorado compared to 91.6 percent nationally. Most Colorado and U.S. children had received age-appropriate immunizations against polio by 7 months of age with 89.2 percent coverage in Colorado and 89.7 percent, nationally.

As Graph 6 illustrates, Colorado polio vaccination rates have remained stable since the late 1990s and close to the Healthy People 2010 objective of 90 percent coverage. In contrast to the 4:3:1:3:3 combined series; the stability of Colorado's polio vaccination rate does not implicate it in the decline observed in the index measure. Polio coverage rates in Colorado are above the estimated herd immunity threshold of 80-86 percent, suggesting that the risk of an outbreak would be small even if an infected person traveled to Colorado.⁶³

Graph 6: Combined 4:3:1:3:3 vaccination series vs. 3 doses of polio vaccine, 19-35 months of age, Colorado



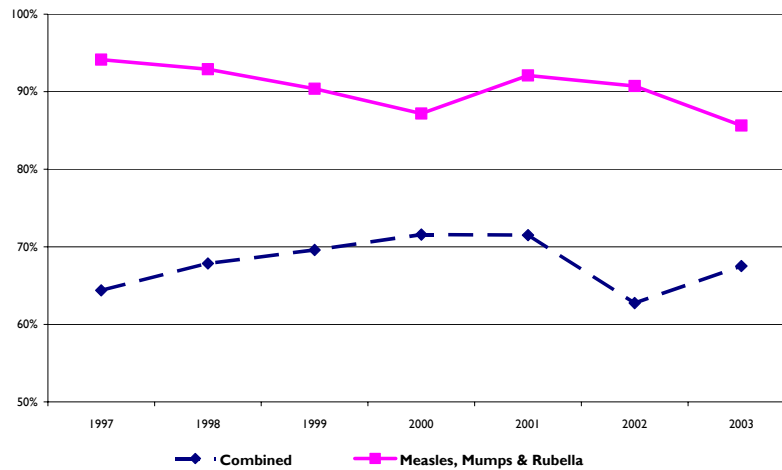
Source: National Immunization Survey (1997-2003)

MMR (MEASLES, MUMPS, RUBELLA) VACCINE

The MMR is a combined vaccination that protects against measles, mumps and rubella. Similar to the pertussis experience, measles, mumps, and rubella incidence has decreased dramatically since the widespread administration of the vaccine, although sporadic outbreaks of each of the three diseases continue. Most of the preschool-aged children who contracted measles in outbreaks during the late 1980s were not immunized.⁶⁴ One observer has noted that the “source of an epidemic is only a plane flight away” and cited two cases of imported measles in different areas of the United States during the past year.⁶⁵

As with pertussis, threshold vaccination rates to prevent the circulation of measles are high at 83-94 percent due to the epidemiology of the disease.⁶⁶ In 2001-02, Colorado rates were above 90 percent and comparable to national rates; however in 2003 the rate dropped to 85.6 percent as opposed to a national rate of 93.0 percent. Plotting Colorado’s I+MMR rate of coverage against the 4:3:3:1:3 combined series reveals a subtle inverse relationship. When the I+MMR rate bumped higher, the series rate tended to dip lower. It should be noted however that these variations in the I+MMR rate were small and not statistically significant. Like the polio vaccine, the I+MMR vaccination does not appear to be implicated in the recent decline in 4:3:1:3:3 combined series rates.

Graph 7: Combined 4:3:1:3:3 vaccination series relative to the I+MMR series, 19-35 months of age, Colorado



Source: National Immunization Survey (1997-2003)

Graph 7 illustrates I+MMR coverage rates for children between the ages of 19-35 months over a seven-year period. Although the ACIP schedule calls for children to receive a measles vaccination by the age of 15 months, a child could receive a measles vaccination at 35 months and be considered up-to-date according to the accepted measure. Examining rates at the age of 19 months provides a better approximation of timeliness. When considering timeliness, Colorado’s I+MMR vaccination rates hover at the lower boundary of the target herd immunity threshold for measles (see Table 4). Several key informants expressed concern at this finding and its implication for increased vulnerability to the disease. It was noted by one informant that because only one immunization is required by 19 months, the I+MMR serves as a bellwether for the effectiveness of the state’s overall immunization outreach strategy.^{67,68}

Table 4: Measles herd immunity threshold and coverage rates by age

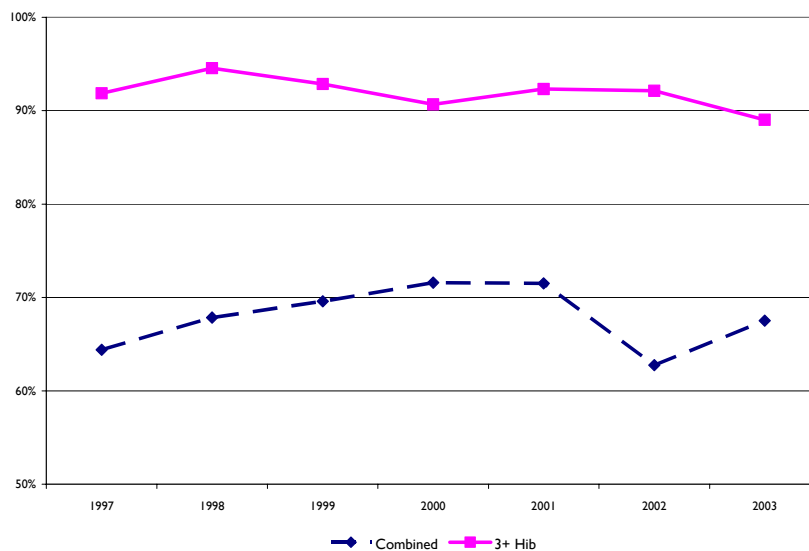
Age	Measles herd immunity threshold	I+MMR U.S.	I+MMR CO
By 19 mos. (ACIP recommends by 15 months)	83-94%	87.6%	83.1%
Between 19-35 mos. (HP 2010 objective)	83-94%	93.0 %	85.6 %

HIB (HAEMOPHILUS INFLUENZAE TYPE B+) VACCINE

The universally recommended vaccination for Haemophilus influenzae type B+ dates to 1986 in Colorado.⁶⁹ One informant noted that the Hib vaccine is “our best current vaccine success story ... virtually eliminating H. flu meningitis, one of the most common life-threatening infections of childhood.”⁷⁰ In 2003, both Colorado and national coverage rates approximated 90 percent, with Colorado at 89.0 percent and the U.S. rate at 93.9 percent for 19-35 month olds.

As Graph 8 illustrates, Hib coverage rates have remained at or near the Healthy People 2010 objective of 90 percent in Colorado since the late 1990s. According to the ACIP schedule, the Hib series should be completed by the age of 15 months. Hib coverage at 19 months was 85.6 percent in Colorado and 91.0 percent nationally. The stability of Hib vaccination rates contrasts with the recent drop in Colorado’s 4:3:1:3:3 combined series rates. Again, Hib vaccination rates do not appear to have contributed to the drop in the combined series rate.

Graph 8: Combined 4:3:1:3:3 vaccination series vs. Haemophilus influenzae type B, 19-35 months of age, Colorado

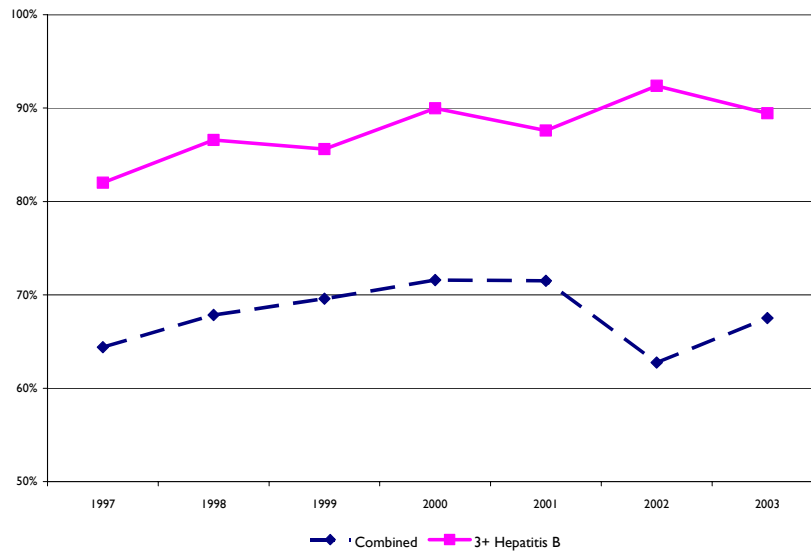


Source: National Immunization Survey (1997-2003)

HEP B (HEPATITIS B) VACCINE

The ACIP recommended universal vaccination for Hepatitis B in 1991.⁷¹ Coverage rates in Colorado have generally increased since the NIS began collecting data in 1997. The upward trend in Hepatitis B coverage contrasts with the recent decline in Colorado’s 4:3:1:3:3 combined series (Graph 9). In 2003, both Colorado and national coverage rates were close to the Healthy People 2010 objective of 90 percent, with Colorado at 89.4 percent and the U.S. average at 92.4 percent of 19-35 month olds covered. According to the ACIP schedule, the Hep B series should be completed by age 19 months; coverage at 19 months was high both in Colorado (85.7 percent) and nationally (88.7 percent).

Graph 9: Combined 4:3:1:3 vaccination series vs. Hepatitis B, 19-35 months of age, Colorado



Source: National Immunization Survey (1997-2003)

OBSERVATIONS FROM THE DATA

Based on Colorado’s performance on the individual vaccine measures, the following observations are made:

- Colorado’s low rates on the combined series measure for 2002-2003 were driven by low administration rates of the fourth dose of DTaP;
- The national DTaP vaccine shortage and the subsequent state policy decisions in Colorado contributed to lower than optimal 4+DTaP rates (See Appendix B for a further discussion);
- Colorado’s coverage rates for 2-year olds for the individual vaccine measures (except 4+DTaP) are at or near the Healthy People 2010 objective of 90 percent coverage;
- High 2-year old coverage rates for individual vaccines mask the fact that age-appropriate administration of ACIP-recommended vaccines remains a problem in Colorado; and,
- Current coverage rates for some diseases, especially pertussis, do not meet herd immunity requirements.

To underscore the importance of timeliness, Table 5 summarizes Colorado’s performance on individual vaccine measures by age and relative to the ACIP schedule. The bolded cells represent coverage levels that are not close to 90 percent (i.e., the Healthy People 2010 objective) portending increased risk for an outbreak. Coverage rates improve as children grow older, suggesting that while many children receive immunizations late, they generally catch-up. Conversely, coverage levels are lowest among infants who are at the greatest risk of adverse outcomes.

Table 5: Coverage rates by various benchmarks

Vaccine	90% on-schedule rate at 5 mos. (ACIP schedule)	90% on-schedule rate at 7 mos. (ACIP schedule)	90% on-schedule coverage at 19 mos. (ACIP schedule)	Healthy People 2010 objective (90% coverage for 19-35 month olds; 80% coverage for 4:3:1:3:3 series)
DTaP	No	No	No	No
Polio	No	Within the confidence interval	No	Within the confidence interval
I+MMR	N/A	N/A	No	Within the confidence interval
Hib	No	No	Within the confidence interval	Within the confidence interval
HepB	No	Within the confidence interval	Within the confidence interval	Within the confidence interval
4:3:1:3:3 (Combined Series)	N/A	N/A	No	No

Demographic determinants of immunization rates

Healthy People 2010 objectives include the goal of increasing the proportion of children who participate in fully operational population-based immunization registries. Specifically, the 2010 target is for the registration of 95 percent of children under the age of 6 years.⁷² An immunization registry renders the exercise of identifying demographic determinants of vaccination status both more precise and less necessary. The primary motivation for understanding risk factors is to identify populations in need of intervention and targeting resources accordingly. A registry identifies the vaccination status of individual children so that interventions can be more precisely focused. Identifying children at-risk for under-immunization through demographic targeting lacks precision, but it is the most efficacious alternative to child-specific data currently available.

Like most states, Colorado does not have a statewide immunization registry. Thus, understanding demographic risk factors to un- and under-immunization remains an important policy and program goal. Demographic data are more readily available than direct estimates of vaccination coverage. The Colorado Department of Public Health and Environment (CDPHE) has mapped demographic risk factors to identify concentrations of at-risk children. For example, they have mapped known maternal correlates of child immunization status including number of siblings, mother's age (less than 21), mother's education (less than high school), and marital status (not married). Because birth

certificates provide a registry of all births in the state, they are a reliable source for identifying maternal risk factors. CDPHE staff has mapped these factors to identify pockets of need for immunization intervention purposes.

National data suggest that under-vaccinated children are more likely to be black, have a younger, unmarried mother with a high school education or less, live in a household with a poverty level family income, and live in a central city.⁷³ Conversely, completely unvaccinated children have been found to have a very different demographic profile. One study found that unvaccinated children tended to be white, live with both parents, have a parent with a college degree, and live in a household with an annual income exceeding \$75,000. Additionally, this study found that the parents of unvaccinated children expressed concern regarding the safety of vaccines, and therefore physicians had little influence over the decision to have their children vaccinated.⁷⁴ Interestingly, another study found that the largest proportion of unvaccinated children lived in the twenty states (including Colorado) that have permissive policies with regard to personal/philosophical immunization exemptions.⁷⁵

It is difficult to quantify the extent to which philosophical exemptions explain Colorado's 2-year old immunization rates, as school certification data regarding exemptions captures this information when children are older. The total Colorado population exercising the philosophical exemption option is estimated to be 2.5 percent.⁷⁶ This estimate may be revised after CDPHE concludes its audit in May 2005. One informant noted that it may be the case that "the same issues that drive philosophical exemptions play a role in parents' immunization decisions for younger children." Although several other informants opined that exemptions were not playing a significant role in explaining Colorado's low 2-year old vaccination rates.⁷⁷ Instead, they suggested that pockets of need found in Colorado result from structural barriers to immunization.⁷⁸

Although it is suboptimal to examine risk factors separately, the following section describes the individual effect of poverty, race/ethnicity, and urbanicity on immunization rates, while recognizing the interrelatedness of these risk factors.

POVERTY

Childhood poverty is the single most commonly identified risk factor for under-immunization in multiple national, state, and regional studies.^{79,80,81} The magnitude of its effect on immunization coverage varies from study to study and is quite sensitive to how income is measured. Studies using more granulated measures of income typically report a larger income effect.

Studies that utilize a poverty measure that sort children into two categories – above and below the federal poverty level – tend to underestimate the effect of income on immunization rates. For example, researchers utilizing this method with 2003 NIS data found poverty-related differences in coverage of 1-3 percentage points. Although small, they were statistically significant for 4+DTaP (86.8 vs. 79.7 percent), polio (92.5 vs. 89.1 percent), and 3+Hib (95.0 vs. 91.1 percent).⁸²

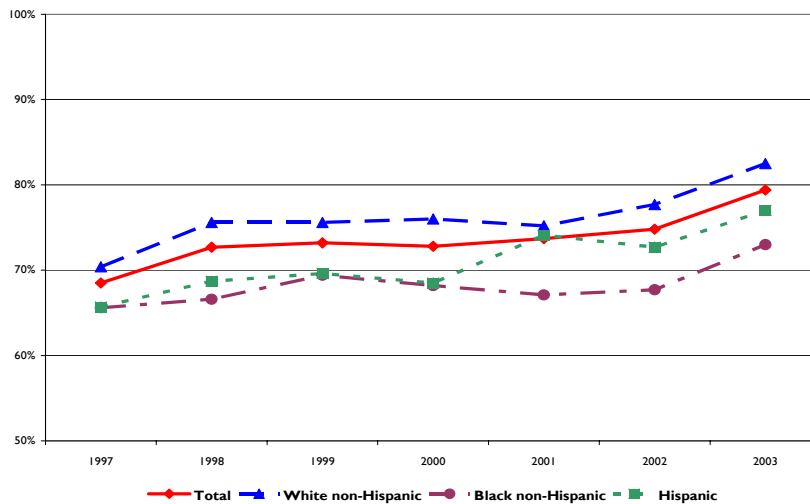
In Colorado, child poverty rates worsened in 2002 due to the economic downturn, but began to improve in 2003 as the economy grew. Because Colorado has a relatively low child poverty rate it could be tempting to discount the poverty effect, however even in a comparatively wealthy state like Colorado, we know that pockets of need persist.

Income status is thought to influence immunization rates in a variety of ways, including parental knowledge, attitudes, and education; utilization of public benefits; lack of social support; psychosocial factors; multiple health care providers; immunization record scatter; inadequate insurance coverage for immunizations; lack of childcare; lack of transportation; scheduling inconvenience; long waiting times; and other structural access barriers.⁸³ One study empirically tested some of these factors and concluded that maternal psychosocial factors were unrelated to immunization rates for low-income children, but did confirm that vaccination rates were influenced by structural barriers such as scheduling inconvenience, lack of childcare and lack of transportation.⁸⁴ Another study documented that poor, minority, and uninsured children use significantly fewer physicians' services and are twice as likely to be under-vaccinated for measles.⁸⁵ Low-income children were found to be more likely to have multiple vaccine providers, thus making immunization status difficult to assess as a result of record scattering.⁸⁶ Many of these factors are discussed as independent risks in subsequent sections of this paper.

RACE AND ETHNICITY

Graph 10 illustrates that national immunization rates for all racial and ethnic groups have steadily improved over the last several years, although small sample sizes preclude a Colorado-specific examination of this risk factor except among Hispanic children. Nationally, immunization disparities between Hispanics and non-Hispanic whites have narrowed only slightly, while the gap between Blacks and other racial and ethnic groups has widened over the same time period. Immunization rates for Black children are still 10-11 percentage points lower than white children for the 4:3:1:3:3 vaccination series. The gap between Hispanic and non-Hispanic rates has closed to 2-6 percentage points, depending on the series examined.

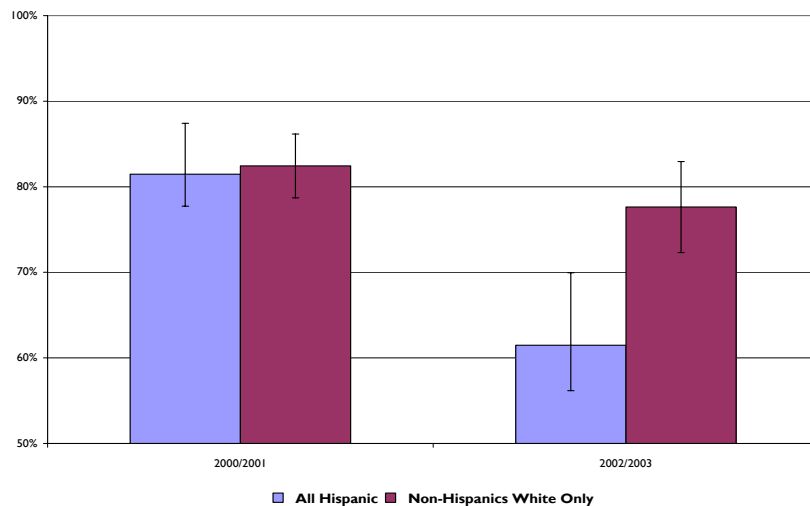
Graph 10: Combined 4:3:1:3:3 vaccination series by race/ethnicity, U.S. children 19-35 months of age



Source: National Immunization Survey (1997-2003)

According to the 2000 U.S. Census, children of Hispanic origin comprised 23.5 percent of Colorado’s child population, representing the state’s largest minority group. The 4+DTaP rate for Hispanic children in Colorado presents an interesting disparity. Graph 11 reveals that Hispanic coverage rates for 4+DTaP were much lower than for non-Hispanic children in the years after the vaccine shortage (2002-2003). A similar disparity did not exist before the shortage, suggesting that the vaccine shortage disproportionately affected Hispanic children.⁸⁷ Although the sample sizes were small, the differences were statistically significant (the vertical lines on Graph 11 represent the confidence intervals, that is, the “plus-or-minus” factor of the immunization rate for each time period).

Graph 11: DTaP coverage, Hispanic and Non-Hispanic White children 19-35 months of age, Colorado



Source: National Immunization Survey (2000-2003), ± 95% Confidence Interval

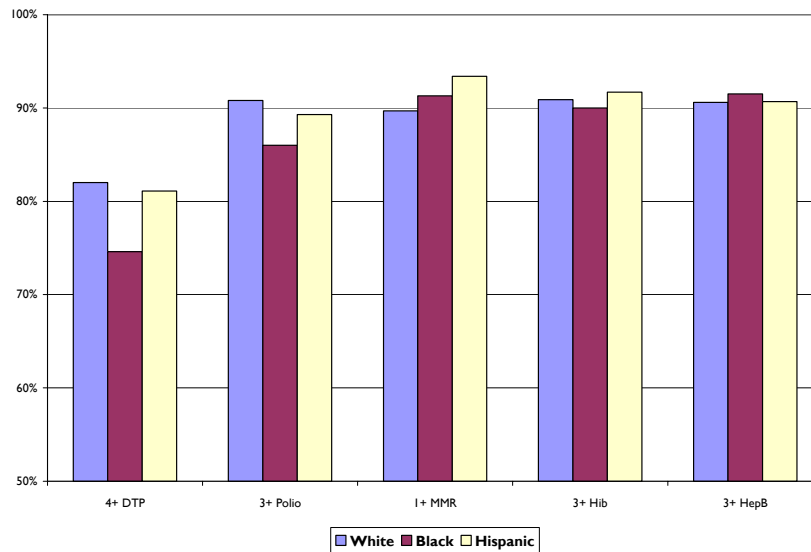
There are several possible explanations for the disparate impact of the shortage on Hispanic children. Several Colorado immunization experts noted that the effects of the DTaP vaccine shortage were unevenly distributed across the state and providers. A 2003 survey of personnel who ordered vaccines in five Colorado communities suggested that the southwestern parts of the state and El Paso County, where large Hispanic populations reside, were especially hard hit.⁸⁸ Several informants also noted that the shortage had a greater effect on the public Vaccines for Children (VFC) program than on private sector programs.⁸⁹ Children of Hispanic descent in Colorado are three times as likely to be uninsured when compared to white non-Hispanic children, and are therefore much more likely to qualify for vaccines through the VFC program.⁹⁰

Limited research on Hispanic families suggests that both ancestry and acculturation influence vaccination coverage. Two studies reviewed documented that recent immigrants had better immunization rates than children from more acculturated families, but the NIS sample size precludes confirmation of these findings in Colorado.^{91,92}

Because of small sample sizes (Blacks comprise just 4 percent of the Colorado population); the NIS does not report Colorado coverage estimates for Blacks, American Indians, Alaskan Natives, Asians, Native Hawaiian or Other Pacific Islanders, multiple races, or other racial groups. While coverage levels in these minority populations are unlikely to affect statewide rates, our inability to describe their coverage experience with NIS data limits our ability to identify pockets of need based on race and ethnicity and subsequently to tailor and evaluate interventions appropriately.

As suggested by Graph 12, the effect of race, ethnicity and poverty varies by vaccination series but the reasons for these differences are not well understood. Some of the racial and ethnic differences observed in Graph 12 were found to be statistically significant. It is of interest to note that because differences vary by vaccination series there is no one racial or ethnic group that represents a consistently under vaccinated group. Understanding the mechanisms that account for these vaccination-specific differences is critical to developing appropriate interventions.

Graph 12: Coverage of five vaccination series by race and ethnicity for children 19-35 months of age below federal poverty level, U.S.



Source: National Immunization Survey (2003)

Income differences across racial and ethnic groups provide a partial explanation for the observed disparities. However, racial and ethnic differences often persist, even after controlling for income.⁹³ Racial and ethnic disparities in child immunizations are thought to result from structural barriers that confront low-income children in general, such as restricted access to health care and other delivery system challenges. For example, the Colorado experience with 4+DTaP coverage suggests that the uneven geographic distribution of limited DTaP vaccine in 2001 interacted with children in the VFC program and minority status to create disparities in access and coverage.

It has been suggested that barriers more specific to minority populations include increased guardedness among minority parents with regard to the health care system, misconceptions about the risks and benefits of vaccination, and less responsiveness among minority populations to the standard recommended interventions found to increase immunization coverage among majority children.⁹⁴

URBANICITY

A 1995 review of the literature on rural/urban differences in vaccination coverage came to a somewhat unexpected conclusion that despite documented access problems in rural areas, immunization rates were typically similar to urban rates.⁹⁵ Two other studies also found that children living in urban areas have vaccination coverage rates on a par with suburban and urban children.^{96,97} Several Colorado informants suggest that rural areas in Colorado have lower rates than urban rates,⁹⁸ although data limitations make it difficult to quantify these assertions.

Although not available on the public use database, CDC collects county level information in the NIS. The state asked CDC on behalf of CHI to calculate regional immunization

rates. After experimenting with several different geographic region definitions, it was concluded that the NIS Colorado sample was simply too small to permit statistically meaningful comparisons of geographic regions.

OBSERVATIONS FROM THE DATA

Examining the literature and Colorado data related to demographic factors that may influence immunization rates, the following observations are made:

- Child poverty is the single most commonly cited risk factor for under-immunization;
- Immunization rates for all racial and ethnic groups have increased since 1997, but disparities remain;
- In the absence of child-specific immunization data, demographic analysis can be useful in identifying subpopulations that are more likely to be under-immunized and to target immunization interventions accordingly.

Provider characteristics related to immunization rates

The immunization literature consistently finds that parents who seek care from pediatricians have children with higher vaccination coverage than parents using family practice physicians.⁹⁹ Immunization patterns by facility type are less consistent. Whereas, some studies suggest that public clinics out-perform private physician offices, others show the opposite. Colorado data are similarly contradictory.

According to 2003 NIS data, Colorado's 4:3:1:3:3 immunization rate is 77.0 percent among private providers as compared to the all-provider rate of 67.5 percent. Although public, mixed, and other facility rates are not separately reported; one or more of these entities is pulling down the all-provider rate in Colorado. The categorization of public is quite broad in the NIS and includes WIC providers, university hospital-based clinics, military health care facilities, public health departments, and federally qualified health centers. National NIS estimates use this broad categorization of 'public' and report public clinics as having the lowest coverage rates. As noted above, the definition of public is so broad, particularly with the significant military presence in Colorado, as to make the statistic less than useful as we attempt to ferret out the relative performance of FQHCs, other public health initiatives, and private physicians' offices.

It should not be surprising that public clinics have lower immunization rates given the higher risk populations they serve. FQHCs serve an exclusively low-income population and are the medical home for one-quarter of Medicaid recipients, one-third of CHP+ children, and half of the low-income uninsured population in Colorado.¹⁰⁰ It is of interest to note that many federally qualified health centers (FQHCs) in Colorado report higher-than-average immunization rates, which they attribute to participation in a program called Together for Tots.

The national Together for Tots program dates back to 1995, there are currently 42 FQHC sites in Colorado participating in the program. The program includes quality improvement immunization teams at each site where immunization software tracks child immunization status, prompts providers with reminders that immunizations are due, and generates biannual immunization performance reports that are shared with all FQHCs. The program has promoted “friendly competition” between the FQHCs and has served to institutionalize the model throughout the FQHC network in Colorado. For participating clinics, the immunization rate is 88 percent for 1-year olds and 75 percent for 2-year olds.¹⁰¹

Denver Health has employed a similar immunization registry and reminder/recall system to achieve an immunization rate of 78 percent. Implementation of quality improvement programs appears to be more predictive of coverage rates than ownership status.

OBSERVATIONS FROM THE DATA

Examining the literature and Colorado data related to provider characteristics and immunization rates suggests that:

- Physician specialty makes a difference, pediatric patients have higher vaccination rates than other primary care specialists;
- Coverage trends based on clinic ownership and auspice are inconsistent;
- Provider-based quality improvement programs are effective at producing high vaccination coverage levels, even among high-risk populations.

Other Factors Influencing Immunization Rates

The immunization literature and key informants largely concur on demographic, provider and other factors that influence immunization rates. Briefly, these other factors fall into three categories: those that affect parental or community demand for immunizations, those that influence access to services, and those that address provider quality of care issues.

These additional factors are listed below but not discussed in detail. Citations for each are supplied. In addition, many of the access-related factors reduce to critiques of existing immunization programs and strategies. These issues are more thoroughly discussed in the following section of the white paper.

COMMUNITY DEMAND AFFECTING IMMUNIZATIONS^{102,103,104,105,106,107,108}

- Parental knowledge, attitudes, and beliefs
- Child birth order and family size
- Colorado’s philosophical exemption from state immunization requirements

ACCESS AFFECTING IMMUNIZATIONS^{109,110,111,112,113,114,115}

- Vaccine supply issues
- Rural provider shortages and travel distances
- Provider reimbursement rates, especially public program rates

- Delivery system factors (e.g., managed care versus fee-for-service)
- Population mobility
- Insurance coverage
- Medicaid/CHP+ program issues
- Vaccines for Children (VFC) program issues
- Public health capacity

QUALITY OF CARE ISSUES AFFECTING IMMUNIZATIONS^{116,117,118,119,120,121}

- Information tracking systems (e.g., immunization status and reporting)
- Training and provider specialty

Immunization Policies and Programs in Colorado

A variety of programs and policies exist that form Colorado’s immunization infrastructure. Many serve as financing mechanisms for purchasing vaccine supplies and subsidizing the delivery of immunizations and include public and private insurance programs as well as federal and state immunization programs. Public and private funds also support the state’s immunization infrastructure by supporting data analysis and planning functions, immunization information systems, advocacy efforts, and other complementary activities. This section reviews major programs and financing mechanisms and identifies program gaps and opportunities.

VACCINES FOR CHILDREN

The Vaccines for Children (VFC) program was established in 1993 and provides free vaccines to children who are uninsured, Medicaid-eligible, under-insured, and Native Americans and Alaska Natives. The CDC negotiates vaccine contracts with manufacturers and then makes them available free-of-charge to participating providers. Immunization studies in the late 1980s revealed that an increasing number of private providers were referring children to public clinics for vaccinations. VFC successfully reversed this trend. For example, in Washington State prior to VFC, 80 percent of low-income children received immunizations in public clinics. After VFC, the figures completely reversed and 20 percent of low-income children received their immunizations in public clinics.¹²² The VFC program allows eligible children to stay in their medical home and strengthens the relationship between public and private sector interests.¹²³

Provider critiques of the VFC program focus on federal regulatory requirements that are perceived as onerous and operational expenses that are not reimbursed. For example, because VFC can only be used for eligible children, providers must keep separate vaccine stock for privately insured and VFC children. Administrative costs such as storing and insuring vaccines and patient education are not covered by VFC.¹²⁴ Children that lack immunization coverage may receive VFC vaccine, but only through a FQHC or a rural health clinic. Critics point out that this is inconsistent with the program intent of strengthening the medical home. Manufacturers of tetanus and diphtheria vaccines have refused to bid on CDC contracts since 1998 due to price caps.¹²⁵ Key informants also

identified the need for better coordination between VFC program administrators, private providers, and the Medicaid program because Colorado does not require Medicaid providers to participate in the VFC program. Key informants described the regulatory and reimbursement policy interface between Medicaid and the VFC program as poorly understood and that this lack of clarity may be serving as a disincentive to Medicaid provider participation.

CDPHE has identified certain data, such as an inventory of Medicaid providers not currently participating in VFC and an inventory of infants and toddlers enrolled in Medicaid by county, as information that would allow it to better target VFC funds to pockets of need or underutilization of VFC resources. Data access, data quality, and analytical capacity each have been cited as a limiting factor in maximizing the effectiveness of publicly-financed immunization resources.

SECTION 317 PROGRAM

The Section 317 program was created in 1963 to help states administer their immunization programs and purchase vaccines for disadvantaged children. The Section 317 program is administered by CDC and provides state grants for vaccine purchase, education, outreach, and disease surveillance.¹²⁶ The Section 317 program is intended to supplement state and local immunization efforts and is the only substantial source of federal financing for many vaccine program operations activities.¹²⁷ Following the implementation of VFC in 1994, states have increasingly used their Section 317 funds to immunize children, adolescents and adults who are not eligible for assistance through VFC, Medicaid, or other programs.¹²⁸ Section 317 funds are flexible and have been used to support diverse activities, from mobile vans to school-based immunizations.¹²⁹ In one national study, it was found that increases in Section 317 infrastructure funding were strongly related to vaccination coverage rate increases.¹³⁰

In Colorado, Section 317 funds have been used to support the development of a statewide immunization registry, the Colorado Immunization Information System (CIIS), and other local initiatives. Examples of local initiatives include reminder/recall programs, expanded clinic hours, professional education, collaboration with the Women, Infants, and Children's (WIC) program, and enforcement of school entry requirements. Section 317 grants are awarded annually in response to proposals submitted by each state.¹³¹ A state's Section 317 grant award is often a function of what it received in the past, as opposed to being based on demonstrated need.¹³² Section 317 funding has not kept pace with population growth or the cost of vaccines.¹³³ Another limitation of 317 funding is that it is rarely applied to private sector initiatives.¹³⁴ The flexibility of the Section 317 program has made grantee evaluation difficult, especially in the context of limited data collection requirements and analytical capacity at the state level.

CDPHE IMMUNIZATION RESPONSIBILITIES

CDPHE has statutory authority to ensure the provision of immunization services to infants between up to 24 months of age, medically indigent school-aged children, and children who are enrolled in the Medicaid program. To meet this obligation, CDPHE

administers state and federal immunization funding to support direct services' infrastructure including, but not limited to, local public health departments and nursing services. While the program provides federally purchased vaccine, CDPHE also offers training, and technical assistance. For example, the CDPHE Immunization Technical Assistance Team offers in-service immunization trainings for health care providers. Non-profit agencies also have played a role in provider training efforts in recent years. The CDPHE Immunization Program is almost entirely supported by federal funding, especially through the VFC and Section 317 programs. Historically, state general funds have been relatively limited.

The Colorado General Assembly allocated approximately \$400,000 annually in state general funds for childhood immunizations prior to 2000. Due to increasingly severe pressures on the general fund, this appropriation was cut out of the 2002-03 budget. Colorado became one of four states not allocating any state dollars for immunizations. In last year's budget (FY 2004-05), the General Assembly restored the cut through a \$476,000 general fund allocation that earmarked \$390,000 for local health departments to expand access to immunizations. The average local award this year has been \$16,000. CDPHE has advised that next year's local grants will be targeted to areas of greatest need based on its "pockets of need" assessment.

Additionally, the 2004-05 state budget redirected \$940,000 in federal dollars to local public health clinics to improve childhood immunization coverage. Approximately \$440,000 of these federal dollars was re-directed from the Preventive Health Services Block Grant, which will be available for local immunization programs in the future, depending on the priorities established by CDPHE.

Because child-specific immunization data are not uniformly available, "pockets of need" analyses necessarily draw heavily on demographic risk factor data. As uniform, quality immunization data at the child level become available, more precise targeting strategies will be possible. For example, CDPHE Immunization Program staff worked with staff at Denver Health and Hospitals to map the immunization status of children by neighborhood using Denver Health's registry data. This analysis was used to target neighborhoods in which immunization outreach clinics were held based on identified need.

Uninsured and Medicaid children often rely on public health clinics for immunizations. Several key informants described this public health capacity as inadequate relative to need. Neither public health clinics nor private physician offices generally have hours of operation that are convenient for low-income families who must rely on public transportation or do not have the flexibility to take time off during the workday to keep office appointments.

PRIVATE INSURANCE

All regulated individual, small and large group health plans sold in Colorado must cover the immunization series recommended by CDC. Health plans may not subject

immunizations to deductibles, but they may charge a co-payment. These co-pays may not exceed the cost of a physician visit. Health plans that are not regulated by the state and therefore not required to cover immunizations include federally regulated ERISA self-funded plans, public employee plans (federal, state and armed services), and Multiple Employer Welfare Associations or MEWAs (of which there are none functioning in Colorado at this time).

The Colorado Business Group on Health publishes annual Health Plan Employer Data and Information Set (HEDIS) performance measures that are sponsored by the National Committee for Quality Assurance (NCQA). These standardized performance measures are collected and reported on health plans throughout the country. Table 5 outlines Colorado specific HEDIS scores for 2-year old immunizations rates. Informants have claimed that the DTaP shortage did not affect the private sector to the same extent it did the public sector. The stability of rates observed in Table 6 between 2001 and 2004 appears consistent with this assertion. However, it is of interest to note that rates were not reported in 2003 due to the shortage.¹³⁵

Table 6: HEDIS 2-year old Immunization Rates¹³⁶

	1997	1998	1999	2000	2001	2002	2003	2004
NCQA benchmark				79%	81%	79%		82%
Aetna Health Plan				59%	68%	70%		70%
CIGNA Health Plan of Colorado			69%	74%	74%	77%		78%
Denver Health Medical Plan					61%	61%		80%
HMO Colorado			42%	46%	50%	66%		72%
Kaiser HMO			87%	76%	76%	77%		85%
PacifiCare of Colorado			NR	68%	68%	68%		72%
Rocky Mountain Health Plans			63%	65%	61%	61%		72%
United Health Plan			53%	55%	61%	66%		72%

Source: Colorado Business Group on Health at: www.coloradohealthonline.com/report_frequency/frequent.htm#top

Kaiser Permanente provides an example of a private sector effort that achieves consistently high childhood immunization rates through an immunization registry containing complete immunization records for all Kaiser enrolled children; an electronic provider reminder list of children who are not up-to-date on immunizations; clinic performance assessments; and a full-time staff person who is responsible for the accuracy of registry data, including calling families whose children are behind on their immunizations.

MEDICAID

Federal law mandates that the Medicaid program cover all CDC-recommended immunizations. It also requires states to notify parents or guardians of immunization benefits through an outreach and case management function, which is administered in

Colorado under contract. However, informants suggested that the federal oversight of state Medicaid agencies immunization practices and outcomes is weak.

In 2003, Medicaid immunization rates by reporting entity ranged from 31 to 65 percent for the recommended vaccination series.¹³⁷ The Primary Care Physician Program managed by Health Care Policy and Financing (HCPF) averaged 56 percent, while the Medicaid Managed Care Program averaged between 51-65 percent. Colorado's Medicaid rates were similar to the national NCQA Medicaid benchmark of 62 percent. However, the immunization rate for children who were not assigned to a primary care provider or enrolled in a managed care plan, i.e., the unassigned, was half the national average at 31 percent.

HCPF staff believes that the rate for unassigned children may be underestimated because the Medicaid HEDIS methodology requires the identification of a primary care provider from which to locate the complete immunization record. Children that are unassigned do not have an identified primary care provider.¹³⁸ Some informants noted that the rate for unassigned Medicaid children is low because finding providers willing to accept a child on a strictly fee-for service basis has become increasingly difficult.¹³⁹ A focused study of Medicaid claims data could shed light on these competing explanations.

Several informants discussed concern about immunization-related issues in the Colorado Medicaid program that included minimum eligibility thresholds for children, low provider participation rates, and protracted enrollment processes. Colorado currently covers low-income children under the age of six up to 133 percent of the federal poverty level (FPL), which represents the minimum eligibility threshold required by federal law. A recent survey of Colorado pediatricians revealed that while 94.8 percent reported accepting privately insured patients on an "open practice" basis, only 23.9 percent accepted Medicaid patients in the same manner.¹⁴⁰ Several informants attribute low provider participation in Medicaid to reimbursement rates that do not adequately cover the costs and administrative burden associated with participating in the program.¹⁴¹

Enrolling newborns in the Medicaid program a timely fashion is a problem that predates the recent implementation of the state's new eligibility determination and enrollment system. Approximately one-third (32.1 percent) of babies born in Colorado are to Medicaid-enrolled women.¹⁴² All of these newborns are automatically eligible for Medicaid at birth. However, there are several manual processes associated with actually enrolling a newborn in the program and therefore it is common for parents to not receive their newborn's Medicaid card until after the 2-month vaccination series is due. This has obvious implications for the timeliness of the entire vaccination series. Medicaid has recently begun a voluntary "add-a-baby" initiative in cooperation with several hospitals to expedite the enrollment of Medicaid-eligible newborns.

Medicaid is an essential partner in any statewide or regional strategy to improve vaccination coverage rates. Many see the passage of Amendment 35 in 2004, a constitutional amendment that includes eligibility expansions in both the Medicaid and

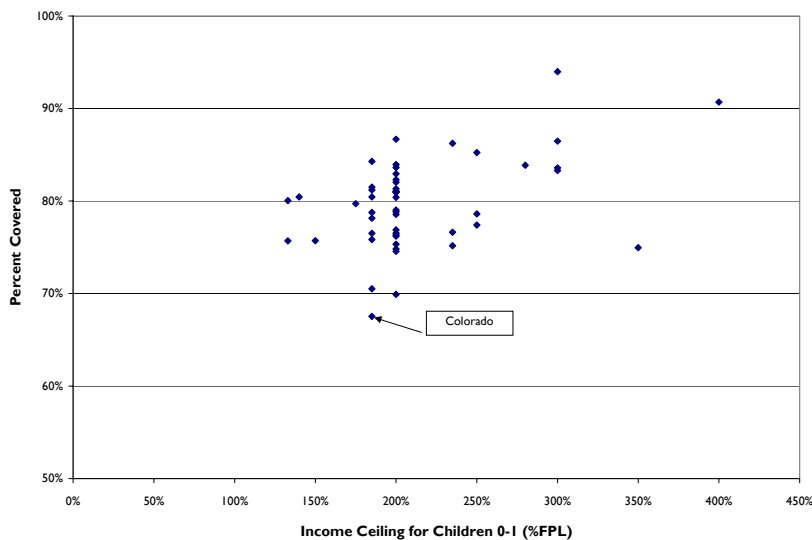
CHP+ programs, as an opportunity to strengthen the role that Medicaid plays in expanding immunization coverage. Similar Medicaid eligibility expansions in the late 1980s and early 1990s at the national level have been credited with improvements in several child health outcomes including decreased prevalence of low-birth weight infants, decreased infant mortality rates, improved immunization rates, and increased primary care visits.^{143,144}

STATE CHILD HEALTH INSURANCE PROGRAM (SCHIP)

The State Child Health Insurance Program known in Colorado as Child Health Plan Plus (CHP+), includes all vaccinations recommended by the CDC in its benefit package. CHP+ children are not eligible for free vaccine through the Vaccines for Children program because it is a covered benefit. The CHP+ program reimburses providers for vaccines at negotiated rates, similar to the commercial managed care products on which it was designed. For mothers in the CHP+ prenatal program, newborns have guaranteed coverage for the first 31 days, again, parallel to commercial market products.

Medicaid and CHP+ expansions hold promise for improved immunization coverage for an expanded group of low-income children in the future. Graph 13 plots state immunization rates against eligibility income ceilings of state-funded health insurance programs. On average, states that set their SCHIP eligibility ceilings higher, also report higher statewide coverage rates.

Graph 13: 2003 combined 4:3:1:3:3 series vaccination coverage by public insurance income eligibility thresholds, 50 states



Source: 2003 National Immunization Survey and Kaiser Family Foundation's 2004 State Health Facts at www.statehealthfacts.org

WOMEN, INFANTS, AND CHILDREN (WIC) PROGRAM

Colorado's Women, Infants, and Children (WIC) program requires local WIC providers to conduct immunization outreach and education by asking parents and/or guardians to bring immunization records to certification visits; to provide parents information on the ACIP-recommended immunization schedule; and to refer infants and children for immunization as necessary. WIC staff is required to assess the immunization status of WIC-enrolled children, particularly the DTaP series, although immunization records are not a requirement for obtaining WIC services.¹⁴⁵ It is not clear whether the emphasis on the DTaP immunization series responds to the 2001 shortage of this vaccine or to the literature suggesting that DTaP status is a marker for overall vaccination status.¹⁴⁶

Although WIC-based immunization programs have been effective at improving immunization rates in other states, Colorado key informants were less likely to embrace WIC involvement as one of the more promising points of intervention. The Tri-County Health Department and Denver Health are two exceptions, as they both report using WIC providers as part of their overall strategy for increasing immunization rates.¹⁴⁷

COLORADO IMMUNIZATION INFORMATION SYSTEM (CIIS)

CDPHE has the authority to develop a comprehensive statewide immunization tracking system to collect and report child-level immunization information to providers, schools, parents and insurance companies.¹⁴⁸ In 2001, CDPHE contracted with the University of Colorado Health Sciences Center to develop an immunization tracking system, the Colorado Immunization Information System (CIIS). CIIS has built a nearly comprehensive database of newborns in Colorado by loading electronic birth certificate data into the registry. CIIS also receives immunization information from health care providers and health plans. In 2005, 48 percent of children under the age of 6 in Colorado had at least one immunization record in the system. CIIS plans include expanding the system to include at least one immunization record for 95 percent of the state's children by 2006, with regular reporting by the majority of Colorado health care providers.¹⁴⁹

Current functions of the CIIS include:

- Consolidation of child-specific immunization information into an easily accessible status report that can be used to make clinical decisions;
- Algorithm based on ACIP recommendations that automatically displays all immunizations that a child needs each time the record is accessed;
- Provider reminders that immunizations are due based on ACIP recommendations;
- Site-based reports indicating the number of children who are not fully vaccinated to be used in provider-based quality improvement;
- Recall reports of children not fully vaccinated to be used for patient recall;
- Maintenance of vaccine inventory for private and VFC vaccines;
- Automatic production of the Certificate of Immunization for Colorado schools and childcare facilities;
- Tracking reports of children who change providers;
- Latitude and longitude data for GIS mapping of child-specific immunization status to develop targeted interventions;

- Epidemiologic studies;
- On-line real time data entry into a Web-based system or electronic batch uploads; and,
- Electronic data retrieval protocols from existing immunization data sources to minimize data entry.

CIIS has protocols and the capacity to interface with all sources of existing immunization data. Sources of immunization data that CIIS has successfully imported and merged into a single record include health department immunization information systems, electronic medical records, electronic billing systems, and electronic claim records. As of January 2005, 256 clinics were enrolled in CIIS, including private practices and a of variety public entities.¹⁵⁰ CIIS expansion efforts have focused on communities rather than individual providers. Consolidation of records at the community level makes the registry immediately useful to health care providers in that community. For example, two Denver-based studies found that practices that used CIIS-based recall systems increased influenza immunization rates in children.^{151 152}

Providers commonly cite the start-up costs associated with participation in a centralized registry as a barrier to participation. Specifically, providers are concerned about the costs vendors charge to download their billing data into the registry, as well as the one time cost of importing/data entering all existing immunization records into the registry.¹⁵³ CIIS is seeking funds for provider subsidies to address these cost barriers.¹⁵⁴ Funding for CIIS currently includes the federal 317 Program, private grants, and in-kind support from the University of Colorado and service clubs throughout Colorado. In partnership with the Colorado Children's Immunization Coalition, CIIS is working to identify additional sources of funding.¹⁵⁵

COLORADO CHILDREN'S IMMUNIZATION COALITION (CCIC)

The CCIC was formed in 1991 to ensure that Colorado children receive recommended vaccinations at the appropriate ages to protect them against vaccine-preventable disease. The CCIC mission is to ensure that Colorado children receive all recommended vaccinations at the appropriate ages, maximally protecting children against vaccine-preventable disease. Current goals of the CCIC include ensuring 90 percent coverage for each recommended vaccine, developing regional immunization programs in high-need areas, and supporting CIIS to achieve 90 percent participation in the immunization registry.

In 1998, the CCIC received a grant from The Colorado Trust to develop quality improvement initiatives with local providers at five Colorado sites. Each site is managed locally and has adopted quality improvement strategies that are responsive to local needs and infrastructure capacity. Beginning in 2002, CCIC began working as a community partner for CIIS in each community site, linking practices through the registry. Currently over 45 practices have been linked to CIIS through this effort. The CCIC also offers statewide provider education that provides practices with information about vaccine schedules, vaccine recall systems, use of registries, and other quality improvement

strategies. The CCIC also supports community outreach and public awareness and advocates for public policy changes to improve immunization.¹⁵⁶

OBSERVATIONS FROM THE FIELD

A review of Colorado programs and policies reveals the following observations:

- Administrative and financial barriers exist to family and provider participation in the VFC program resulting in its underutilization;
- Many financial barriers exist that affect rates of coverage other than those directly related to the costs of immunizations. These barriers include low eligibility thresholds for public insurance programs, low provider participation rates in Medicaid, inadequate public health capacity, inadequate benefit coverage in segments of the private insurance market, and lack of regulatory oversight for benefits in self-funded ERISA plans.
- Many logistical barriers exist that are not specific to immunizations but affect immunization rates including delays in newborn enrollment in the CHP+ and Medicaid programs and clinical hours that are not compatible with work and transportation barriers faced by low-income families;
- Federal and state funds used to finance the immunization infrastructure are fragmented across multiple state agencies;
- Coordination between state agencies and the private sector is critical but currently lacks a coherent strategy and leadership;
- Cross-agency data that would facilitate program coordination efforts and identify pockets of need are difficult to obtain;
- The child-specific and provider-based data needed to facilitate a comprehensive immunization planning effort are difficult and/or expensive to obtain and maintain, especially in interoperable data-sharing formats;
- Child-specific immunization data are available through the CIIS but only in certain geographic areas in Colorado at the present time;
- The analytical capacity across state agencies is not sufficiently coordinated for immunization program planning and evaluation purposes;
- Successful public and private models exist that have achieved high immunization rates among high-risk populations in Colorado such as the Together for Tots Program, the Denver Health immunization registry and outreach program, and the Kaiser Permanente immunization registry and outreach program.

Successful programs and policies for improving immunization rates: A national perspective

The CDC commissioned a Task Force on Community Preventive Services (hereafter, CDC Task Force) in 2000 to conduct an exhaustive review of the scientific literature and produce a set of evidence-based recommendations for improving vaccination rates among the universally recommended vaccine series. The CDC Task Force reviewed 197 published studies of programs from 1980-1997 that included policies

and interventions designed to improve immunization rates. It reduced this vast literature to three main conceptual approaches:

- Increasing community demand for vaccinations;
- Enhancing access to vaccinations; and
- Improving quality of care.¹⁵⁷

Immunization reminders, state vaccination requirements, educational campaigns, and social marketing are all strategies to increase community demand for vaccinations. Access enhancing interventions such as provider subsidies, health insurance coverage, and expanded clinic hours were developed to mitigate or remove financial and structural barriers to immunizations. Quality focused approaches that target health care providers are intended to improve the efficiency and appropriateness of clinical practices related to the administration of recommended vaccine series.

Within these three conceptual approaches, the CDC Task Force identified 17 different types of interventions that were “likely to have a significant impact or were widely practiced.”¹⁵⁸ Overall, the task force found that multi-component interventions worked better than those employing a single strategy. However, because many studies of multi-component approaches did not separately assess each individual strategy, it was often hard to disentangle the components that accounted for overall program success.

Interestingly, the program impact of multi-component interventions as measured in increased immunization coverage, was often larger than the sum of the parts. For example, the task force concluded that many educational strategies *used in isolation* did not improve immunization rates, yet it found strong scientific evidence that multi-component interventions that include education with other demand, access and quality strategies not only worked, but that the education component appeared to enhance the effectiveness of the strategies with which it was paired.

The CDC Task Force offered four possible explanations for this ‘sum is greater than the parts’ finding -- the literature was weighted toward multi-component interventions; multiple components resulted in greater overall intensity of effort; multi-component approaches produced synergy between the elemental parts of the intervention; and education facilitated implementation of other intervention strategies.¹⁵⁹

The CDC Task Force based its recommendation on the strength of the scientific evidence as evaluated by the “numbers of available studies, strength of their design and execution, and size and consistency of reported effects” on vaccination coverage.¹⁶⁰ It judged that nine of the 17 interventions had a scientific basis that was sufficient to justify endorsing their widespread adoption. The final nine recommended strategies were:

- I. Increasing community demand for vaccinations through:
 - Family reminder/recall systems;

- Multi-component interventions that include family, community and/or provider education; and
 - Vaccination requirements for entry into childcare, K-12 education and college
2. Enhancing access to vaccinations through:
- Reducing out-of-pocket costs;
 - Multi-component interventions that involve expanding access to health care in a range of settings;
 - Vaccination programs in WIC settings; and
 - Home visitation programs.
3. Improving provider quality of care in the clinical setting through:¹⁶¹
- Provider reminder/recall opportunities; and
 - Immunization assessment and feedback systems for health care providers.

Conversely, the CDC Task Force judged the following interventions as having insufficient evidence to evaluate their effectiveness: community-wide education as a singular strategy; clinic-based education as a singular strategy; family incentive systems; family-based immunization record-keeping systems; vaccine programs in schools and childcare centers; health care provider education as a singular strategy; and standing orders for pediatric patients. A judgment of insufficient evidence usually involved a small number of studies, small and statistically insignificant effect sizes on immunization rates, and/or study design limitations. Although some of these interventions are commonly practiced, the CDC judged that more rigorous research was needed to document their effectiveness.

The following section applies the CDC Task Force findings to Colorado immunization efforts to put the interventions in a familiar context. The primary purpose of the Colorado examples is to be illustrative, not to suggest that the Colorado programs discussed been evaluated with the same rigor as the task force. A tabular summary of the findings of the CDC exercise can be found in Appendix C.

INCREASING COMMUNITY DEMAND FOR VACCINATIONS

Family reminder/recall systems

A family reminder/recall system targets parents and guardians who are supportive of vaccinations but who lack up-to-date knowledge about the ACIP immunization schedule. A reminder system notifies parents when their child's vaccinations are due through a reminder contact; whereas a recall system contacts parents after an immunization has been missed. Many systems combine the two approaches, hence the name reminder/recall. The task force assessed family reminder/recall systems in multiple subpopulations and across a variety of practice and community settings. Summarizing these studies, reminder/recall interventions raise vaccination coverage rates by an average of 12 percentage points. Reminder/recall programs that focus on parents and guardians were strongly recommended.

Reminder/recall programs require paper or electronic means to track immunization histories and administrative resources to maintain immunization histories. A manual system would utilize a clinical or administrative staff to call parents and/or mail notices. Automated reminder/recall systems require personnel to assure the data quality of the information systems.

As described in the Colorado programs section, Kaiser Permanente and Denver Health employ their own reminder/recall systems, while several FQHCs in Colorado participate in the Together for Tots program, a practice-based reminder/recall system. Key informants assert that all three settings boast comparatively high immunizations rates that they attribute, in part, to the reminder/recall systems.

Multi-component interventions that include education

Multi-component interventions that include education have been described as strategies that seek to “provide knowledge to target populations and sometimes, to vaccination providers, and use at least one other activity to improve vaccination coverage...[they] are based on the premise that prerequisites to health include the physical, social, and political environment in which health risks occur.”¹⁶² The analysis did not offer any best practices guidance with respect to the ideal pairing of interventions. The CDC Task Force found that diverse interventions when paired with education improved immunization rates by an average of 16 percentage points. Multi-component interventions with an education component received a strong recommendation.

The Colorado Children’s Immunization Coalition (CCIC) is an example of a multi-component intervention that includes an educational program. The CCIC conducts public education and outreach, targeted provider education, provider technical assistance and advocates for immunization infrastructure, including a statewide immunization registry.

Vaccination requirements for childcare, K-12 education, and college admission

The CDC Task Force defined vaccination requirements for childcare, K-12, and college admission as laws and policies that condition school enrollment on the documentation of immunization status or immunity from vaccine-preventable diseases. States widely adopted immunization requirements for school-aged children during the 1970s, whereas childcare centers and college admission policies are a more recent phenomenon. Only three studies assessed vaccination coverage as an outcome of these policies but found an average improvement of 15 percentage points; vaccination requirements received a strong recommendation.

As already described, children under the age of 18 who attend childcare centers and primary and secondary schools in Colorado must have a certificate of immunization documenting that they have received immunizations as specified by the State Board of Health.¹⁶³ Colorado is one of 20 states that permit philosophical as well as religious and medical exemptions from this policy.¹⁶⁴ Colorado colleges are required to provide

meningitis vaccine information to incoming students but immunization is not an admissions requirement.¹⁶⁵

ENHANCING ACCESS TO VACCINATIONS

Reducing out-of-pocket costs

Reducing out-of-pocket costs to parents is intended to remove financial barriers to immunizations. The literature documents two common approaches using this strategy: provider subsidies for vaccines and/or administration costs and co-payment reductions. The CDC Task Force did not compare the relative merits of each approach in terms of reducing parental costs for vaccinations. On average, interventions that reduced out-of-pocket costs to families improved immunization rates by 15 percentage points; therefore cost reduction strategies received a strong recommendation.

The federally funded Vaccines for Children (VFC) and the Section 317 programs, described elsewhere, are examples of programs that underwrite the costs of vaccines in Colorado. Medicaid, CHP+, and state-regulated insurance plans in Colorado all mandate immunization coverage. Further, federal rules prohibit Medicaid providers from charging co-payments for immunization services.

Multi-component interventions that include expanding health care access

Access strategies focus on remedying structural barriers to immunizations. These interventions often include reminder/recall and pair it with other access enhancements such as drop-in clinics, dedicated immunization clinics, expanded clinic hours, vaccinations in emergency departments and inpatient settings, and/or transportation assistance.¹⁶⁶ Multi-component access interventions increased vaccination coverage by an average of 13 percentage points and therefore were strongly recommended.

In Colorado, the CDPHE Immunization Program collaboration with Denver Health and Hospitals which mapped immunization status by neighborhood using registry data is an example of such an approach. The analysis was used to target neighborhoods in which to hold immunization outreach clinics.

Vaccination programs in Women, Infants and Children (WIC) settings

WIC-based immunization interventions leverage the fact that WIC-enrolled infants and children match the demographic profile of the under-insured. Activities range from assessment of immunization status and education and referral to the direct provision of vaccinations. Of the four studies that assessed vaccination coverage, each demonstrated that WIC-based programs had a positive effect on vaccination coverage, although the task force did not attempt to quantify the average effect in percentage points. With this caveat, WIC-based interventions received a task force recommendation.

As noted earlier, Colorado WIC providers are required to ask parents to bring immunization records to certification visits, to assess immunization status and to refer to immunization providers as necessary.¹⁶⁷ The Tri-County Health has explicitly targeted the WIC population as a strategic group to increase immunization rates.

Home visits

As the name implies, home visitation consists of in-home visits with parents, usually new parents or at-risk families. Like WIC-based interventions, the content of home visits ranges from assessment of immunization status to education and referral and the direct provision of vaccinations. On average, home visitation programs were found to increase immunization coverage by 10 percentage points and therefore received a task force recommendation.

The Nurse-Family Partnership developed in Colorado provides comprehensive home visitation by nurses during a woman's pregnancy and the first two years after the birth of her first child. The program links women with social supports and needed health services. Several rigorous studies have documented that the Nurse-Family Partnership has resulted in long-term improvements to child health (including immunization rates), and improved educational and social outcomes among participating families long into the child's social and emotional development.¹⁶⁸

IMPROVING PROVIDER QUALITY OF CARE¹⁶⁹

Provider reminder/recall

Provider reminder/recall systems operate much like family reminder/recall except that clinicians rather than parents are the target for immunization notices. The Task Force assessed provider reminder/recall in a variety of practice and community settings and found that immunization rates increased an average of 17 percentage points with the use of these systems; therefore they received a strong recommendation.

As noted earlier, several Colorado health plans including Kaiser Permanente, Denver Health and a number of the federally funded community health centers, maintain a family reminder/recall system and a provider reminder/recall function.

Provider assessment and feedback on immunization status of patients

Whereas provider reminder approaches are prospective in their orientation, assessment and feedback are retrospective reviews of provider performance. This utilization review function for improving immunization rates is commonly implemented in managed care settings. Performance is often compared to benchmarks and sometimes linked to financial incentives. Assessment and feedback approaches were found to increase vaccination coverage by an average of 16 percentage points and therefore the strategy received a strong recommendation from the CDC Task Force.

Many Colorado health plans and provider organizations that have implemented a family reminder/recall system and/or a provider reminder/recall system also tend to assess provider performance and provide feedback to their providers.

Options for improving Colorado childhood immunization coverage

The options for improving Colorado childhood immunization coverage presented in this section consider the scientific evidence on program effectiveness in light of Colorado's current vaccination status, population risk factors, immunization infrastructure, and key informant insights. With this in mind, CHI has identified three opportunities to improve timely and age-appropriate vaccinations for all Colorado children:

- Create a state-level vision and plan that strengthens coordination between the programs currently administered by HCPF and CDPHE and builds on the active involvement of the private sector;
- Invest in information systems to improve data for planning, evaluation and immunization monitoring; and
- Make strategic investments that improve access to immunizations and address Colorado immunization priorities.

Understanding that these options are not meant to be exhaustive or mutually exclusive, this final section of the paper describes each in some detail. Before turning to the options, however, we briefly review the Colorado context in which these options are embedded.

The data analysis and key informants identified three specific, inter-related priorities with regard to Colorado's vaccination coverage:

- Improve 2-year old immunization rates for under-immunized populations;
- Improve the timeliness of all immunizations, especially for infants under the age of one; and,
- Ensure that the fourth dose of DTaP is administered by 19 months.

To meet these three immunization goals, Colorado key informants concurred with the CDC task force's three-pronged approach to:

- Increase community demand for vaccinations;
- Enhance access to vaccinations; and
- Improve provider quality of care.

Many of the ingredients are already in place to improve Colorado childhood vaccination coverage through multi-component intervention strategies. For example, the major CDPHE and HCPF programs that collectively comprise the public immunization infrastructure in Colorado appropriately focus on poor and otherwise at-risk children. These programs address access to immunizations, which is the barrier most frequently cited by Colorado key informants. In addition, the two agencies have implemented

initiatives to increase demand for immunizations and improve quality. However, the current programs often operate independent of the other, thus potentially compromising their overall effectiveness. Data for program planning, evaluation and monitoring is siloed in the individual agencies. It has been argued though that even if existing programs were perfectly aligned, access barriers would persist due to inadequate public and private investments relative to the scope of the problem.

To address these deficiencies, Colorado would benefit from a coordinated state-level planning process that results in better coordination between public immunization programs and includes a data-driven analysis of additional resource needs. As described more fully below, this state planning effort would maximize existing resources and enable public and private funders to target the most promising investment opportunities to improve Colorado's childhood immunization rates and the timeliness of their administration.

OPTION I: CREATE A STATE-LEVEL PLAN TO BETTER SYNCHRONIZE HCPF AND CDPHE PROGRAMS

To maximize current immunization efforts, Colorado needs to develop a unified state-level vision and strategic plan for improving immunization coverage. Whether derived through voluntary or mandatory means, this action plan should synchronize the independent efforts of the various immunization programs and activities administered by HCPF and CDPHE and include the active participation of private sector interests.

Collectively, the immunization programs administered by CDPHE and HCPF comprise the backbone of the public immunization infrastructure serving low-income children most at-risk for under-immunization. Because federal funds support many of the state's immunization programs, and because these federal funds come to states as dedicated funding streams, states are stymied in their ability to seamlessly integrate these funds. However, several other states have successfully integrated programs through interagency agreements and cooperative planning efforts, despite the dedicated nature of the federal funding streams. To achieve this level of interagency coordination requires leadership at the highest levels of state government.

High-level leadership can promote coordinated action through legislation, cooperative planning processes such as interagency task forces and blue ribbon panels, or both. Coordination efforts will need to engage leadership at the highest level of state government, i.e., the Governor's Office or his designee in partnership with state agencies to ensure the active participation of agency staff at all levels. We suggest development of a coordinated action plan that focuses on the three inter-related vaccination priorities identified in this paper and that system performance monitoring be included in this effort:

- Improve 2-year old immunization rates for under-immunized populations;
- Improve the timeliness of all immunizations, especially for infants under the age of 12-months; and,

- Ensure that the fourth dose of DTaP is administered by 19 months of age.

This white paper highlights factors known to influence demand for and access to immunizations and discusses quality considerations in the development of an overall immunization strategy for the state. Additionally, it describes program gaps and highlights evidence-based opportunities for intervention. It was the goal of CHI in producing this white paper to provide a working template for public and private decision-makers with regard to best practices for setting a coordinated vision for immunization policy in Colorado. Next steps will necessarily include key public and private decision-makers articulating a shared vision, clarifying respective roles and responsibilities at the state agency and community level, and developing an accountability structure that tracks systems and individual program performance over time.

We suggest that a coordinated statewide effort must include the active involvement of the public and private sectors as roles and responsibilities are parceled out to create a fully integrated statewide effort.

OPTION II: INVESTMENTS IN INFORMATION SYSTEMS THAT COLLECT CHILD-LEVEL IMMUNIZATION DATA FOR PLANNING AND EVALUATION

Colorado informants repeatedly stressed the extent to which lack of immunization data limits the ability of state agencies to assess the effectiveness of current immunization efforts. Without uniform immunization data collected at the community level, program managers and funders are stymied in their efforts to appropriately target programs and interventions to children in areas of greatest need. Similarly, these data limitations compromise our ability to evaluate whether interventions have succeeded in improving immunization coverage.

Presently, immunization program staff makes use of national surveillance data in combination with statewide and regional demographic data to address Colorado coverage issues and target programs to population groups in greatest need. While this approach makes optimal use of available data, it is sub-optimal for targeting specific geographic pockets of need and identifying subgroups of under-immunized children.

We suggest that public and private funders consider both short and longer-term data needs when making investments in information system infrastructures and include attention to weighing the outcomes of the relative investments. For example, child-level data collected for the purpose of provider quality improvement interventions could also be used for estimating population coverage rates; this duality of function could be an integral component of a quality improvement system that gets built into a new system at the design phase of the project.

Tracking the immunization status of children can be accomplished in at least two ways:

- Immunization-specific registries
- General purpose health information technologies (HIT) including personal health records, electronic medical records, and interoperable management and clinical information systems

Immunization-specific registries

As previously described, immunization registries can be practice-based, system-based or population-based. There are strengths and weaknesses to each approach. High-risk children and families are typically more mobile than the general population and therefore state level population-based registries best address this “record scatter” issue.

However, some Colorado informants noted a preference for practice or community-based registries in high-risk areas because they believe that provider support attenuates when registries get too centralized. The choices do not have to be mutually exclusive. Integrated systems like Kaiser Permanente and Denver Health operate their own registries but also participate in the Colorado Integrated Immunization System, which is a statewide, population-based approach.

Advantages of an immunization-specific information system stem from its single purpose. Tracking immunization histories is particularly challenging because it is a service delivered at multiple points in time, often at different provider sites, and over an extended period of time. Quality assurance is vital and perhaps more easily ensured in a dedicated immunization system. In addition, a variety of different immunization functions can be built in to the design, such as performance monitoring (e.g., HEDIS), reminder/recall notices, provider quality assessments, VFC provider enrollment, and epidemiological studies.

General purpose health information technologies (HIT)

An alternative and potentially complementary approach to immunization-specific registries is the current interest in the development of health information technology (HIT) infrastructures at the state and community levels. In July 2004, the federal government released a 10-year plan to build a national electronic health information infrastructure in the United States that has at its core an “always-current, always available” electronic health record that follows the patient through the health care system. The federal report on HIT speaks specifically to streamlining public health surveillance activities, such as immunization tracking, as one of its four goals. The vision calls for interconnected data systems that allow providers to share and update patient medical information. In 2004, Colorado received one of five in the country federal grants (\$5 million over a five-year period) to demonstrate that health information exchange is feasibility at the community and state level.

It is possible that HIT networks will eventually subsume many of the activities performed by registries today. Then again, given the competing demands envisioned for HIT systems, it may be easier to download electronic medical record information into an immunization registry. Registries and the electronic medical record superhighway do not

need to be mutually exclusive or competing approaches. Indeed, population-based registries are already wrestling with standards, protocols, hardware, and software to facilitate the import and export of data from a variety of health providers and systems. Registries may well provide best practices models for emerging HIT initiatives.

OPTION III: MAKING STRATEGIC INVESTMENTS TO ADDRESS COLORADO COVERAGE PRIORITIES

Ensuring that Colorado children receive all vaccinations according to the recommended schedule will require additional resources and strategic investments. Ideally, public and private funders with an interest in funding new immunization efforts could refer to a state-level strategic plan to improve childhood immunizations. Until such a plan exists, Option III offers preliminary guidance to funders as they assess the merits of new or existing immunization programs in which to invest.

Target specific populations

Proposed immunization interventions should clearly identify who will be served and the documentation for this targeted group should be solidly described. It is not sufficient to justify an immunization-related funding request by citing that Colorado ranks 50th in vaccination coverage nationally. Greater specificity in the problem statement is needed. Interventions that focus on and address the three coverage priorities highlighted in this paper should receive funding priority. Given the analytical challenges in measuring coverage rates in small geographic areas and subpopulations, interventions that aim to improve vaccination coverage in “pockets of need” should clearly describe how the at-risk population was identified. Strategies that address alternative coverage goals should include a thorough literature review or similar justification.

Link intervention goals to identified population need

Intervention strategies and program goals should clearly describe the program theory that connects the specific intervention to the immunization coverage goal. For example, an intervention should specify whether the program strategy specifically addresses demand, access, or quality barriers to immunization coverage. We suggest funders carefully scrutinize the linkage between target population, immunization coverage goals, and the strategy proposed for consistency and feasibility.

Emphasize a Colorado context

In addition to being responsive to Colorado-specific immunization goals, proposed interventions should demonstrate knowledge of Colorado environmental factors including subpopulation group needs, infrastructure issues, and existing program performance factors. Several options ranging from replicating best practices to addressing newly documented access needs exist. For example, the success of client reminder/recall systems in Colorado suggests that community demand for immunizations is high, but understanding of the recommended vaccination schedule is low. Provider and practice-level quality improvement programs are variable, but best practices clearly exist for replication. On the other hand, access-related issues, particularly those structural factors

that impede access to immunizations, were widely cited as the weakest leg of the Colorado demand, access, and quality stool, and therefore we suggest that access to immunizations be given a high priority in any funding strategy.

Encourage evidence-based interventions

In contrast to other areas in health services research in which little is known about what works, immunization interventions have been well-studied. The recent CDC Task Force effort synthesized a vast immunization literature and produced a solid evidence base that funders can consider when making investments in immunization projects. The task force recommendations for interventions that were found to have a scientific basis include:

- Family-based and provider-based reminder/recall programs
- Multi-component interventions that include an educational component
- State vaccination requirements for childcare centers, K-12 and college admissions
- Reducing out-of-pocket costs associated with immunizations
- Multi-component interventions that focus on structural access issues
- Interventions that coordinate with WIC programs
- Home visitation programs
- Quality assessment and feedback mechanisms for providers

Because the CDC Task Force found that interventions that combine multiple approaches often achieve the largest gains in coverage rates, funders may want to consider explicitly encouraging multi-component intervention proposals. Appendix C summarizes assessments of these eight multi-component interventions reviewed. If funders choose to support proposals that the Task Force judged as having insufficient evidence to evaluate, we suggest they require the intervention be paired with a rigorous evaluation.

Consider rural, minority and other special population foci

The rural health literature includes numerous examples of interventions designed for urban populations that do not translate, or require adaptation, when applied to a rural population. Similarly, not all interventions work equally well with all racial and ethnic groups. Some, but not all of the Task Force recommended approaches were evaluated specifically with rural and minority population groups (see Appendix C for a fuller discussion). We suggest that intervention proposals clearly describe the target population in terms of race, ethnicity, and geographic location as a demonstration of the importance of these population-specific risk factors.

Appendix A: Vaccine Safety¹⁷⁰

School exemption policies, particularly philosophical exemptions, respond to parent concerns about vaccine safety. The CDC and vaccine manufacturers go to great lengths to make vaccines safe for both adults and children. Unfortunately, vaccines are not 100 percent safe and can cause very rare and sometimes serious side effects. As vaccines become more effective, the diseases they prevent fade from memory, leaving only the rare side effects in the public's eye. Much of the movement to implement more flexible exemption laws stems from concerns about vaccine safety. CDC has defined three goals for its vaccine safety assurance role: early detection of rare, serious side-effects, ability to assess causality, and promoting public confidence in the safety, value and importance of immunizations.

The vaccine safety assurance process occurs at many different agencies within the federal government. Prior to mass production, a vaccine goes through extensive testing by the Federal Drug Administration (FDA). Once a vaccine becomes FDA approved and distributed, any suspected adverse reactions are reported to Vaccine Adverse Event Reporting System (VAERS). This system contains the medical and immunization histories of more than 7.5 million people. The VAERS system serves as a data source for a network of academic medical centers that study adverse events known as the Clinical Immunization Safety Assessment (CISA) Network. The Institute of Medicine also has periodically synthesized the literature on vaccine safety. Finally, the National Vaccine Injury Compensation Program (VICP) was created to assist families of children who have suffered vaccine side effects and help stabilize the vaccine supply by decreasing the number of lawsuits against manufacturers.

Appendix B

Chronology of DTaP Vaccine Shortage

In response to a national shortage of DTaP, school-entry immunization requirements for the fourth and fifth dose of DTaP were suspended between April 2001 and October 2002. Colorado officials suspended the 4th and 5th shot because they worried about the vaccine supply available for providers that work with low-income populations.

- 2000** Wyeth Pharmaceuticals stopped making DTaP vaccine; CDC reports an inadequate supply of DTaP vaccine
- 3/2001** In response to the shortage, ACIP recommends that states defer administration of the 5th dose of DTaP and the 4th dose, if necessary. The 4th dose is typically delivered by 18 months and the 5th dose is recommended for 5-year-olds.
- 4/2001** CDPHE suspends the school entry requirement for 4th and 5th doses of DTaP. Other states defer only the 5th dose and use state funds to purchase available vaccine at a higher price.^{171,172} Colorado does not exercise this option due to a lack of state funding. The Vaccines for Children program and other public programs are disproportionately affected by the shortage. The private sector in Colorado is less affected because health insurers often have national purchasing power to buy higher-priced vaccine.
- 12/2001** DTaP shortage persists. ACIP does not lift the recommendation to states to defer 4th and 5th doses at the states' discretion.
- 6/2002** DTaP shortage abates. ACIP returns to recommended schedule of 4th dose by 18 months and 5th dose at 5 years. ACIP recommends that states hold off on actively pursuing children who have had 4th and 5th doses deferred until the supply improves further.
- 10/2002** CDC recommends that states begin actively contacting those children whose 4th and 5th doses of DTaP were deferred. Colorado did not begin contacting children at this time. However, CDC imposed monthly caps on the amount of DTaP that state's VFC programs could order during the shortage. Therefore, Colorado did not immediately have the inventory on hand to ensure that vaccine was available to recall all VFC eligible children needing 4th and 5th doses of DTaP.
- 2002** Colorado has the lowest vaccination coverage levels in the nation, well below Healthy People 2010 rates, according to the National Immunization Survey (NIS). Suspending 4th DTaP shot caused 4:3:1:3:3 rates to drop significantly.
- 3/2003** Colorado begins to contact those children whose 4th and 5th doses of DTaP had been deferred.
- 2003** Colorado has the lowest vaccination coverage levels in the nation for the second straight year according to the National Immunization Survey (NIS)

Appendix C

CDC Task Force Recommended Interventions

STRATEGY	Intervention Recommended by CDC Task Force	Median Effect on Immunization Rates ¹	Infrastructure Requirements	Encourages Medical Home	Rural Impact Evaluated	Disparity Analysis	Colorado Experience/ Examples	Key Informant Perspectives
Reminder/Recall (Client and Provider) (n=60 client studies) (n=60 provider studies)	Strongly recommended	12% Client Range 8% - 47% 17% Provider Range 1% - 67%	Information system; administrative capacity; access to health care	Yes, typically Several studies found that other clinical outcomes (e.g., preventive services) also improved	Evaluated in urban, rural, and suburban settings.	Client R/R evaluated in <i>numerous</i> population groups and practice settings. Provider R/R evaluated in <i>numerous</i> provider specialties and practice settings.	Kaiser Denver Health CHC Together for Tots	Endorsed by a majority of experts. Several also argued that Medicaid funds should be sought to support the infrastructure requirements.
Multi-Component Educational Strategies (n=34 studies)	Strongly recommended	16% Range 4% - 29%	Varies; coordination between multiple strategies	Varies	No	Evaluated in <i>numerous</i> population groups and practice settings.	CICC CDPHE public education campaign (planned)	No consensus; three experts supported social marketing but others questioned the expense and sustainability of public education campaigns
Reducing Out-of-Pocket Costs (n=26 studies)	Strongly recommended	15% Range 8% - 47%	Fragmentation of payment mechanisms; administrative complexity	Varies	Evaluated in urban and rural settings.	Evaluated in a variety of income groups and practice settings.	VFC program Medicaid/CHP+ Section 317 program	Experts agreed that the VFC program has been successful but provider enrollment needs to be improved. One expert argued for expanding Medicaid/CHP+ eligibility.

¹ The CDC Task Force found that multi-component interventions, those that use more than one strategy, performed better on average than those that employed a single strategy. Where data exists, “median effect on immunization rates” in this table includes evaluation of the intervention as a single and as a part of a multi-component strategy. “Single” refers to the average effect on rates when the strategy is used alone. “Multi” identifies the mean change in immunization rates when the intervention is used in combination with other strategies.

STRATEGY	Intervention Recommended by CDC Task Force	Median Effect on Immunization Rates ¹	Infrastructure Requirements	Encourages Medical Home	Rural Impact Evaluated	Disparity Analysis	Colorado Experience/ Examples	Key Informant Perspectives
Multi-component access to health care (n=25 studies)	Strongly recommended	13% Range 8% - 35%	Varies; coordination with the medical home; lack of records; assessment of immunization status; contraindications to immunizations (e.g., febrile children in ER); mission conflict	Varies	No	Evaluated in a variety of practice settings.	Denver health outreach clinics 317-funded expansions of public health clinic hours	Key informants all identified access as a major barrier in Colorado. Experts agreed that the VFC should enroll additional, especially Medicaid providers. The VFC program should provide routine technical assistance to providers. Experts recommended better coordination, between Medicaid and public health programs. Several experts cited the need to enroll more Medicaid providers and to improve operations (e.g., enrolling newborns) and improving reimbursement rates A couple experts sought to increase the capacity of FQHCs. Experts disagreed about the relative importance of public health vs. primary care approaches to immunizations.
Provider Assessment and Feedback (n=27 studies)	Strongly recommended	16% Range 1% -43%	Administrative capacity, information systems TJ: statistical validity?	Yes, typically Several studies found that other clinical outcomes (e.g., preventive services) also improved	No	Evaluated in numerous provider specialties and practice settings.	Kaiser CHC Together for Tots Medicaid and private sector HEDIS measures	CDC's AFIX software is free and shown to increase coverage, but does not integrate well with other systems. Many experts would like to see quality improvement programs paired with financial incentives at the practice level.
WIC-Based Interventions (n=10 studies)	Recommended	Study designs too variable to summarize	Coordination with the medical home; integration with WIC mission	No	Urban only	Low-income, predominantly minority populations.	All experts agreed that working with programs that target low-income	MCH funds could be available to fund a WIC-based immunization program.

STRATEGY	Intervention Recommended by CDC Task Force	Median Effect on Immunization Rates ¹	Infrastructure Requirements	Encourages Medical Home	Rural Impact Evaluated	Disparity Analysis	Colorado Experience/ Examples	Key Informant Perspectives
							populations, like WIC, is an effective way to raise immunization rates.	
Vaccination Requirements for Child Care, School, College Attendance (n=10 studies)	Recommended	15% Range 5% - 35%	Administrative capacity; interagency coordination; legislation and regulations	No	No	All 50 states included but subpopulation analysis not typically reported.	School and child care attendance policy.	A couple experts argued for eliminating or narrowing Colorado's "philosophical exemption" policy. Others argued that objectors are numerically small and scarce resources are better allocated to other populations.
Home Visits (n=15 studies)	Recommended	10% Range 1% - 49%	Staff training and safety assurance	Yes, typically Several studies found that other clinical outcomes (e.g., preventive services) also improved	No	Low-income populations	Nurse Family Partnership (David Olds)	Not mentioned

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- ¹²⁵ CDC (2004). Programs in Brief: Vaccines for Children Program. Atlanta, Georgia: Centers for Disease Control and Prevention at: <http://www.cdc.gov/programs/immun04.htm>
- ¹²⁶ Donlin J. (2004). Immunizations: A snapshot for state legislatures. National Conference of State Legislatures: Washington, DC.
- ¹²⁷ Rein DB, Honeycutt A, and Rojas-Smith L (2005). Does federal immunization infrastructure funding improve immunization coverage rates? The case of Public Health Services Section 317 immunization grants. Working paper. RTI International. Atlanta, GA.
- ¹²⁸ Key informant N.
- ¹²⁹ Ibid.

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- ¹³⁰ Rein DB, Honeycutt A, and Rojas-Smith L (2005). Does federal immunization infrastructure funding improve immunization coverage rates? The case of Public Health Services Section 317 immunization grants. Working paper. RTI International. Atlanta, GA.
- ¹³¹ Programs in Brief: Immunization Grant Program Section 317 (2004). Centers for Disease Control and Prevention, Atlanta, GA at: <http://www.cdc.gov/programs/immun04.htm> retrieved on 1/25/05.
- ¹³² Key informant D.
- ¹³³ Ibid.
- ¹³⁴ Key informant N.
- ¹³⁵ Key informant F.
- ¹³⁶ Colorado Business Group on Health reports Health Plan Employer Data and Information Set (HEDIS) performance measures that are similar but not directly comparable to NIS measures.
- ¹³⁷ HCPF reports immunization status using Medicaid HEDIS measures that are similar but not directly comparable to NIS measures. Medicaid HEDIS methodology calculates immunization rates for only a subset of the Medicaid population, specifically, children who have been enrolled one-year prior to their second birthday. The average duration of Medicaid eligibility for Colorado children (of all ages) is less than a year, within a given fiscal year.
- ¹³⁸ Key informant M.
- ¹³⁹ Key informant P.
- ¹⁴⁰ Todd J and Berman S. (2004). State of Health of Colorado's Children. Access to Primary-Care Physicians and Preventive Primary-Care Services for Colorado Children Enrolled In Medicaid. Denver, CO: The Children's Hospital, August.
- ¹⁴¹ Ibid.
- ¹⁴² Drisko J et al. (2002). Colorado PRAMS 2001 Surveillance Report. Denver, CO: State of Colorado Department of Public Health and Environment.
- ¹⁴³ O'Brien E. et al. (2003). Maintaining the gains: The importance of preserving coverage in Medicaid and SCHIP. Georgetown University Health Policy Institute: Washington, DC: October.
- ¹⁴⁴ Mayer M et al. (1999). The role of state policies and programs in buffering the effects of poverty on children's immunization receipt. *Am J Public Health*, 89(2): pps. 164-170.
- ¹⁴⁵ CDPHE Policy Letter #13 (2003). Immunization Information and Referral -4th DTaP Shot. To Local Agency WIC Clinics, June 19.
- ¹⁴⁶ DTaP as shorthand for entire series.
- ¹⁴⁷ Key informant A.
- ¹⁴⁸ §CRS 25-4-1705.
- ¹⁴⁹ Key Informant G.
- ¹⁵⁰ Key Informant G.
- ¹⁵¹ Daley M et al. (2004). Identification and Recall of Children with Chronic Medical Conditions for Influenza Vaccinations. *Pediatrics*, 113(1): pps. 26-33, January.
- ¹⁵² Kempe A et al. (2005). Implementation of Universal Influenza Recommendations for Healthy Young Children: Results of a Randomized, Controlled Trial with Registry-Based Recall. *Pediatrics*, 115(1): pps. 146-54, January.
- ¹⁵³ Key Informant J.
- ¹⁵⁴ Key Informant G.
- ¹⁵⁵ Key Informant G.
- ¹⁵⁶ Key Informant B.
- ¹⁵⁷ CDC Task Force on Community Preventive Services refers to these as "provider-based interventions."
- ¹⁵⁸ Briss PA et al. (2000). Reviews of Evidence Regarding Interventions to Improve Vaccination Coverage in Children, Adolescents, and Adults. *Am J Prev Med*, 18(1S): p. 99.
- ¹⁵⁹ Ibid p. 102.
- ¹⁶⁰ Ibid p. 125.
- ¹⁶¹ CDC Task Force on Community Preventive Services refers to these as "provider-based interventions."
- ¹⁶² Op cit. Briss PA et al. p. 102.
- ¹⁶³ §C.R.S. 25-4-901.
- ¹⁶⁴ §C.R.S. 25-4-903.
- ¹⁶⁵ National Conference of State Legislatures, 23-5-128.

¹⁶⁶ Op cit. Briss PA et al. , p. 109.

¹⁶⁷ CDPHE Policy Letter #13: Immunization Information and Referral -4th DTaP Shot. (To Local Agency WIC Clinics). June 19, 2003.

¹⁶⁸ Olds D. and H. Kitzman. (1993). Review of research on home visitation for pregnant women and parents of young children. *The Future of Children* 3(3): pps. 53-92.

¹⁶⁹ CDC Task Force on Community Preventive Services refers to these as “provider-based interventions.”

¹⁷⁰ Adapted with permission from Donlin J. (2004). Immunizations: A Snapshot for State Legislatures. National Conference of State Legislatures, Denver, CO: pps. 11-12.

¹⁷¹ After the DTaP shortage experience, CDC requests that states not purchase directly from manufacturers. Especially during times of shortage, the federal government needs to manage the supply and its bargaining power is diminished by states that make private arrangements. CDC reports that most states are in compliance with this request.