The Centers for Disease Control ranks vaccination as one of the top 10 most effective public health measures in the last 100 years, and yet the 2002 and 2003 National Immunization Surveys rank Colorado as the worst of 50 states in overall childhood vaccination rates. This study was undertaken to determine if the low vaccination rates reported by NIS are accurate, if they are associated with an increased rate of vaccine-preventable diseases in Colorado, and to identify the consequences and risk factors associated with these illnesses.
Summary of Methods

A number of data sources are available to measure vaccination and disease rates in Colorado. The Colorado Department of Public Health and Environment (CDPHE) has collected data on reportable diseases since 1920. The Colorado Hospital Association (CHA) provides data on all hospital discharges beginning in the year 1995. The Vaccine Adverse Event Reporting System (VAERS) is a national system for reporting possible adverse events that might be associated with vaccines. The National Immunization Survey (NIS) measures vaccination rates annually throughout the United States.

There are still some vaccine-preventable infections that continue to circulate in the population and cause disease and death in our state. Using the above data sources, it is possible to estimate the impact of various vaccine-preventable diseases on the children of Colorado. For the purposes of this study, the focus was on patients discharged with discharge codes for one or more of five vaccine-preventable diseases known to occur in Colorado at the present time. These include: varicella (chicken pox), pertussis (whooping cough), influenza, *S. pneumoniae* (a common cause of meningitis), and *H. influenzae*. An analysis of the patients selected showed that 82 percent of the cases had such codes as either the principal diagnosis or the second diagnosis. The number of hospital admissions and charges associated with each hospitalization were measured and the patient’s insurance status was grouped into one of three categories: no insurance, public insurance (Medicaid/SCHIP), or private insurance, to estimate the public and private costs of hospitalization for these diseases.

**Figure 1**: Vaccines have been very effective in reducing most vaccine-preventable diseases in Colorado.

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**Vaccines have been highly effective in Colorado: Selected Vaccine-preventable Diseases: 1920-2002**

*Data Source: CDPHE*

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diphtheria</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pertussis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polio</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

---

**YEAR**

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**CASES/1,000,000**

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2 / State of the Health of Colorado’s Children
Results

**Vaccines are highly effective.** The CDC ranks vaccination as the most effective public health measure in the last 100 years. They have reduced the incidence of many common and often fatal childhood infections by more than 99 percent in the United States. More importantly, the introduction of vaccines in Colorado has had a dramatic effect on reducing vaccine-preventable diseases such as diphtheria, tetanus, polio, measles, mumps, rubella, smallpox and *Haemophilus influenzae* meningitis. Figure 1 shows the effect of vaccines on several of these diseases in Colorado since 1920. If these vaccines were not routinely used, Colorado could expect more than 70,000 cases of vaccine-preventable infections (DTP, MMR, polio) in children per year. This calculation was based on the assumptions that 22 percent of the population are children and that 75 percent of these diseases primarily occur in children.

**Vaccines are very safe.** Severe adverse events to vaccines are very rare. The Food and Drug Administration is very concerned with vaccine safety and will not approve a vaccine for use without extensive safety testing. As illustrated in Table 1, Colorado data in 2002 shows that there were only nine severe adverse events (resulting in hospitalization) reported to VAERS, resulting in no deaths and one disability (autism) that current data suggests was not likely caused by vaccination.

NIS emphasizes that: *"when reporting and evaluating data from VAERS, it is important to note that for any reported event, no cause and effect relationship has been established. The event may have been related to an underlying disease or condition, to drugs being taken concurrently, or may have occurred by chance shortly after a vaccine was administered."* Even so, for every one possible severe event reported, vaccines prevent an estimated 8,000 severe vaccine-preventable illnesses in Colorado children.

<table>
<thead>
<tr>
<th>Disease/Vaccine</th>
<th>Estimated # Cases of Disease Prevented</th>
<th>Unverified Adverse Events (VAERS)</th>
<th>Disease Prevented to Severe Adverse Event</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td># Mild</td>
<td># Severe</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>169</td>
<td>9</td>
</tr>
</tbody>
</table>

**Table 1:**

Low rate of severe adverse events possibly related to vaccines compared to high vaccine efficacy Colorado, 2002 (Data Source: CDPHE, VAERS).

**Reported NIS vaccination rates correlate with actual vaccine-preventable disease rates in Colorado (as vaccination goes up disease goes down).** The 2002 National Immunization Survey ranks Colorado as the worst of 50 states in childhood overall vaccination rates. By 19 months, children should have the following vaccine doses:

- 4 diphtheria, pertussis, tetanus (DTP)
- 3 polio
- 1 measles, mumps, rubella (MMR)
- 3 *Haemophilus influenzae* (Hib)
- 3 hepatitis B (hep B)
- 1 varicella
In 2002, Colorado ranked last out of 50 states for most of these vaccine combinations: (Colorado rank out of 50)

- 4:3:1:3:3:1  45th
- 4:3:1:3:3  50th
- 4:3:1:3  50th
- 4:3:1:3  50th
- 4:3:1:3  50th
- 4:3:1  50th

As an example of the accuracy of the National Immunization Survey in Colorado, Figure 2 demonstrates the clear inverse relationship between the decreasing number of chicken pox cases in Colorado and the increasing vaccination rate for varicella as measured by NIS.

**Figure 2:** Decreasing incidence of chicken pox hospitalization in Colorado due to increased use of varicella vaccine. (Data Source: CHA, NIS)

**Cases of Varicella vs. % Immunized (NIS)**

Delaying vaccines puts Colorado children, especially the more vulnerable infants and young children, at risk for vaccine-preventable diseases and their complications. Figure 3 shows the distribution of vaccine-preventable diseases in Colorado in 2002; over half of the cases occur in children under 2 years of age. Although school immunization laws result in a high rate of vaccination by the time a child gets to school, the greatest risk of many of these diseases is in young infants.
**Figure 3:**
Greater than 50 percent of Colorado children with vaccine-preventable diseases are under 2 years of age. (Data Source: CHA, 2002)

For some diseases, current vaccination rates in Colorado are not sufficient to prevent increasing rates of disease. As shown in Figure 1, since 1920, vaccines have reduced the incidence of many common childhood diseases such as diphtheria in Colorado by 99 percent - especially those with rare external (imported) exposures; but those due to the more common, internal exposures (e.g. pertussis) continue to cause significant morbidity, mortality and cost. Even rare, external exposures have caused outbreaks in Colorado children who haven’t been vaccinated (e.g. diphtheria, measles).

**Figure 4:** Whooping cough rates in Colorado are higher than the rest of the U.S. and correlate with low Colorado vaccination rates (Data Source: CDPHE, NIS).
Commensurate with Colorado’s low vaccination rates for pertussis, CDPHE data show a rising rate of whooping cough infection in children that is significantly higher and increasing faster than the rate for the entire United States (Figure 4).

**Besides the morbidity and mortality associated with vaccine-preventable diseases, delaying or not giving vaccines costs all the people of Colorado money.** As shown in Table 2, for pertussis, varicella, influenza, *Streptococcus pneumoniae* and *Haemophilus influenzae*, there were more than $13 million in hospital charges for severe disease associated with these infections in Colorado children in 2002.

**Table 2:** Hospital charges for VPD in Colorado children cost the public and private sectors millions. (Data Source: CDPHE, CHA)

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pertussis</td>
<td>365</td>
<td>49</td>
<td>967,803</td>
<td>26</td>
<td>531,039</td>
<td>106,208</td>
</tr>
<tr>
<td>Pneumococcal</td>
<td>75</td>
<td>124</td>
<td>6,053,337</td>
<td>42</td>
<td>2,051,613</td>
<td>410,323</td>
</tr>
<tr>
<td>Influenza</td>
<td>2136</td>
<td>302</td>
<td>4,973,550</td>
<td>102</td>
<td>2,823,617</td>
<td>564,723</td>
</tr>
<tr>
<td>H. influenzae</td>
<td>6</td>
<td>1</td>
<td>193,218</td>
<td>1</td>
<td>193,218</td>
<td>38,740</td>
</tr>
<tr>
<td>Varicella</td>
<td>NR*</td>
<td>28</td>
<td>871,646</td>
<td>11</td>
<td>102,055</td>
<td>20,411</td>
</tr>
<tr>
<td>Total</td>
<td>2,582</td>
<td>504</td>
<td>$13,059,554</td>
<td>182</td>
<td>$5,701,542</td>
<td>$1,140,405</td>
</tr>
</tbody>
</table>

*NR = Not Reported

The table actually underestimates two- to three-fold the potential cost savings, since it does not include those hospitalized children with respiratory disease that can be attributed to influenza, or children with vaccine-preventable diseases who were not admitted to the hospital. Better immunization of children will also lead to less exposure of adults—resulting in an even greater cost savings and reduced work absenteeism.
Vaccine-preventable disease occurs in all parts of Colorado, both urban and rural, and all social strata. The rate of vaccine-preventable disease is higher in children who have public-funded coverage than those with private insurance (Table 3). In fact, the odds of getting a vaccine-preventable disease are 3.5 times higher for children in Colorado with Medicaid/SCHIP coverage than private insurance. Possible explanations for this observation include problems in access to care or delays in implementing the immunization schedule.

As shown in Figure 5, there are high rates of vaccine-preventable disease that occur in many areas throughout Colorado. The number of cases of disease (dots) predominately clustered in metropolitan areas, while the highest rates of disease (shaded) are found in many rural areas in Colorado.

Table 3:
The rate of vaccine-preventable diseases in Colorado children in 2002 was 3.5 times higher in those covered by public insurance as compared to private insurance. (Data Source: CHA, AAP)

<table>
<thead>
<tr>
<th>Insurance</th>
<th>Total VPD</th>
<th>Insurance Coverage</th>
<th>VPD Rate per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>38</td>
<td>180,517</td>
<td>21.1</td>
</tr>
<tr>
<td>Medicaid/SCHIP</td>
<td>182</td>
<td>154,452</td>
<td>118</td>
</tr>
<tr>
<td>Private</td>
<td>284</td>
<td>863,622</td>
<td>32.9</td>
</tr>
</tbody>
</table>

Figure 5:
High rates of VPD in 2001-2 occur both in urban and rural areas of CO (orange = 2-3 times Colorado average, red = 4-24 times average; Dots = cases (>2), Data Source: CHA).
The problem is clear. There is a clear association between vaccine-preventable diseases and low vaccination rates in Colorado's children. This appears to be a state-wide problem. The hospital-related charges for treating these vaccine-preventable diseases in children run in the tens of millions of dollars yearly, and significantly impact both the public and private sectors. The fact that Colorado is last out of 50 states in its vaccination rates suggests that proven approaches might be effectively adopted from other states. Although requiring vaccinations prior to school entry ensures school-aged children are ultimately protected, most vaccine-preventable diseases occur prior to school age. Developing systems that assure access to vaccines for all children, as well as timely vaccinations, will be critically important, especially during the first two years of life, when children are at the highest risk of these diseases.