INTERRUPTION OF INDIGENOUS MEASLES TRANSMISSION IN BOLIVIA SINCE OCTOBER 2000

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Measles incidence in Bolivia declined after the introduction of campaign strategies in the 1980s. From 1990 to 1993, the peak incidence of measles (59 cases/100,000 population) was in 1992. In 1994, after the goal of interruption of measles transmission was adopted, a national vaccination campaign targeting children <15 years old was conducted and achieved 96% coverage. During 1995–1997, cases declined, although routine coverage was <90% in most years. During 1998–2000, a nationwide epidemic occurred among 2567 case-patients, most of whom were unvaccinated. A national vaccination campaign, with strong supervision, was conducted during November and December 1999 and targeted areas with low coverage. Only 122 cases were confirmed in 2000, with the last confirmed case occurring in October. Crucial to the control of the outbreak were sufficient resources and political support, intensive local planning, door-to-door vaccination with strict supervision, and rapid house-to-house coverage monitoring that improved accountability at the local level and timely and thorough outbreak investigations.

Measles is one of the most infectious human diseases. Before the introduction of the measles vaccine, the true incidence of the disease was essentially equal to the number of surviving children in all but the most isolated corners of the world [1]. The Global Burden of Disease Study, which ranked 107 causes of death among all age groups, ranked measles as eighth overall, accounting for 1.1 million deaths in 1990 and 1 million in 1996 [2]. Today, measles is still the leading cause of vaccine-preventable deaths worldwide, with estimates of 30 million cases and 770,000 deaths every year [3].

Because of the measles burden and the availability of an efficacious and cost-effective vaccine, countries in the Region of the Americas set a goal in 1994 of interrupting indigenous measles transmission by the end of 2000 [4] by using a vaccination strategy developed by the Pan American Health Organization (PAHO). Bolivia, with one of the region’s highest mortality rates among children <5 years old [5], was among the countries that would benefit most from the interruption of measles transmission. Bolivia embraced the 1994 initiative and followed the PAHO recommendations for achieving its goal. Here we summarize how Bolivia successfully interrupted indigenous measles transmission.

METHODS

Bolivia followed the PAHO recommended strategy for the interruption of measles transmission. The strategy includes an initial mass vaccination campaign (catch-up) for all children aged 9 months to 14 years, vaccination of children ≥12 months old in the routine vaccination services (keep-up), and mass vaccination campaigns every 4 years (follow-up) that target all 1- to 4-year-old children regardless of previous vaccination status [6]. PAHO recommends reaching a 95% coverage in all catch-up, keep-up, and follow-up vaccination activities in every municipality of the countries.
involved [7, 8]. The strategy is complemented by a sensitive surveillance system capable of the timely detection of suspected measles circulation, the confirmation and thorough investigation of all cases, an effective virologic surveillance system, and strong supervision of vaccination activities, including rapid house-to-house monitoring of vaccination coverage [7, 8].

**RESULTS**

**Measles Coverage and Surveillance, 1970–1997**

Measles surveillance was started in Bolivia during the 1970s, and the national vaccination program was officially initiated in 1979. During the 1970s, measles circulated in Bolivia during all years, and major outbreaks occurred every 1–2 years (figure 1). Reported cases fluctuated between 1967 (42/100,000 population) in 1973 and 8315 (181/100,000 population) in 1972. During this period, measles surveillance was based on passive reporting. Thus, the real number of cases should have been higher. After the introduction of national vaccination campaigns and the progressive increase in routine vaccination coverage, measles incidence declined during 1980–1993 to between 4 and 69 per 100,000 population. Measles-related deaths have been reported since 1989, when 5 deaths were reported. The peak incidence of reported measles-related deaths (20) was in 1990. However, since a passive reporting system was used, the real number of deaths may have been higher.

In 1994, Bolivia adopted the regional goal of interruption of indigenous measles transmission. Toward that end, a national measles vaccination campaign targeting all children <15 years of age was conducted and reportedly achieved 96% vaccination coverage. This campaign had strong political support. During 1995–1997, the yearly number of reported cases decreased to between 7 and 76 (none were laboratory tested), although routine measles vaccination coverage was >90% in only 1 of these 3 years (figure 1). The administrative coverage data generated by the National Health Information System reported higher coverage than the data obtained through national demography and health surveys.

**The 1998–2000 Measles Epidemic**

In 1998, after an importation of measles from Argentina, which was experiencing a major epidemic (>12,000 cases in 1998), an outbreak began in Yacuba, bordering Argentina, in the Department of Tarija (figure 2), and spread to all departments in a succession of outbreaks that continued for >2.5 years until October 2000. The number of confirmed cases was 2567 (32/100,000 population), with 4 deaths. Measles incidence rates by state ranged from 5% (Chuquisaca) to 64% (Tarija) (figure 2). Of all cases, 80% occurred in Santa Cruz, Cochabamba, and La Paz, the country’s most populated departments and also those with the most immigration from rural areas. Most cases occurred in the capital cities, and most case-patients (91%) had no history of vaccination.

Of the cases for which age was known, 55% occurred among children <5 years old. The highest incidence rate (209/100,000 population) was among children aged 6–11 months, followed by those 1–4 years and by young adults (20–24 years) (figure 3).

**Nationwide Active Searches**

During active-case searches implemented during 1999–2000, 159,085 diagnoses were reviewed and 3758 health workers from 1236 health facilities nationwide were interviewed. In addition, 5397 interviews with health personnel and personnel from other institutions (schools, military, religious institutions) and 73,587 interviews in the community and among school students were performed. In all, 28 suspected cases were identified na-
tionwide, of which 1 was confirmed as measles. The investigation of this case led to the identification and control of the last significant measles outbreak in Bolivia, which occurred in a remote Andean community bordering Peru. The active-case searches were complemented by the display, in physician’s offices and clinics, of photographs of measles cases with instructions on how to report them. As a consequence, the number of reported but subsequently discarded suspected measles cases increased seven-fold during 1998–2001 (from 268 [3/100,000] during 1998 to 562 [7/100,000] during 1999 to 1391 [17/100,000] during 2000 to 1673 [20/100,000] during 2001).

Outbreak Investigations

A case study developed during the investigation of the Guayaramerín outbreak (along the border with Brazil) was used to train health personnel throughout Bolivia in outbreak investigations [9]. In 2000, all cases identified through routine surveillance or active search were thoroughly investigated. These investigations included household visits to investigate contacts (a standardized questionnaire was used) and visits to neighborhood and all other areas that the case-patient had visited during the 7–18 days before rash onset (exposure period) or during the period between the beginning of respiratory symptoms until 4 days after rash onset (transmission period). These investigations were done to identify the source of infection and any secondary cases. Because of these efforts, during January through October 2000, 122 cases were identified in five departments. The most significant investigations included outbreaks in Guayaramerín, rural Santa Cruz, Amarete, Cochabamba, among Mennonites, and sporadic cases associated with the use of public transportation.

In the Guayaramerín outbreak, after 2 suspected cases were reported on 29 January 2000, investigators identified a total of 16 cases that occurred in the Bolivian Amazon basin that borders Brazil from December 1999 through February 2000. The cases were mostly among adolescents and young adults of rural origin and with no history of vaccination. No cases occurred among children aged 1–4 years. The outbreak began among military recruits, and transmission primarily occurred in a private clinic that had neglected to report cases or to take infection-control measures.

In the outbreak among farm workers in rural Santa Cruz, 2 cases were identified among young adult migrant seasonal workers who had come from underserved areas of western Bolivia. In the Amarete outbreak (figure 4), 12 cases occurred in April and May 2000 in this isolated, hard-to-reach, indigenous rural community that borders Peru. None of the cases were reported through the surveillance system. The first case to be identified was detected during an active-case finding in La Paz, the country’s capital. One of the last cases from this outbreak was a 5-year-old boy who had been vaccinated 7 days before rash onset, which was reported as a vaccine-related rash. A virologic specimen was obtained from the child, and wild measles was identified.

In the Mennonite-associated measles outbreaks, 66 cases occurred in a Mennonite colony in Santa Cruz from March through June 2000 (figure 4). The outbreak was detected after the regional PAHO office in Washington, DC, received a report of a measles case in a Canadian national who had recently visited Bolivia. The Canadian had been infected at a Mennonite community in rural Santa Cruz. The investigation found that measles had been circulating (undetected by health authorities) since November 1999 in 2 Mennonite communities. The total duration of the outbreak among the 2 communities was 7 months. In one community, vaccination coverage for children aged 1–4 years (determined by household census) was 36%, and 91% of all cases had no history of measles vaccination. The measles incidence rate was 58%. During the subsequent intervention, 23,659 Mennonites of all ages were vaccinated in 33 colonies during a 2-month period. Because the intervention achieved 97% coverage (confirmed by household census), the
Bolivian Mennonites became the best vaccinated group in Bolivia [10].

Five sporadic cases among people from three departments were associated with the use of public transportation. No infection source was identified for any of these cases, although a careful investigation revealed that all used interdepartmental public transportation during the 7–18 days before rash onset, and 2 had been at the same bus terminal in Cochabamba during a 30-min period when 1 was infectious and the other was within 7–18 days before rash onset.

One of the last 2 confirmed cases was an unvaccinated homeless child with rash onset in September 2000. The boy lived in the same municipality as the last confirmed case, which occurred in a 20-year-old unvaccinated woman from Cochabamba with rash onset on 1 October 2000. No contact between these 2 cases could be confirmed, and no other cases were identified despite active search.

Control Measures

Initial interventions. During 1998, due to scarcity of vaccines, vaccination efforts were initially concentrated in Yacuiba and in the main cities. Four months after onset of the epidemic, a follow-up vaccination campaign targeted children ≤5 years of age. According to official data, 85% nationwide coverage was achieved. Despite these interventions, the epidemic intensified, affecting all departments of Bolivia in 1999 (figure 4).

November–December 1999 vaccination campaign. With the collaboration of PAHO and the members of the Expanded Program on Immunization’s Interagency Cooperating Committee, an emergency plan for the interruption of measles transmission was prepared and financed with government and international donor support. This plan had six components.

First, there was a carefully planned nationwide door-to-door vaccination campaign for children aged 6 months to 4 years, regardless of vaccination status. Second, children up to age 14 years were vaccinated in rural areas of the departments of Beni and Pando in the Amazon region (figure 2), the least populated areas of the country. Third, there was strong supervision (1 supervisor for every 5 vaccinators), and fourth, rapid house-to-house monitoring [8] by trained supervisors. The latter was a requirement to determine that areas were well vaccinated. Fifth, mop-up vaccination was done in areas that either did not achieve 95% coverage or for which the rapid house-to-house monitoring revealed unvaccinated children, and sixth, there was active case-finding by vaccinators during the campaign. In addition, the Minister of Health made all health directors accountable for the campaign outcome. The campaign officially achieved 98% national coverage, resulting in a dramatic reduction in cases (figure 4). After the campaign, the emphasis switched to an active search for cases and thorough outbreak investigations.

Rapid response teams. During 2000, rapid response vaccination teams, comprising 120 nursing auxiliaries from all departments, were field trained to perform and supervise vaccination activities and to do rapid house-to-house monitoring. The teams were trained for outbreak control efforts and for work in municipalities at high risk for low vaccination.

The 2000 vaccination campaign. From September

Figure 4. Confirmed measles in Bolivia by week, including week 20 of 1998 through week 19 of 2001. During weeks 13–24 in 2000, there were outbreaks in Amarete (La Paz) and Mennonite colonies (Santa Cruz).
through December 2002, a nationwide house-to-house vaccination campaign for children aged 6 months to 4 years was implemented. As part of supervision, rapid house-to-house monitoring of a convenience sample of children was used in all areas to determine where to prioritize vaccination activities. A municipality was considered for mop-up activities if coverage among interviewed children was <95%. The final official administrative coverage obtained was 95%, and rapid house-to-house monitoring indicated that 92% of all children interviewed had been vaccinated (table 1). In departments where coverage was low, additional vaccination was implemented. As of 24 October 2002, no confirmed measles cases had been identified in Bolivia since 1 October 2000.

**DISCUSSION**

A number of lessons were learned from the experience in Bolivia. The failure of the initial vaccination strategies to stop an outbreak showed the need for a critical analysis of the potential of a measles outbreak to spread and the need to intervene aggressively with sufficient resources and political support.

The successful 1999 and 2000 campaigns also showed that to reach high coverage, measles vaccination campaigns must be carefully planned at the local level, use door-to-door vaccination, and include strict daily supervision and rapid house-to-house monitoring of coverage to improve accountability at the local level. Also, the thorough field training and subsequent use of the 120-member rapid response team in vaccination activities in all departments permitted uniform high coverage during outbreak control efforts, particularly in hard-to-reach places and among populations opposed to vaccination. This experience also showed that high motivation and discipline, even in the absence of significant formal training, remain the best guarantee of high-quality outreach vaccination efforts.

During this epidemic, the nationwide use of active-case searches in health establishments, schools, and other institutions succeeded in identifying only 1 confirmed case, but the searches were fundamental to keeping practitioners and the community aware of measles and permitted unprecedented improvements in measles surveillance that were sustained even after the interruption of measles transmission. The rates of 17 and 20 discarded measles cases per 100,000 persons per year reported by Bolivia during 2000 and 2001, respectively, are among the highest in the region.

Above all, the outbreak investigations were fundamental for identifying groups at high risk for measles transmission and, therefore, guided policy decisions that allowed Bolivia to interrupt transmission. Specifically, the Guayaramerin outbreak investigation was used to develop a training tool still in use in Bolivia and elsewhere, it helped decision-makers develop vaccination policies for military recruits and young adults of rural origin, and it reminded program managers of the importance of stressing good infection control practices and the need to encourage reporting by private practitioners [9].

The investigation among farm workers in rural Santa Cruz led policymakers to pay attention to the needs of seasonal workers and to start outreach vaccination and other services for them. The Mennonite outbreak showed the importance of international disease surveillance cooperation and showed that without intervention, measles transmission can be maintained for long periods even in relatively small rural communities and that efforts to vaccinate communities opposed to vaccination are worthwhile [10]. The Amarete outbreak obliged field investigators to successfully test a parenteral nutrition prepara-

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**Table 1.** Rapid house-to-house monitoring: number and percentage of children vaccinated and total interviewed by Department, Bolivia, from August to December 2000.

<table>
<thead>
<tr>
<th>Department</th>
<th>No. of areas monitored</th>
<th>No. of children surveyed</th>
<th>No. of children vaccinated</th>
<th>Coverage (%) among children interviewed</th>
</tr>
</thead>
<tbody>
<tr>
<td>La Paz</td>
<td>47</td>
<td>3641</td>
<td>3350</td>
<td>92</td>
</tr>
<tr>
<td>Santa Cruz</td>
<td>25</td>
<td>3007</td>
<td>2808</td>
<td>93</td>
</tr>
<tr>
<td>Cochabamba</td>
<td>28</td>
<td>2579</td>
<td>2450</td>
<td>95</td>
</tr>
<tr>
<td>Chuquisaca</td>
<td>21</td>
<td>2078</td>
<td>1768</td>
<td>85</td>
</tr>
<tr>
<td>Potosi</td>
<td>11</td>
<td>1946</td>
<td>1781</td>
<td>92</td>
</tr>
<tr>
<td>Oruro</td>
<td>11</td>
<td>9301</td>
<td>8296</td>
<td>89</td>
</tr>
<tr>
<td>Tarija</td>
<td>16</td>
<td>799</td>
<td>773</td>
<td>97</td>
</tr>
<tr>
<td>Beni</td>
<td>26</td>
<td>2113</td>
<td>1805</td>
<td>85</td>
</tr>
<tr>
<td>Pando</td>
<td>10</td>
<td>3502</td>
<td>3299</td>
<td>94</td>
</tr>
<tr>
<td>El Alto</td>
<td>21</td>
<td>4883</td>
<td>4653</td>
<td>95</td>
</tr>
<tr>
<td>Total</td>
<td>216</td>
<td>33,849</td>
<td>30,983</td>
<td>92</td>
</tr>
</tbody>
</table>
tion, which is available in all major hospitals, as replacement for the viral media used to transport specimens, and led PAHO to issue a new set of recommendations to define when a suspected case is classified as vaccine-related rash. It also motivated health authorities to extend the use of pictures of measles cases to promote case reporting during active-search and campaign activities. The investigation of young adults possibly infected while using public transportation encouraged authorities to set up temporary vaccination centers at bus terminals and gateways, assisting primarily in the vaccination of young adults of rural origin. Finally, the investigation of measles in a homeless child motivated authorities to organize the vaccination of homeless children.

Many outbreak investigations in Bolivia showed how young adults of rural origin assist measles transmission, likely because of their low exposure to wild measles and lack of measles vaccinations in rural underserved areas. These findings highlight the need for vaccination activities specifically geared toward such persons and also emphasize the need for sustainable high-coverage (≥95%) childhood vaccination in all areas of the country during both routine and campaign activities.

CONCLUSIONS

The absence of confirmed measles in Bolivia during the last 2 years despite strong disease surveillance indicates the success of Bolivia’s efforts to interrupt indigenous measles transmission. Keys to this success were the availability of sufficient resources and political support for campaign intervention; campaign microplanning at the local level, use of door-to-door vaccination and strict daily supervision to reach 95% coverage by municipality; the use of rapid house-to-house monitoring of vaccination coverage as a supervisory tool, permitting improved accountability at the local level in a way acceptable to local staff; the field training and operations of the highly motivated special rapid response teams of vaccinators, which contributed substantially to the effective outbreak response in at-risk municipalities in rural and urban areas; the use of active-case searches as quality control for the surveillance system, which helped maintain and improve the surveillance system even in the absence of measles circulation; and the practical training of epidemiologists and local personnel in outbreak investigations and the priority given to these investigations, enabling the timely and complete investigation of all cases during 2000, thus permitting the identification of high-risk groups in need of special vaccination interventions.

References