Supplementary polio immunization activities and prior use of routine immunization services in non-polio-endemic sub-Saharan Africa

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Objective To determine participation in polio supplementary immunization activities (SIAs) in sub-Saharan Africa among users and non-users of routine immunization services and among users who were compliant with the routine oral poliovirus vaccine (OPV) schedule.

Methods Data were obtained from household-based surveys in non-polio-endemic sub-Saharan African countries. Routine immunization service users were children (aged < 5 years) who had ever had a health card containing their vaccination history; non-users were children who had never had a health card. Users were considered compliant with the OPV routine immunization schedule if, by the SIA date, their health card reflected receipt of required OPV doses. Logistic regression measured associations between SIA participation and use of both routine immunization services and compliance with routine OPV among users.

Findings Data from 21 SIAs conducted between 1999 and 2010 in 15 different countries met inclusion criteria. Overall SIA participation ranged from 70.2% to 96.1%. It was consistently lower among infants than among children aged 1–4 years. In adjusted analyses, participation among routine immunization services users was > 85% in 12 SIAs but non-user participation was > 85% in only 5 SIAs. In 18 SIAs, participation was greater among users (P < 0.01 in 16, 0.05 in 1 and < 0.10 in 1) than non-users. In 14 SIAs, adjusted analyses revealed lower participation among non-compliant users than among compliant users (P < 0.01 in 10, < 0.05 in 2 and < 0.10 in 2).

Conclusion Large percentages of children participated in SIAs. Prior use of routine immunization services and compliance with the routine OPV schedule showed a strong positive association with SIA participation.

Introduction

Since the late 1980s, use of supplementary immunization activities (SIAs) has been a key strategy of the Global Polio Eradication Initiative (GPEI). SIAs are mass vaccination campaigns that aim to administer additional doses of oral poliovirus vaccine (OPV) to each child aged < 5 years, regardless of their vaccination history. In doing so, SIAs attempt to remedy the limited ability of routine immunization services to reach at-risk children with the number of OPV doses required to generate immunity. In many countries, SIAs have largely contributed to the 99% global reduction in the incidence of paralytic poliomyelitis observed since the 1988 launch of the GPEI.

Despite the central role of SIAs in eradication efforts, setbacks in the GPEI have been attributed to low-quality SIAs. Target dates for eradication have repeatedly been pushed back and, at present, transmission of wild poliovirus remains endemic in Afghanistan, Nigeria and Pakistan. Four countries where circulation of wild poliovirus had stopped (Angola, Chad, Democratic Republic of the Congo and South Sudan) have been labelled as having “re-established polio transmission” and several other countries previously considered to be “polio free” have reported cases of acute flaccid paralysis due to wild poliovirus strains originating from northern Nigeria. A wild poliovirus “importation belt” thus stretches from Senegal to the Horn of Africa. To achieve eradication, the 2010–2012 GPEI strategic plan sets strict targets of > 90% coverage for each SIA conducted in the importation belt. Even in such highly immunized populations, however, outbreaks may still occur if much lower coverage is achieved for particular subpopulations. In particular, the influence of SIAs on population-level immunity against polio may be lowered if children who do not access routine immunization services and are thus less likely to be immune to polio and other vaccine-preventable diseases) also participate less frequently in SIAs.

Very limited data on patterns of SIA participation are available that consider past use of routine immunization services. In a study of the 1997 Madagascar SIA, Andrianarivelos and colleagues reported significantly increased SIA-associated immunity among children who had not used routine immunization services or had missed routine OPV doses. Currently collected data on SIA coverage do not include an assessment of the immunization history of children who were not vaccinated during SIAs. The effectiveness of polio SIAs at supplementing routine immunization services in non-polio-endemic sub-Saharan African countries is thus not known. In this article, we test the hypothesis that children who did not use routine immunization services before an SIA were less likely to participate in that SIA, compared with children who were users of routine services. We also measured SIA participation among users of routine immunization services who were compliant with the routine OPV

Abstract: in العربية, 中文, Français, Русский and Español at the end of each article.

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immunization schedule, compared with users who were non-compliant.

**Methods**

**Data collection and study groups**

We used three data sources: Demographic and Health Surveys (DHSs), Multiple Indicator Cluster Surveys (MICs) and the 2010 Mobile Technology for Community Health (MoTeCH) survey (Appendix A, available at: http://www.columbia.edu/~sh2813/appendix-02292012sh.pdf). The first two sources are nationally representative household-based surveys conducted, on average, every 3–6 years in several sub-Saharan countries. The MoTeCH survey is a household-based survey conducted among women residing in the Kassena-Nankana East and West districts in Ghana’s Upper East Region. In all surveys, data on participation in SIAs and use of routine immunization services were collected in a similar manner. Mothers were asked to provide vaccination information for their surviving children <5 years old. They were first asked whether their child had ever had a health card. Health cards are small booklets, usually given to mothers or guardians at the time of delivery or during the first vaccination visit, in which health workers record receipt of various antigens recommended through the World Health Organization’s (WHO’s) Expanded Programme on Immunization. For children whose health card was available at the time of the survey, interviewers transcribed the date of each vaccination recorded in the card. Interviewers then asked mothers to specify types of undocumented vaccination, if any, these children received. For children whose health card was not available at the time of the survey or who had never had a health card, interviewers asked mothers to specify every vaccination these children received but vaccination dates were not requested.

Because vaccinations received during polio SIAs are not recorded in children’s health cards by health workers and volunteers, OPV doses documented in health cards represent doses obtained through routine immunization services. We thus used health-card data to measure children’s prior use of routine immunization services in two ways. First, we used ownership of a health card to distinguish children who had ever used routine immunization services (hereafter, “users”) from children who had never used routine immunization services (hereafter “non-users”). Second, among users, we distinguished children who were compliant with routine OPV immunization from children who were not compliant by examining the age at which each OPV dose was received. Most countries in sub-Saharan Africa use a standard schedule for OPV: the first OPV dose is administered at 6 weeks of age; the second, at 10 weeks; and the third, at 14 weeks. Thus, we classified children as compliant if, at the time of the SIA, their health card reflected receipt of each required OPV dose. For example, a child who was 20 weeks old at the time of an SIA and had the third OPV dose documented in their health card would be classified as compliant, whereas a child who was 11 weeks old at the time of an SIA and had only the first OPV dose documented in their health card would be classified as non-compliant.

In many of the MICs and DHSs and in the MoTeCH survey, mothers are asked about their children’s participation in recent polio SIAs. In some surveys, mothers are asked only whether their children participated in any SIA in recent years. In other surveys, mothers are asked whether their children participated in a specific SIA. Surveys were included in this study only if they included assessment of participation in a specific SIA for which the date of implementation was available. We obtained dates of SIAs directly from the survey questionnaire or indirectly from the WHO calendar of SIAs (available at: http://apps.who.int/immunization_monitoring/en/globalsummary/siacalendar/padvancements.cfm). To limit recall bias, we further excluded SIA data if collection of survey data began >12 months after an SIA. We also excluded subnational SIAs because it was impossible to determine which of the children included in survey data sets were targeted.

**Data analysis**

All analyses excluded children whose day of birth was unavailable or who were born after the SIA of interest was held. Analyses of SIA participation among compliant and non-compliant users excluded children whose health card was not reviewed by the interviewer, was incomplete or had an invalid sequence of receipt dates for routine OPV doses (e.g. the date of the second dose was more recent than the date of the third dose).

Primary analyses used logistic regression models to measure the associations between SIA participation and prior routine immunization use and between SIA participation and routine immunization compliance. Such models included SIA participation as the (dichotomous) dependent variable and controlled for child age and sex, mother age and education level and household characteristics (i.e. religion and ethnicity of the household head, wealth quintile and urban/rural residence). We also included a set of regional fixed effects. Standard errors were adjusted for the clustering of observations within enumeration areas and households. We reported adjusted frequencies of SIA participation derived from the logistic regression models, by routine immunization service use and routine OPV immunization compliance. These frequencies were computed using the margin command in Stata, version 12 (StataCorp, College Station, United States of America), after setting other covariates at their mean value.

We conducted two robustness tests of the logistic regression models used in our primary analyses. The first test re-estimated the models after inclusion of all children for whom the month but not day of birth was available. In this test, only children who were aged >4 months at the time of the SIA and, thus, were supposed to have completed the routine OPV schedule were included. The second test re-estimated the models after reclassification of children who first used routine immunization services after the SIA of interest as non-users.

In a secondary investigation, we compared the organizational attributes, human resources and budgetary allocations for three SIAs conducted in Benin, to explore why some SIAs are more successful than others at reaching undervaccinated children. Benin was selected for this investigation because (i) it is the only country for which we had survey data on participation in 3 SIAs, (ii) SIA implementation records were available to the study team and (iii) SIA participation among non-users of routine services during SIAs in 2005 and 2006 was significantly less than that during an SIA in 2000 (61–64% in 2005–2006 versus 91% in 2000, see below).
**Flowchart of data set selection for evaluation of polio supplementary immunization activities (SIAs) participation in non-polio-endemic sub-Saharan African countries**

DHS, Demographic and Health Survey; MICS, Multiple Indicator Cluster Survey; OPV, oral poliovirus vaccine.

- 5 surveys\(^a\) were not publicly available
- 65 surveys\(^b\) had no participation data for a specific SIA
- 5 surveys\(^c\) had SIA participation data derived from free recall
- 2 surveys\(^d\) occurred >1 y after all evaluated SIAs
- 21 surveys\(^e\) had unknown dates for SIAs
- 2 surveys\(^f\) were conducted at same time as SIA
- 13 SIAs\(^g\) did not involve OPV administration
- 17 SIAs\(^h\) were conducted >1 y before survey
- 2 SIAs\(^i\) were subnational

19 surveys had requisite information for 53 SIAs

Survey data on participation in 21 polio SIAs were included in the study

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**Results**

**Characteristics of SIAs and children**

We reviewed data from 119 surveys conducted between 1988 and 2010. Data from 21 SIAs (Fig. 1) met inclusion criteria. These primarily included SIAs conducted in the wild poliovirus importation belt, as well as one in Lesotho and two in Namibia. One SIA was conducted in 1999, three in 2000, four in 2004, nine in 2005, three in 2006 and one in 2010.

The proportion of children with a known date of birth varied greatly across countries (Table 1). Among children with a known birthday, between 74.5% (during the 2000 Benin SIA) and 93.6% (during the 2004 Lesotho SIA) were alive at the time of the SIA. Between 94.3% and 99.8% of respondents answered the specific SIA questions. Prior use of routine immunization services varied significantly across countries: during the 2004 Lesotho SIA, only 1.3% of sampled children were non-users of routine immunization services, whereas during the 2000 Mali SIA, non-users comprised 29.2% of children.

**SIA participation**

Full results of logistic regression analyses of the probability of SIA participation are reported in Appendix B (available at: [http://www.columbia.edu/~sh2813/appendix-02292012sh.pdf](http://www.columbia.edu/~sh2813/appendix-02292012sh.pdf)). SIA participation ranged from 70.2% (during the 2004 Lesotho SIA) to 96.1% (during the 1999 Burundi SIA). In most SIAs, participation was lower among infants than among children 1–4 years old. SIA participation increased with age and educational level of the mother or guardian. In 8 of 17 SIAs, SIA participation was highest among wealthier households. In 7 SIAs, participation was associated with residential location: 2 SIAs (the 1999 Burundi SIA and the 2005 Sierra Leone SIA) had greater participation in rural areas and 5 SIAs (the 2000 Mali SIA, the 2000 Benin SIA, the 2005 Burkina-Faso SIA, the 2005 Gambia SIA and the 2006 Namibia SIA) had greater participation in urban areas. There were regional differences in participation in all SIAs but differences as-
Table 1. Data on surveys and surveyed children aged < 5 years used to evaluate participation in polio supplementary immunization activities (SIAs) in 15 non-polio-endemic sub-Saharan African countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Year of most recent WPV case</th>
<th>Date of SIA&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Type</th>
<th>No of months between survey and SIA</th>
<th>Total no.</th>
<th>Had known birth date&lt;sup&gt;d&lt;/sup&gt;</th>
<th>Born by time of SIA&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Had valid SIA participation data&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Had health card&lt;sup&gt;e&lt;/sup&gt;</th>
<th>Had health card seen&lt;sup&gt;e&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burundi</td>
<td>2009</td>
<td>22 Sep. 1999</td>
<td>MICS</td>
<td>7–8</td>
<td>3,325</td>
<td>2,821 84.8</td>
<td>2,317 82.1</td>
<td>2,177 94.0</td>
<td>1,905 87.5</td>
<td>1,172 61.5</td>
</tr>
<tr>
<td>Namibia</td>
<td>2006</td>
<td>15 Jun. 2000</td>
<td>DHS</td>
<td>3–7</td>
<td>3,784</td>
<td>2,979 78.7</td>
<td>2,656 89.2</td>
<td>2,507 94.4</td>
<td>2,451 97.8</td>
<td>1,727 70.5</td>
</tr>
<tr>
<td>Mali</td>
<td>2011</td>
<td>20 Oct. 2000</td>
<td>DHS</td>
<td>3–7</td>
<td>11,109</td>
<td>9,199 82.8</td>
<td>8,036 87.4</td>
<td>7,832 97.5</td>
<td>5,459 69.7</td>
<td>2,784 51.0</td>
</tr>
<tr>
<td>Benin</td>
<td>2009</td>
<td>19 Oct. 2000</td>
<td>DHS</td>
<td>10–12</td>
<td>4,740</td>
<td>3,260 68.8</td>
<td>2,429 74.5</td>
<td>2,354 96.9</td>
<td>2,244 95.4</td>
<td>1,669 74.4</td>
</tr>
<tr>
<td>Lesotho</td>
<td>Pre-1996</td>
<td>26 Jul. 2004</td>
<td>DHS</td>
<td>1–5</td>
<td>3,340</td>
<td>1,511 45.2</td>
<td>1,414 93.6</td>
<td>1,374 97.2</td>
<td>1,349 98.2</td>
<td>986 73.1</td>
</tr>
<tr>
<td>Senegal</td>
<td>2010</td>
<td>8 Oct. 2004</td>
<td>DHS</td>
<td>4–8</td>
<td>10,106</td>
<td>2,623 26.0</td>
<td>2,207 84.1</td>
<td>2,198 99.6</td>
<td>2,092 95.2</td>
<td>1,320 63.1</td>
</tr>
<tr>
<td>Guinea</td>
<td>2011</td>
<td>8 Oct. 2004</td>
<td>DHS</td>
<td>4–8</td>
<td>5,641</td>
<td>1,341 23.8</td>
<td>1,087 81.1</td>
<td>1,073 98.7</td>
<td>984 91.7</td>
<td>688 69.9</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>2010</td>
<td>8 Oct. 2004</td>
<td>MICS</td>
<td>11–13</td>
<td>5,246</td>
<td>4,101 78.2</td>
<td>3,233 78.8</td>
<td>3,143 97.2</td>
<td>2,704 86.0</td>
<td>1,121 41.5</td>
</tr>
<tr>
<td>Sierra Leone</td>
<td>2010</td>
<td>15 Feb. 2005</td>
<td>MICS</td>
<td>7–9</td>
<td>5,246</td>
<td>4,101 78.2</td>
<td>3,451 84.2</td>
<td>3,420 99.1</td>
<td>2,944 86.1</td>
<td>1,267 43.0</td>
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<tr>
<td>Niger</td>
<td>2011</td>
<td>9 Apr. 2005</td>
<td>DHS</td>
<td>9–13</td>
<td>8,209</td>
<td>2,228 27.1</td>
<td>1,714 76.9</td>
<td>1,683 98.2</td>
<td>1,190 70.7</td>
<td>805 67.6</td>
</tr>
<tr>
<td>Benin</td>
<td>2009</td>
<td>11 Nov. 2005</td>
<td>DHS</td>
<td>9–13</td>
<td>14,682</td>
<td>9,741 66.3</td>
<td>7,528 77.3</td>
<td>7,419 98.5</td>
<td>7,061 95.2</td>
<td>4,421 62.6</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>2009</td>
<td>15 Nov. 2005</td>
<td>MICS</td>
<td>4–7</td>
<td>5,283</td>
<td>3,383 64.0</td>
<td>2,974 87.9</td>
<td>2,947 99.1</td>
<td>2,796 94.9</td>
<td>2,376 85.0</td>
</tr>
<tr>
<td>Guinea-Bissau</td>
<td>Pre-1996</td>
<td>18 Nov. 2005</td>
<td>MICS</td>
<td>6–8</td>
<td>5,845</td>
<td>5,288 90.5</td>
<td>4,608 87.1</td>
<td>4,473 97.1</td>
<td>4,280 95.7</td>
<td>2,923 68.3</td>
</tr>
<tr>
<td>Côte d’Ivoire</td>
<td>2011</td>
<td>11 Nov. 2005</td>
<td>MICS</td>
<td>9–11</td>
<td>8,604</td>
<td>7,443 86.5</td>
<td>5,849 78.6</td>
<td>5,692 97.3</td>
<td>5,042 88.6</td>
<td>3,907 77.5</td>
</tr>
<tr>
<td>Gambia</td>
<td>2000</td>
<td>11 Nov. 2005</td>
<td>MICS</td>
<td>1–4</td>
<td>6,543</td>
<td>6,050 99.4</td>
<td>6,016 92.5</td>
<td>6,004 99.8</td>
<td>5,896 98.2</td>
<td>3,605 61.1</td>
</tr>
<tr>
<td>Togo</td>
<td>2009</td>
<td>11 Nov. 2005</td>
<td>MICS</td>
<td>6–8</td>
<td>3,820</td>
<td>2,983 78.1</td>
<td>2,579 86.5</td>
<td>2,531 98.1</td>
<td>2,300 90.9</td>
<td>1,645 71.5</td>
</tr>
<tr>
<td>Niger</td>
<td>2011</td>
<td>12 Nov. 2005</td>
<td>DHS</td>
<td>2–6</td>
<td>8,209</td>
<td>2,228 27.1</td>
<td>1,999 89.7</td>
<td>1,963 98.2</td>
<td>1,403 71.5</td>
<td>984 70.1</td>
</tr>
<tr>
<td>Côte d’Ivoire</td>
<td>2011</td>
<td>12 May 2006</td>
<td>MICS</td>
<td>3–5</td>
<td>8,604</td>
<td>7,443 86.5</td>
<td>6,789 91.2</td>
<td>6,664 98.2</td>
<td>5,920 88.8</td>
<td>4,603 77.8</td>
</tr>
<tr>
<td>Benin</td>
<td>2009</td>
<td>27 May 2006</td>
<td>DHS</td>
<td>3–6</td>
<td>14,682</td>
<td>9,741 66.3</td>
<td>8,907 91.4</td>
<td>8,778 98.5</td>
<td>8,353 95.2</td>
<td>5,452 65.3</td>
</tr>
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<td>Namibia</td>
<td>2006</td>
<td>20 Jun. 2006</td>
<td>MICS</td>
<td>5–9</td>
<td>4,858</td>
<td>3,899 80.3</td>
<td>3,231 82.9</td>
<td>3,154 97.6</td>
<td>3,069 97.3</td>
<td>2,159 70.4</td>
</tr>
<tr>
<td>Ghana&lt;sup&gt;f&lt;/sup&gt;</td>
<td>2008</td>
<td>6 Mar. 2010</td>
<td>MoTeCH</td>
<td>1–5</td>
<td>1,594</td>
<td>1,594 1000</td>
<td>1,482 93.0</td>
<td>1,463 98.7</td>
<td>1,443 98.6</td>
<td>1,379 95.6</td>
</tr>
</tbody>
</table>


<sup>b</sup> Obtained either from survey questionnaires or from a calendar of SIAs, maintained by WHO (available at: http://apps.who.int/immunization_monitoring/en/globalsummary/vacicalendar/padvancedsia.cfm).

<sup>c</sup> Determined by comparing the reported date of birth and the date of the SIA. Percentages were calculated by dividing these values by the no. of children with a known birth date.

<sup>d</sup> Denotes children who were alive at the time of the survey.

<sup>e</sup> Obtained from children with a known day, month and year of birth. Percentages were calculated by dividing these values by the no. of children surveyed.

<sup>f</sup> Denotes children with a health card containing their vaccination history. Percentages were calculated by dividing these values by the no. of children with a health card.

Sources: DHSs, MICSs, MoTeCH survey and WHO.
Participants in polio supplementary immunization activities (SIAs) in non-polio-endemic sub-Saharan African countries, by use or non-use of routine immunization (RI) services

- Non-RI users
- RI users

*P < 0.01; **P < 0.05; ***P < 0.10 (for differences in participation between RI service users and non-users, by logistic regression analysis)

* SIAs appear in chronological order, moving clockwise, starting with the 1999 Burundi SIA. Data denote the adjusted proportions of children participating in an SIA among RI users (defined as children who owned a health card containing their vaccination history) and non-RI users (defined as children who did not own a health card). Full results including estimates of coefficients for covariates are shown in Appendix B (available at: http://www.columbia.edu/~sh2813/appendix-02292012sh.pdf).

Discussion

In this study, we used data from the MICS, the DHS and a recent survey we conducted in two districts of Ghana’s Upper East Region to document patterns of participation in polio SIAs in sub-Saharan African countries where polio is not endemic. We found that a large percentage of undervaccinated children benefit from vaccination opportunities offered during SIAs every year but that SIAs only imperfectly remedied the limited reach of routine immunization services. In the 21 SIAs we analysed, reported SIA participation among routine immunization users was often significantly higher than that among non-users. Compliant users were also often more likely than non-compliant users to participate in SIAs, but these differences were of much smaller magnitude than those between users and non-users. Of 3 SIAs in Benin, the one with the highest participation among non-users had the greatest percentage of the total SIA budget invested in community mobilization. During the 2010 Ghana SIA, some of the possible reasons for low SIA participation among non-users of routine immunization services included inappropriate marking of houses in the targeted areas, incomplete training of volunteers, lack of local maps of the targeted areas among teams and suboptimal supervision.

Our study has several potential limitations. First, analyses were limited to 21
Compliant RI users

Third, SIA participation was determined when the month but not day of birth was known (Appendix C) and are derived from a limited sample of thousands of SIAs conducted since the launch of the GPEI and excluded SIAs conducted in countries where polio transmission is endemic or considered to be re-established. Also, most data were for SIAs conducted before 2006. Although analyses of the 2010 Ghana SIA suggest that large differences in SIA participation between routine immunization service users and non-users may have persisted in recent years, data from the MoTeCH survey are not nationally representative and are derived from a limited sample size. Second, data were limited to children for whom a valid birth date was reported and were thus possibly affected by sample selection bias. However, robustness analyses involving children for whom the month but not day of birth was known (Appendix C) yielded results very similar to those for children whose birth date was known (Fig. 1 and Fig. 2). Third, SIA participation was determined on the basis of maternal recall and self-report rather than on the basis of more objective methods (e.g. finger marking). Although we attempted to minimize recall bias by excluding SIA data if the associated survey was conducted > 12 months after the SIA, a desire to state socially acceptable responses to survey questions might have tempted some mothers to exaggerate the extent to which their children participated in SIAs. Fourth, the criterion used to distinguish routine immunization users from non-users is a potential source of information bias. If SIAs stimulate interest in immunization among undervaccinated children, non-users who participate in an SIA might subsequently begin accessing routine immunization services, which could result in their misclassification as routine immunization service users at the time of the SIA. The results in Appendix D, however, indicate that this source of bias is unlikely to have explained the observed patterns. Fifth, our data have limitations common to retrospective studies of vaccination status (e.g. they exclude children who died or moved before the survey). Finally, our exploration of the factors that may explain low SIA coverage among non-users of routine immunization services was limited. It was based solely on the comparison of three SIAs conducted in one country (Benin); used only data from SIA budgets and planning documents, rather than data tracking the implementation of SIAs at the local (i.e. district) level; and did not incorporate elements (e.g. rumours and fatigue) characterizing the demand for SIAs and immunization among local populations.

Of thousands of SIAs conducted since the launch of the GPEI and excluded SIAs conducted in countries where polio transmission is endemic or considered to be re-established. Also, most data were for SIAs conducted before 2006. Although analyses of the 2010 Ghana SIA suggest that large differences in SIA participation between routine immunization service users and non-users may have persisted in recent years, data from the MoTeCH survey are not nationally representative and are derived from a limited sample size. Second, data were limited to children for whom a valid birth date was reported and were thus possibly affected by sample selection bias. However, robustness analyses involving children for whom the month but not day of birth was known (Appendix C) yielded results very similar to those for children whose birth date was known (Fig. 1 and Fig. 2). Third, SIA participation was determined on the basis of maternal recall and self-report rather than on the basis of more objective methods (e.g. finger marking). Although we attempted to minimize recall bias by excluding SIA data if the associated survey was conducted > 12 months after the SIA, a desire to state socially acceptable responses to survey questions might have tempted some mothers to exaggerate the extent to which their children participated in SIAs. Fourth, the criterion used to distinguish routine immunization users from non-users is a potential source of information bias. If SIAs stimulate interest in immunization among undervaccinated children, non-users who participate in an SIA might subsequently begin accessing routine immunization services, which could result in their misclassification as routine immunization service users at the time of the SIA. The results in Appendix D, however, indicate that this source of bias is unlikely to have explained the observed patterns. Fifth, our data have limitations common to retrospective studies of vaccination status (e.g. they exclude children who died or moved before the survey). Finally, our exploration of the factors that may explain low SIA coverage among non-users of routine immunization services was limited. It was based solely on the comparison of three SIAs conducted in one country (Benin); used only data from SIA budgets and planning documents, rather than data tracking the implementation of SIAs at the local (i.e. district) level; and did not incorporate elements (e.g. rumours and fatigue) characterizing the demand for SIAs and immunization among local populations.

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Our study nonetheless has important implications for polio eradication. First, our findings provide insights into factors explaining the recurrent importation of wild poliovirus in previously polio-free sub-Saharan countries since 2002. Specifically, differences in SIA coverage between routine immunization service users and non-users may have maintained local pockets of susceptibility to polio importation. Second, our analyses suggest that SIA monitoring in the GPEI should include an assessment of the vaccination history of children “missed” by vaccination teams during SIAs. Current monitoring practices do not include such assessment and thus do not permit identification of possible pockets of individuals susceptible to infection. Whereas the 2010 Ghana SIA met the GPEI’s quality criterion of > 90% participation in the two Kassena-Nankana districts, we found very low coverage among non-users of routine immunization services, who are most likely to be undervaccinated. Finally, our analyses have implications for strategies to improve SIA quality in the GPEI. At present, quality assessments are focused on estimating the proportion of children who were not reached during an SIA and on determining why they were not reached (e.g. refusal and conflict-related inaccessibility). Such data are descriptive and do not permit identification of the SIA characteristics (e.g. poor microplanning, lack of supervision and insufficient or ineffective community mobilization) that explain poor SIA coverage among populations at greatest risk of experiencing polio outbreaks. To sustain high levels of immunity against polio and achieve eradication, an ambitious agenda of operational research on the characteristics of undervaccinated children (e.g. location...
Table 2. Characteristics of polio supplementary immunization activities (SIAs) conducted in Benin between 2000 and 2006

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>2000 Benin; SIA coverage high among users and non-users of RI services</th>
<th>2005 Benin; SIA coverage high among users and low among non-users of RI services</th>
<th>2006 Benin; SIA coverage high among users and low among non-users of RI services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational attribute</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vaccine used</td>
<td>Trivalent OPV</td>
<td>Trivalent OPV</td>
<td>Trivalent OPV</td>
</tr>
<tr>
<td>Time since previous polio SIA (months)</td>
<td>9</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Human resource</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vaccinators (no.)</td>
<td>13 856</td>
<td>NA</td>
<td>14 573</td>
</tr>
<tr>
<td>Community mobilization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning, training</td>
<td>24.6</td>
<td>33.9</td>
<td>33.1</td>
</tr>
<tr>
<td>Transport</td>
<td>198</td>
<td>10.1</td>
<td>11.1</td>
</tr>
<tr>
<td>Other supplies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monitoring, evaluation</td>
<td>9.7</td>
<td>8.4</td>
<td>8.7</td>
</tr>
<tr>
<td>Staff</td>
<td>8.0</td>
<td>5.7</td>
<td>5.6</td>
</tr>
<tr>
<td>Total SIA budget (PPPS)</td>
<td>3 101 123</td>
<td>3 843 797</td>
<td>3 993 680</td>
</tr>
</tbody>
</table>

NA, not available; PPP$, purchasing power parity dollars; RI, routine immunization.

* Data are percentages of the total SIA budget.

* Include items associated with the cold chain, chalk used for house marking, indelible ink used for finger marking, gum boots and other waterproof gear for vaccinators and supplies (e.g. life vests and boat engines) required for reaching remote populations.

The following exchange rates, from the Penn world table version 7,1 were used: 2000, 239.41 CFA francs per PPP$; 2005, 248.27 CFA francs per PPP$; 2006, 244.01 CFA francs per PPP$.

Sources: SIA implementation records and comprehensive budgets.

and socioeconomic characteristics) and the organizational determinants of SIA participation is thus urgently needed. Findings from this research will help guide SIA quality improvement strategies and help develop new interventions to promote participation in immunization activities among children who are not reached by both routine immunization services and SIAs.

Acknowledgements

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Competing interests: None declared.

ملخص

أنشطة التمنيع التكميلية من شلل الأطفال والاستخدام السابق لخدمات التمنيع الروتيني واللفاق الفموي المضاد لفيروس السنجابية (OPV) في بلدان أفريقيا جنوب الصحراء الكبرى التي لا يستوطنها شلل الأطفال وتشمل في هذا التحليل 21 من أنشطة التمنيع التكميلية من شلل الأطفال في بلدان أفريقيا جنوب الصحراء الكبرى (SIA) في 2000، 2005، و 2006. وتتراوح أعمار الأطفال الذين تم الت)][بكلية من شلل الأطفال بين 15 و 70.2 في 101.1%. وكانت مشاركة الأطفال في نشاط واحد، و 85.1% بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم 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الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال الذين تم التلاعب بهم بين الأطفال 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Supplementary polio immunization in sub-Saharan Africa

Stephane Helleringer et al.


Résumé

Campagnes de vaccination antipoliomyélitique supplémentaire et recours antérieur aux services de vaccination de routine en Afrique subsaharienne non-polio-endémique.

Objectif Déterminer la participation aux campagnes de supplémentation vaccinale en Afrique subsaharienne parmi les utilisateurs et les non-utilisateurs des services de vaccination de routine et parmi les utilisateurs conformes ou non-conformes au protocole de vaccination antipoliomyélitique orale.

Méthodes Les données ont été obtenues à partir d’enquêtes de ménages conduites dans des pays non-polio-endémiques d’Afrique subsaharienne. Les utilisateurs des services de vaccination de routine étaient des enfants (âgés de moins de 5 ans) ayant possédé un jour un carnet de santé contenant leur historique vaccinal; les non-utilisateurs étaient des enfants n’ayant jamais possédé de carnet de santé. Les utilisateurs ont été considérés comme conformes conformes au protocole de vaccination antipoliomyélitique orale si, à la date de la campagne, leur carnet de santé reflétait l’administration des doses de vaccination antipoliomyélitique orale requises. Une régression logistique a mesuré les associations entre la participation à la campagne et tant le recours aux services de vaccination de routine que la conformité au protocole de vaccination antipoliomyélitique orale des utilisateurs.

Résultats Les données provenant de 21 campagnes de supplémentation vaccinale menées entre 1999 et 2010 dans 14 pays différents ont satisfait les critères d’inclusion. La participation globale aux campagnes variait de 70,2% à 96,1%. Elle était toujours plus faible chez les nourrissons âgés de 1 à 4 ans. Dans les analyses ajustées, la participation parmi les utilisateurs de services de vaccination de routine était >85% dans 12 campagnes, mais la participation des non-utilisateurs était >85% pour seulement 5 campagnes. Dans 18 campagnes, la participation était plus élevée chez les utilisateurs (P < 0,01 pour 16, <0,05 pour 1 et <0,10 pour 1) que chez les non-utilisateurs. Dans 14 campagnes, les analyses ajustées ont révélé une plus faible participation chez les utilisateurs non-conformes que chez les utilisateurs conformes (P < 0,01 pour 10, <0,05 pour 2 et <0,10 pour 2).

Conclusion Un pourcentage élevé d’enfants ont participé à des campagnes. Le recours antérieur aux services de vaccination de routine et la conformité au protocole de vaccination orale ont montré une forte corrélation positive avec la participation aux campagnes.
до 96,1%. Для младенцев оно было стабильно ниже, чем для детей в возрасте 1-4 лет. Скорректированный анализ показал более низкий уровень участия среди пользователей, которые не соблюдали график, чем среди пользователей, которые соблюдали график (P < 0,01 для 8, < 0,05 для 5 и < 0,10 для 2).

**Вывод** В МДИ участвовал большой процент детей. Предварительное пользование услугами регулярной иммунизации и соблюдение графика регулярной вакцинации ИПВ показало тесную прямую связь с участием в МДИ.

**References**