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Measles and rubella vaccination coverage in Haiti, 2012: progress towards verifying and challenges to maintaining measles and rubella elimination

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Abstract

Objectives—We conducted a nationwide survey to assess measles containing vaccine (MCV) coverage among children aged 1–9 years in Haiti and identify factors associated with vaccination before and during the 2012 nationwide supplementary immunisation activities (SIA).

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Methods—Haiti was stratified into five geographic regions (Metropolitan Port-au-Prince, North, Centre, South and West), 40 clusters were randomly selected in each region, and 35 households were selected per cluster.

Results—Among the 7000 visited households, 75.8% had at least one child aged 1–9 years; of these, 5279 (99.5%) households consented to participate in the survey. Of 9883 children enrolled, 91% received MCV before and/or during the SIA; 31% received MR for the first time during the SIA, and 50.7% received two doses of MCV (one before and one during the 2012 SIA). Among the 1685 unvaccinated children during the SIA, the primary reason of non-vaccination was caregivers not being aware of the SIA (31.0%). Children aged 1–4 years had significantly lower MR SIA coverage than those aged 5–9 years (79.5% vs. 84.8%) ($P < 0.0001$). A higher proportion of children living in the West (12.3%) and Centre (11.2%) regions had never been vaccinated than in other regions (4.8–9.1%). Awareness, educational level of the mother and region were significantly associated with MR vaccination during and before the SIA ($P < 0.001$).

Conclusions—The 2012 SIA successfully increased MR coverage; however, to maintain measles and rubella elimination, coverage needs to be further increased among children aged 1–4 years and in regions with lower coverage.

Keywords

coverage survey; Haiti; measles; rubella; supplementary immunisation activity

Introduction

In 2007, member states of the Pan American Health Organization (PAHO) passed a resolution to verify and document the interruption of endemic measles and rubella virus transmission in the Americas (PAHO 2007). To verify and maintain the elimination of endemic measles and rubella, countries need to maintain high population immunity by achieving high two-dose vaccination coverage (≥95%), have a surveillance system able to detect, investigate and test all suspected measles and rubella cases and respond to detected cases (PAHO 2011). In addition, the Global Vaccine Action Plan highlights the need to achieve measles elimination in at least four WHO regions and rubella elimination in at least two WHO regions by 2015 (WHO 2013a).

Measles vaccine was introduced in Haiti in 1982 and was replaced by combination measles–rubella (MR) vaccine in 2008 after a supplementary immunisation activity (SIA) that targeted persons aged 1–19 years. One dose of measles containing vaccine (MCV) at the age of 9 months is recommended in the routine immunisation schedule. Although the last confirmed cases of measles and rubella in Haiti were reported in 2001 and 2006, respectively (De Quadros *et al.* 2003; CDC 2008), challenges for achieving and verifying measles, rubella and congenital rubella syndrome (CRS) elimination include low routine MR coverage and a weak surveillance system. Since 2009, reported administrative vaccination coverage with one dose of MCV among infants aged 12 months has ranged from 45% to 60% (WHO 2013b). In addition, a national survey conducted in 2009 found that only 9.2% [95% confidence interval (CI): 6.0–12.4] of children aged 12–23 months had received MCV by the age of 10 months (Rainey *et al.* 2012). Since the 2010 earthquake, there was a

large influx into Haiti of people from a number of countries, including some where measles and rubella are still endemic, for humanitarian aid and other support activities, putting the island nation at high risk of measles and rubella virus importation.

PAHO recommends conducting periodic 'follow-up' SIAs to provide an additional opportunity to administer MR to children missed by the routine vaccination programme and to close immunity gaps, because the efficacy of a single measles vaccine dose is 85–95% (De Quadros *et al.* 2003; WHO 2009; Castillo-Solórzano *et al.* 2011). From April to June 2012, the Haiti Ministry of Public Health and Population (French Acronym: MSPP) implemented several essential activities to verify and maintain measles, rubella and CRS elimination: (i) a nationwide MR SIA targeting children aged 9 months to 9 years regardless of previous vaccination history (oral polio vaccine, vitamin A and albendazole were also administered); (ii) active community-based and institutional searches for suspected measles, rubella and CRS cases; and (iii) a retrospective review of hospital records for CRS cases (PAHO 2012). The SIA was conducted at fixed vaccination posts (i.e. schools, markets and health facilities) and door-to-door in remote areas. Special vaccination cards were distributed to children vaccinated during the SIA.

Because of the importance of estimating population immunity for the verification of measles and rubella elimination (PAHO 2011), we implemented a national MR vaccination coverage survey following the SIA, to estimate MCV vaccination coverage and identify factors associated with MCV vaccination during and before the 2012 SIA.

Methods

Sampling and study population

Haiti is divided into 10 administrative departments, including Metropolitan Port-au-Prince. Using information from the 2011 household and population estimates provided by the Haitian Institute of Statistics and Information that were updated after the 2010 earthquake to account for population growth and movement, we combined departments to create five regions taking into account geographic proximity and size (Figure 1): (i) Metropolitan Port-au-Prince; (ii) North region (Nord, Nord-Est and Nord-Ouest departments); (iii) Centre region (Centre and Artibonite departments); (iv) South region (Sud, Nippes and Grande Anse departments); and (v) West region (Ouest department (excluding Metropolitan Port-au-Prince) and Sud-Est departments). We determined the sample size for each region (stratum), by assuming vaccination coverage of 85% (Rainey *et al.* 2011a), a desired precision of ±5%, a probability of achieving that precision of 0.95 and a design effect of 2 and estimating that 28% of households visited would have a child aged 1–4 years (Cayemittes *et al.* 2007). Expected precision for national coverage based on the same assumptions is ±2%.

The survey was based on a stratified cluster sampling design. We used the 2011 household and population estimates provided by the Haitian Institute of Statistics and Information to randomly select 40 enumeration areas (EA) in each of the five regions by probability proportional to size. In each selected EA, 35 households were selected using systematic

sampling. We included all eligible children aged 1–9 years living in the selected households in the survey.

The protocol was approved by the national ethics committee in Haiti. The protocol was reviewed by the human subjects protection offices at CDC and PAHO and judged to not be human subject research (programme evaluation activity) and therefore determined to be exempt from review by the institutional review boards at CDC and PAHO.

Data collection

The survey was conducted from 27 July to 2 September 2012 by eight survey teams, each consisting of two interviewers and one supervisor. Interviewers had previous experience conducting national surveys [Demographic and Health Surveys (DHS)], were not employed by MSPP and were not involved in the SIA. Teams were trained on vaccination coverage survey methodology, interview strategies and use of Global Positioning System (GPS) units and smartphones. Upon arrival to the cluster, interviewers used GPS units with pre-loaded maps of the selected EA to delineate the boundaries of the EA. The first household, defined as a group of people who live under one roof and eat together, was selected at one of the corners of the EA and was marked on the map. Survey teams moved in a clockwise manner selecting households based on pre-assigned, investigator-determined sampling interval (estimated total number of households in EA/35). Selected households that were excluded due to ineligibility still counted towards the sample size of 35 households per EA. That is, they were not be replaced. Households were visited at least twice if there was no one present during the first visit. Interviewers obtained oral informed consent from a child's caretaker before starting the interview. Caretaker interviews were conducted in Haitian Creole. If possible, children >5 years were interviewed at the same time as the parent because they might have received the vaccine at school.

The questionnaire consisted of a household component and a child component. The household component assessed household composition (total number of persons and total number of children aged 1–9 years living in the household), socio-economic characteristics (availability of a person with permanent employment in the household, marital status, age, educational level of the mother, and access to drinkable water) and caregiver awareness about the SIA (defined as having heard of the MR SIA conducted April–June 2012). Mother's education was classified as no education (never entered school), primary (1–8 years of school), secondary (9–12 years of school) and university (any university education). The child component of the questionnaire was completed for every child aged 1–9 years living in the household and included demographics (i.e. sex, age, date of birth), MR vaccination during the 2012 SIA (either by SIA vaccination card or by parental recall if the card was not available) and MCV vaccination before the 2012 SIA (during routine immunisation and/or previous SIAs, either by card or by recall) with documentation of dates of vaccine administration if the vaccination card was available. In addition, reasons for non-vaccination during the 2012 SIA were assessed. To ensure that the parent understood that the questions referred to MR vaccination, interviewers asked specific questions to verify that the parent was able to correctly identify the location of the vaccination post during the SIA (i.e. school, market, health institution, mobile clinic), the route of vaccine administration

(i.e. injection) and the anatomical site of MR vaccination (i.e. arm because MR was the only injectable vaccine given during the 2012 SIA).

Statistical analysis

Descriptive analyses of household demographics and reasons for not being vaccinated during the SIA are presented as proportions and means with standard deviations where appropriate. Coverage estimates and 95% confidence intervals (CI) based on Taylor series linearisation method were calculated for the country and regions, overall and stratified by age and gender, separately, taking into account the sampling design (stratum, cluster and region-specific weight) using appropriate survey procedures in SAS v.9.3. For regional estimates, we assumed the sample was self-weighted; national estimates took into account weights based on the proportion of the total population represented in each region. Rao-Scott chi-square tests were used to compare coverage between various subpopulations. Overall national MCV coverage (at least one dose, only one dose and two or more doses) was estimated for each birth cohort (2002–2011).

To assess factors associated with children aged 1–4 and 5–9 years being vaccinated before and during the 2012 SIA, one child per age group was randomly selected from each household. A multivariable logistic regression model, also accounting for the survey design, was fit including household characteristics (i.e. region, the presence of person with permanent job in household, caregiver awareness about the SIA) and maternal characteristics (i.e. marital status, education, age). Weights were adjusted to account for the selection probability within each household, and the presence of confounding and effect modification was evaluated. A P-value <0.05 was considered statistically significant.

Results

Household characteristics

Among the 7000 visited households, 5304 (75.8%) had at least one child aged 1–9 years; of these, 5279 (99.5%) households consented to participate in the survey. The distribution of participating households was as follows: 953 (18.1%) in Metropolitan Port-au-Prince, 1056 (20.0%) in the North region, 1088 (20.6%) in the Centre region, 1088 (20.6%) in the South region and 1094 (20.7%) in the West region. Mean household size was 6.2 ± 2.4 persons, and the mean number of children aged 1–9 years residing in each household was 1.9 ± 1.0. Overall, 2961 (56.1%) households included a resident who was regularly employed, and 4872 (92.3%) lacked access to treated drinking water in the house; 31.7% of households without access had to walk for >30 min to obtain treated drinking water. Among participating mothers, 65% were unmarried, 68.3% had no or primary education, and 60.4% were >30 years of age.

Vaccination coverage during the 2012 SIA

Overall, 4280 (80.0%) caregivers said that they were aware of the 2012 SIA. Awareness varied by region with the lowest awareness reported in the Centre (67.7%) and North (75.7%) regions and the highest in the South (89.5%), Metropolitan Port-au-Prince (86.0%) and West (86.8%) regions. Among households with caretakers who were aware of the SIA,

the principal reported sources of information about the SIA were town criers (43.1%) and healthcare professionals (27.8%). Radio was an important source of information in the Metropolitan Port-au-Prince region (24.3%).

Among the 9883 children who participated in the survey, 4849 (48.9%) were aged 1–4 years and 4752 (48.0%) were male. Although 89.3% of children vaccinated during the SIA reported receiving a card after vaccination, card retention was lower as not everyone could document vaccination during the SIA by card. Overall, 82.2% (95% CI: 80.2–84.1) of children received MR during the 2012 SIA (43.3% by card documentation and 38.9% by recall). MR coverage during the SIA ranged from 77.8% in the West region to 87.7% in the South region (Table 1). National vaccination coverage varied by age group with children aged 1–4 years (79.5%, 95% CI: 77.4–81.5; 46.6% by card and 32.9% by recall) having lower coverage than those aged 5–9 years (84.8%, 95% CI: 82.6–86.8; 39.9% by card and 45% by recall) ($P < 0.0001$). The difference in coverage by age group was particularly pronounced in the Metropolitan Port-au-Prince (74.3% *vs.* 85.2%, $P < 0.001$), South (84.5% *vs.* 91.2%, $P < 0.001$) and West (74.6% *vs.* 80.7%, $P < 0.01$) regions. MR coverage did not differ by sex of the child (Table 1).

Among the 5279 households with an eligible child, 4120 (78%) had all eligible children vaccinated. There were 765 (14.5%) households with no vaccinated children; 41% of these households had more than one child. In 394 (7.5%) households where some but not all children were vaccinated, there were 491 (44%) unvaccinated children, of which 61% were 1–4 years old.

A total of 1686 children were not vaccinated during the SIA. Of the 1685 children who provided reasons for non-vaccination during the SIA, the primary reasons were related to caregivers not being aware of the SIA (31.0%), the child being absent from home or school when vaccinators came (14.4%), or caregivers not knowing the place and time of the SIA (8.2%) (Table 2). Almost 8% of children were not vaccinated during the SIA because they had previously received MR; a higher proportion of these were in the Metropolitan Port-au-Prince region (13.9%) compared with other regions (3.2–12.9%). Few caregivers reported lack of vaccine availability (5%); however, this was more frequently reported in the West region (9.4%) than in other regions (1.6–5.0%).

Vaccination coverage before the 2012 SIA

A total of 5959 (59.4%; 95% CI: 56.5–62.3) children aged 1–9 years had received MCV before the 2012 SIA (29.1% documented by card and 30.3% by recall). Coverage varied significantly by region, with highest pre-SIA coverage in the South region (69.8%, 95% CI: 64.0– 75.6) followed by the North (64%, 95% CI: 58.6–69.4), Metropolitan Port-au-Prince (59%, 95% CI: 53.4–64.5), West (56.4%, 95% CI: 49.2–63.5) and Centre regions (52.1%, 95% CI: 45.3–59.0). MCV coverage before the SIA was higher among children aged 5–9 years (61.0%, 95% CI: 57.4–64.6; 24.6% by card and 36.4% by recall) than among those aged 1–4 years (57.7%, 95% CI: 54.9–60.5; 33.7% by card and 24.0% by recall) ($P < 0.05$). MCV had been received before the 2012 SIA by all 1- to 9-year-old children in 49.8% of households, some 1- to 9-year-old children in 18.5% of households and no 1- to 9-year-old children in 31.6% of households.

Overall MCV coverage

Overall, 91% (95% CI: 89.4–92.3) of children aged 1–9 years had received at least one MCV dose before the 2012 SIA, during the SIA, or both, with variability in vaccination coverage by region and age group. A higher proportion of 1- to 4-year-olds never received MCV compared with those aged 5–9 years (10.6% *vs.* 7.6%, $P < 0.001$). A higher proportion of children living in the West (12.3%) and Centre (11.2%) regions had never been vaccinated than in other regions (4.8–9.1%). Overall, 31.5% of children aged 1–9 years received MR for the first time during the 2012 SIA, half (50.7%) received at least two MCV doses (a dose during the SIA and at least one dose before the SIA), and 8.7% had been vaccinated only before the 2012 SIA.

Measles containing vaccine coverage and number of doses received varied by year of birth with lowest coverage among children born in 2011. Overall, 55.4% of children born from 2002 to 2008 had received at least two MCV doses, while only 27.2% of children born in 2011 received two MCV doses (Table 3).

Factors associated with vaccination during the 2012 SIA and before the SIA

As shown in Table 4, factors associated with receiving MCV differed depending on the age group. For factors associated with vaccination during the SIA, in both age groups, a child living in the North, Centre and South regions was more likely to be vaccinated during the SIA than a child living in Metropolitan Port-au-Prince region (Table 4). A child aged 1–4 years was less likely to be vaccinated during the SIA if a person in the household had a permanent job [OR=0.75 (95% CI: 0.58–0.98)] compared with a child in a household that did not include a person with a permanent job. Additionally, children aged 1–4 years whose mother had a university education were 55% less likely to be vaccinated during the SIA [OR = 0.45 (95% CI: 0.25–0.83)] than those whose mother did not have any education. All children whose caregiver was aware of the SIA were significantly more likely to be vaccinated.

In comparison, children aged 1–4 years whose mother had primary or higher education and children aged 5–9 years whose mother had secondary and higher education were two to three times more likely to have been vaccinated before the SIA than children whose mother was not educated (Table 4). Children without a mother were less likely to be vaccinated before the SIA.

Discussion

We found that overall, 91% of children aged 1–9 years surveyed in Haiti after the 2012 SIA had received at least one MCV dose; 82.2% were vaccinated during the SIA, and 59.4% were vaccinated before the SIA. Our findings provide evidence of a significant increase in MR vaccination coverage since 2010. A survey completed following an SIA conducted immediately after the 2010 earthquake in Metropolitan Port-au-Prince, West and Artibonite departments found that 65% of children aged 9 months to 5 years had received at least one MR dose (MSPP *et al.* 2011). Based on DHS findings, MCV vaccination (documented by card and recall) among children aged 12–23 months increased from 58% (95% CI: 53–62) in

2005 to 65% (95% CI: 61–69) in the DHS completed in 2012 prior to the SIA (Cayemittes *et al.* 2007; IHE & Measure DHS 2012).

What is of significance is that almost a third of the surveyed children received their first MR dose, and half of the children were protected with a second MCV dose during the 2012 SIA. This highlights the need for these 'follow-up' vaccination campaigns in reaching children who were missed during the routine immunisation and in providing an opportunity to give a second MCV dose to close immunity gaps. Very few studies have assessed the contribution of SIAs in getting unreached children. The majority of studies reported that 10–15% of children received their first dose of MCV during an SIA (Vijayaraghavan *et al.* 2007; Oliphant *et al.* 2010; Goodson *et al.* 2012), which is lower than our findings. This highlights the success of the 2012 SIA in Haiti in reaching children who were not vaccinated previously.

However, despite these achievements, the low reported coverage among children aged 1–4 years requires particular attention. In 2000–2001, a measles outbreak precipitated by an international importation disproportionately affected children <4 years of age in Haiti, particularly in Metropolitan Port-au-Prince, because of low vaccination coverage in this age group (De Quadros *et al.* 2003). Furthermore, large percentages of unvaccinated children in Metropolitan Port-au-Prince, West and Centre regions, which are densely populated, put those regions at the risk of sustained measles outbreaks in the event of a virus importation. Targeted vaccination activities are needed in these areas to ensure that Haiti remains free of measles and rubella and to prevent virus importation to other countries in the Americas.

The actual proportion of children protected against measles might be lower than the estimated coverage suggests. In Haiti, MR vaccine is recommended at age 9 months when the effectiveness of a single dose of measles vaccine is estimated to be 85% versus 95% if received after 12 months of age (Tulchinsky *et al.* 1993; Orenstein *et al.* 2000; WHO 2009; Uzinanin & Zimmerman 2011). Administering a second measles vaccine dose provides immunity to almost 99% of recipients (Stetler *et al.* 1986; Christenson & Böttiger 1991; WHO 2009). In Haiti, half of the children received two doses of vaccine and 40% received one dose (estimated 85–95% immunity); hence, the actual proportion of children aged 1–9 years protected against measles is estimated to be 85–88%. In contrast to measles vaccine, one dose of rubella vaccine is 95% effective (WHO 2011). To address the potential for vaccine failure among children vaccinated at the age of 9 months, one of the activities listed in the Haiti 2011–2015 comprehensive multiyear plan for immunisation is to consider adding a second MR [or measles–mumps–rubella (MMR)] dose to the routine vaccination schedule and continuing implementation of 'follow-up' MR campaigns.

To our knowledge, this study is the first to assess the factors associated with receiving vaccines during routine immunisation and vaccination campaigns. Our finding is that children with mothers who had secondary and higher education were more likely to be vaccinated before the SIA (mainly routine immunisation) than children with mothers who had no education are consistent with reports from other countries (Torun & Bakirci 2006; Rainey *et al.* 2011b; Bosch-Capblanch *et al.* 2012; Park *et al.* 2012). However, during the SIA, children <4 years old were less likely to be vaccinated if the mother was highly

educated. This finding could be either due to a mother's false belief that a previously vaccinated child did not need to be vaccinated again or unavailability of the mother to take the child for vaccination during the campaign due to work commitments. Availability of a person with a permanent job in the household also led to lower likelihood of children aged 1–4 years to be vaccinated during the SIA, indicating the potential lack of a caregiver during the day to take the child for vaccination. Hence, vaccination sessions might be needed later in the afternoon to accommodate the schedule of working mothers. In contrast, SIA participation for children aged 5–9 years, who were vaccinated predominantly in schools, was not associated with the mother's educational level.

Our study reinforces the importance of complementing administrative coverage estimates with coverage surveys to obtain a more accurate estimate of coverage, particularly when the target population size is uncertain (Dietz *et al.* 2004). While our survey indicates that 82.2% of children aged 1–9 years received MR vaccine during the 2012 SIA, the administrative coverage estimate (calculated by dividing the number of doses of MR vaccine given during the SIA by the estimated number of the target population) was 117%. Inconsistencies between administrative and survey coverage estimates were also documented during the 2007–2008 SIA in Haiti (Lacapère *et al.* 2011; Rainey *et al.* 2011a). Inaccuracy of administrative coverage estimates is also encountered in other resource poor countries (Murray *et al.* 2003; Lim *et al.* 2008). In Haiti, the most recent census was conducted in 2003 and since then, particularly after the 2010 earthquake, changes in the distribution and size of the population have occurred. Another contributing factor to overestimating administrative coverage could be vaccinating children outside the target age group during SIAs.

This survey has several limitations. First, we had to assume that the samples within each region were self-weighting due to not updating the household line lists for selected EA. However, the sampling frame was based on recently updated data, we did improve representativeness using a pre-defined skip interval, and we avoided selection bias by not replacing households. Second, as is often the case with coverage surveys, vaccination status relied on caregiver recall when a card was not available. However, the survey was conducted one to 2 months after the completion of the SIA, which would reduce recall bias for the campaign, and almost all the parents could correctly identify the vaccination site, location and route of MR administration. For previous doses of MR vaccine, recall might be a limitation, especially for older children. The impact of this limitation means that the non-sampling error could be much greater than the reported sampling error.

While elimination of endemic measles and rubella has most likely been achieved in Haiti, maintaining elimination is challenging particularly with the influx of international workers after the 2010 earthquake and wide circulation of the measles and rubella viruses globally.

After the gains in MR coverage achieved through the 2012 SIA, remaining priority activities include improving routine vaccination coverage to ensure protection of children <12 months of age, introduction of a second MCV dose in the routine childhood vaccination schedule, reinforcing communication messages about vaccination sessions and need to vaccinate children and performing more frequent and systematic mobile outreach sessions to ensure

that children aged <4 years, those not attending schools, and those living in regions with the lowest coverage are reached and vaccinated. As recommended by PAHO, SIAs will be needed every 3–4 years to maintain elimination and ensure high population immunity if routine immunisation coverage remains low.

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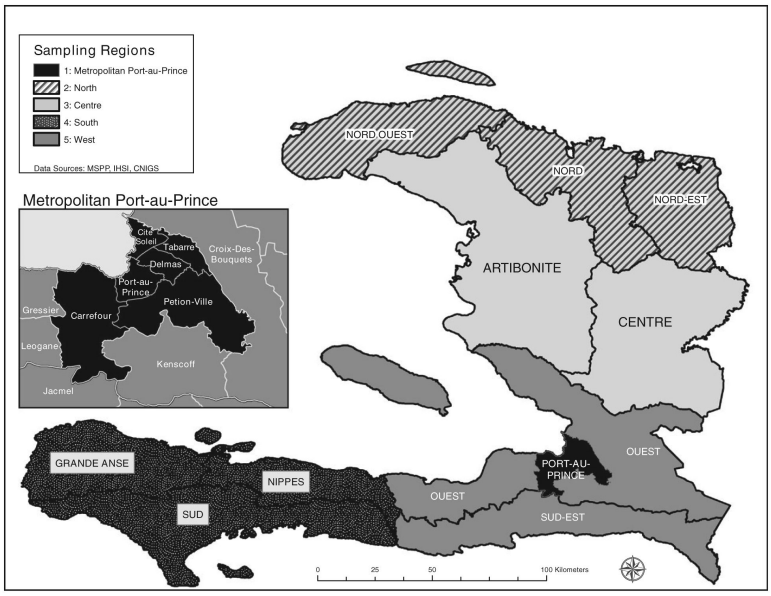

Figure 1.

Regions sampled in the vaccination coverage survey – Haiti, 2012. Regions were selected as follows: Metropolitan Port-au-Prince region includes Port-au-Prince and the surrounding urban areas (Cite-Soleil, Tabarre, Delmas, Petion-ville and Carrefour); North region includes the Nord, Nord-Est and Nord-Ouest departments; Centre region includes the Centre and Artibonite departments; South region includes the Sud, Nippes and Grande Anse departments; and West region includes the Ouest and Sud-Est departments.

Table 1

Estimates of measles and rubella vaccination coverage by region during the April–June 2012 nationwide supplementary immunisation activities (SIA)* – Haiti

Region	National *N* = 9883 % (95% CI)	Metropolitan Port-au-Prince *N* = 1534 % (95% CI)	North *N* = 2099 % (95% CI)	Centre *N* = 2142 % (95% CI)	South *N* = 2072 % (95% CI)	West *N* = 2036 % (95% CI)
Overall	82.2 (80.2–84.1)	79.7 (76.3–83.0)	86.2 (81.9–89.5)	80.5 (76.6–83.9)	87.7 (84.8–91.1)	77.8 (71.4–84.2)
Age of child						
1–4 years	79.5 (77.4–81.5)†	74.3 (69.8–78.8)	84.4 (80.3–87.7)	79.2 (74.9–83.5)	84.5 (80.9–87.5)	74.6 (68.3–80.9)
5–9 years	84.8 (82.6–86.8)†	85.2 (81.7–88.2)	87.8 (82.8–91.5)	81.8 (77.8–85.1)	91.2 (88.0–93.6)	80.7 (72.7–86.8)
Sex of child						
Male	81.7 (79.3–83.8)	80.0 (76.1–83.9)	85.2 (79.7–89.4)	79.6 (75.1–84.2)	87.5 (84.2–90.2)	77.3 (70.2–84.3)
Female	82.7 (80.7–84.5)	79.3 (75.5–83.2)	87.1 (83.3–90.1)	81.3 (77.7–84.5)	88.0 (84.7–90.6)	78.3 (71.8–84.7)
Total population	9 064 730	1 910 035	1 905 399	2 143 148	1 425 445	1 680 703
Total target population (1–9 years old)‡	2 447 477	515 709	514 458	578 650	384 870	453 790

*Vaccination status during the SIA was assessed from special cards distributed to document vaccine doses administered during the SIA, if available, or by parental or child recall; CI, confidence interval.

†Design effect (DE) and estimated intraclass correlations (ICC) = (DE – 1)/(*b* – 1) where *b* is the average number of responses per cluster, for age group: 1–4 years : DE = 3.4 and ICC = 0.105; and age group 5–9 years : DE = 4.8 and ICC = 0.157.

‡Target population (children aged 1–9 years old) is estimated as 27% of the total population as recommended by the immunisation programme in Haiti. The total population estimates were obtained from the 2011 household, and population estimates provided by the Haitian Institute of Statistics and Information.

Table 2

Reported primary reason for child not being vaccinated during the April–June 2012 nationwide supplementary immunisation activities (SIA), by region – Haiti

Region	Total *N* = 1685 *n* (%)	Metropolitan Port-au-Prince *N* = 294 *n* (%)	North *N* = 283 *n* (%)	Centre *N* = 411 *n* (%)	South *N* = 248 *n* (%)	West *N* = 449 *n* (%)
Reasons for non-vaccination*						
Caregiver did not hear about SIA	523 (31.0)	30 (10.2)	122 (43.1)	151 (36.7)	51 (20.6)	169 (37.6)
Child/parents were absent from school/home when vaccinators came	243 (14.4)	36 (12.2)	51 (18.0)	36 (8.8)	70 (28.2)	50 (11.1)
Did not know when or where to go	138 (8.2)	40 (13.6)	14 (4.9)	46 (11.2)	10 (4.0)	28 (6.2)
Child previously received measles–rubella vaccine (MR)	133 (7.9)	41 (13.9)	18 (6.4)	13 (3.2)	32 (12.9)	29 (6.5)
Caregiver was busy/had no time	133 (7.9)	26 (8.8)	13 (4.6)	36 (8.8)	15 (6.0)	43 (9.6)
Child was sick/had fever	87 (5.2)	21 (7.1)	9 (3.2)	23 (5.6)	15 (6.0)	19 (4.2)
Vaccines were not available	85 (5.0)	8 (2.7)	13 (4.6)	18 (4.4)	4 (1.6)	42 (9.4)
Vaccinator refused to vaccinate	58 (3.4)	8 (2.7)	13 (4.6)	11 (2.7)	13 (5.2)	13 (2.9)
Did not think vaccination was important/necessary	35 (2.1)	5 (1.7)	2 (0.7)	22 (5.4)	1 (0.4)	5 (1.1)
Does not think vaccines are safe/vaccines can harm the child	33 (2.0)	12 (4.1)	3 (1.1)	4 (1.0)	11 (4.4)	3 (0.7)
Caregiver forgot to go	22 (1.3)	5 (1.7)	3 (1.1)	8 (1.9)	4 (1.6)	2 (0.4)
Caregiver took the child but vaccinator was not at the vaccination site	22 (1.3)	2 (0.7)	0 (0.0)	11 (2.7)	0 (0.0)	9 (2.0)
Child not old enough to receive MR	20 (1.2)	3 (1.0)	4 (1.4)	2 (0.5)	10 (4.0)	1 (0.2)
Planning to vaccinate child later	18 (1.1)	10 (3.4)	3 (1.1)	1 (0.2)	3 (1.2)	1 (0.2)
Other reasons	135 (8.0)	47 (16.0)	15 (5.3)	29 (7.1)	9 (3.6)	35 (7.8)

*Among caregivers of children who were reported not to be vaccinated, respondents were allowed to give only one primary reason.

Table 3

Measles containing vaccine (MCV) coverage by birth cohort and number of doses received – Haiti, 2012

Year of birth	*N* *	Received at least one MCV dose % (95% CI)	Received only one MCV dose % (95% CI)	Received at least two MCV doses % (95% CI)
2002	203	90.8 (85.7–94.2)	30.5 (23.3–37.6)	60.3 (52.0–68.6)
2003	933	93.1 (91.2–94.6)	41.9 (37.8–46.0)	51.2 (46.8–55.6)
2004	1030	92.9 (90.5–94.8)	41.8 (37.8–45.9)	51.1 (46.4–55.8)
2005	1057	92.0 (89.6–93.9)	39.9 (36.1–43.8)	52.1 (47.6–56.5)
2006	1048	92.7 (90.4–94.5)	36.0 (32.2–39.7)	56.7 (52.4–61.1)
2007	1157	91.7 (89.4–93.6)	34.5 (31.6–37.5)	57.2 (53.5–60.9)
2008	1208	92.1 (89.8–93.9)	35.8 (32.8–38.8)	56.3 (52.7–59.9)
2009	1261	89.2 (86.5–91.4)	39.8 (36.6–43.0)	49.4 (45.5–53.3)
2010	1265	89.4 (87.0–91.5)	43.7 (40.2–47.2)	45.7 (41.8–49.7)
2011	718	83.5 (80.2–86.4)	56.4 (52.4–60.3)	27.2 (23.1–31.2)
Total	9880	90.9 (89.4–92.4)	40.2 (38.1–42.3)	50.7 (47.8–53.6)

* Three children had missing years of birth.

Table 4

Factors associated with vaccination during and before the April–June 2012 nationwide supplementary immunisation activities among children aged 1–4 and 5–9 years* – Haiti

	1–4 years (*N* = 3704)					5–9 years (*N* = 3582)				
HH Characteristics	***n***	**Child vaccinated during 2012 SIA OR (95% CI)**	***P*-value**	**Child vaccinated before 2012 SIA OR (95% CI)**	***P*-value**	***n***	**Child vaccinated during 2012 SIA OR (95% CI)**	***P*-value**	**Child vaccinated before 2012 SIA OR (95% CI)**	***P*-value**
Region										
Metro Port-au-Prince (referent)	640	1.00 (−)	<0.0001	1.00 (−)	0.0002	590	1.00 (−)	0.0005	1.00 (−)	0.005
North	731	2.51 (1.64–3.85)		1.51 (1.03–2.21)		749	2.51 (1.51–4.18)		1.39 (0.96–2.02)	
Centre	761	1.96 (1.26–3.04)		1.11 (0.76–1.62)		782	1.80 (1.12–2.89)		0.74 (0.48–1.14)	
South	814	1.76 (1.19–2.62)		2.01 (1.40–2.89)		703	1.90 (1.17–3.11)		1.68 (1.03–2.74)	
West	758	1.00 (0.65–1.53)		1.05 (0.74–1.48)		758	0.93 (0.58–1.51)		0.95 (0.58–1.56)	
Person with permanent job in household										
No (referent)	1595	1.00 (−)	0.03	1.00 (−)	0.8	1540	1.00 (−)	0.1	1.00 (−)	0.2
Yes	2108	0.75 (0.58–0.98)		0.98 (0.81–1.18)		2040	0.81 (0.60–1.09)		1.15 (0.92–1.44)	
Married mother										
No (referent)	2489	1.00 (−)	0.6	1.00 (−)	<0.0001	2218	1.00 (−)	0.9	1.00 (−)	<0.0001
Yes	1166	1.10 (0.87–1.39)		1.11 (0.92–1.33)		1295	1.01 (0.79–1.29)		1.22 (1.01–1.47)	
No mother	49	0.80 (0.38–1.71)		0.14 (0.06–0.32)		69	0.89 (0.46–1.72)		0.24 (0.13–0.44)	
Education level of mother										
None (referent)	898	1.00 (−)	0.0001	1.00 (−)	<0.0001	1064	1.00 (−)	<0.0001	1.00 (−)	0.02
Primary	1600	1.10 (0.87–1.40)		1.33 (1.09–1.63)		1539	1.31 (1.00–1.72)		1.03 (0.84–1.27)	
Secondary	1097	1.30 (0.97–1.73)		1.81 (1.41–2.32)		897	2.00 (1.35–2.96)		1.37 (1.04–1.80)	
University	95	0.45 (0.25–0.83)		3.54 (2.00–6.27)		66	0.48 (0.22–1.08)		2.16 (1.14–4.07)	
Age of mother										
<20 years (referent)	91	1.00 (−)	0.2	1.00 (−)	0.09	11	1.00 (−)	0.8	1.00 (−)	0.7
20–30 years	1601	1.67 (0.95–2.94)		1.60 (1.05–2.44)		1067	1.40 (0.20–9.56)		1.55 (0.49–4.95)	
>30 years	2002	1.71 (0.93–3.14)		1.59 (1.03–2.45)		2493	1.33 (0.19–9.12)		1.51 (0.46–4.96)	
Aware about 2012 SIA										
No (referent)	671	1.00 (−)	<0.0001	1.00 (−)	0.1	685	1.00 (−)	<0.0001	1.00 (−)	0.005
Yes	3033	8.04 (6.21–10.4)		1.17 (0.93–1.47)		2897	8.78 (6.47–11.91)		1.36 (1.10–1.69)	

* One child per household in each age group was selected. Weights accounted for selection probability within household. Each column represents a single multivariable model. We adjusted for all variables listed in the table.