Use of rapid needs assessment as a tool to identify vaccination delays in Guatemala and Peru

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\textbf{A B S T R A C T}

Objective: To explore the use of rapid needs assessment (RNA) surveys to determine the prevalence and factors contributing to delays in vaccination of children in two low middle-income countries (LMIC).

Methods: Data from two RNA surveys performed as part of program improvement evaluations in Guatemala and Peru were used for this analysis. The primary endpoint was the timeliness of immunization with delay defined as administration of vaccines beyond 28 days from recommended age for DTwp–HepB–Hib (Penta) and measles–mumps–rubella (MMR) vaccines, as well as past age-restrictions for rotavirus vaccine. Independent risk factors analyzed included child’s gender, birth year, number of children in household, maternal age, maternal education, and food insecurity.

Results: Vaccine information was available from 811 children from 838 households surveyed. High rate of immunization delays was observed, with 75.6\% of children in Guatemala and 57.8\% of children in Peru being delayed for the third dose of Penta primary series. Factors associated with delayed vacation in Guatemala included advanced maternal age and increased number of children in household. In Peru, significant associations were birth year before 2009, lower maternal education level, and increased number of children in household.

Conclusions: RNA is a fast and effective method to identify timely vaccine coverage and derive a hypothesis of factors possibly associated with vaccination delay.

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1. Introduction

Immunization has proven to be the most effective way to prevent childhood infectious diseases at the individual and population levels when adminstered before the period of risk. Delays in vaccination not only expose children to infections at the time they are most vulnerable, but also place them at risk for never completing their immunization schedule [1,2]. Worldwide, the Global Vaccine Action Plan (GVAP) goal – endorsed by the 194 Member States of the World Health Assembly in May 2012 – seeks to make the benefits of immunizations equitably extended to all people “reaching every community” and engaging underserved and marginalized groups by 2020. The World Health Organization (WHO) has issued immunization guidelines that address the recommended number of doses that can be adapted to each individual country’s immunization strategy [3].

Latin America is a pioneer and model region for immunizations that has resulted in the elimination of measles and congenital rubella [4]. Most countries report 90\% or more national coverage of immunization in young children; however timeliness of vaccination remains a challenge [4,5]. This trend holds true globally, as studies have shown difficulty in reaching the last 10–15\% of unimmunized children in most of low and middle-income countries (LMIC) due to multiple factors associated with immunization delays [6–14]. There is no standardized method to evaluate immunization delay; past studies have utilized a wide range of statistical methods including case control studies, retrospective studies, and cross-sectional survey studies [15]. To our knowledge, no study has utilized a rapid needs assessment (RNA) to evaluate vaccine coverage and factors that could be contributing to immunization delay.

RNA is a fast and reliable tool that can be utilized to quickly develop an initial understanding of a community health status...
and develop hypotheses for future studies and interventions [16]. We took advantage of data available from two RNAs coordinated by the Center for Global Health (CGH) of the Colorado School of Public Health to evaluate maternal and child health programs in Guatemala and Peru to estimate the timeliness of immunization and identify possible factors associated with delays in vaccination.

2. Methods

2.1. Population

Rural communities in the southwest departments of Quetzaltenango and San Marcos in Guatemala, as well as rural and urban communities in the Loreto Region of Peru, were surveyed as part of two RNAs conducted by the CGH and aimed at evaluating maternal-child health needs and program outcomes. Both surveys were considered to be program evaluation rather than human subject research by the Colorado Multiple Institutional Review Board, and therefore informed consent was not required. Interviews were conducted with mothers of children less than 5 years of age who resided in the target communities. In Guatemala, the RNA was designed to evaluate the impact of “Mis Mejores Familias” (MMF), a local health education program intended to improve maternal and child well-being [17]. Preliminary results on vaccine coverage by age in the MMF vs. non-MMF children in Guatemala showed no significant differences, allowing us to use both populations for this study. The target communities in Peru were part of the area of influence of Centura Health’s Global Health Initiative on-going maternal-child health programs [18]. Guatemala offers free access to vaccines through the Ministry of Health [19]. Peru has a decentralized health care system, where the Ministry of Health accounts for 60% of coverage, and a combination of private and public insurance accounts for the remaining [20]. Regions targeted by this study in both Guatemala and Peru are considered to be underserved in healthcare resources.

2.2. Design and data abstraction

The RNA surveys consisted of a 90-item questionnaire administered by students and community health workers under the coordination of the CGH in October 2011 in Guatemala and July 2012 in Peru. Families were identified using a cluster sampling technique following the Lot Quality Assurance Sampling (LQAS) method adapted from the WHO [21,22,23]. Thirty clusters of seven households were included in Guatemala using the house of a MMF program participant as the index for each cluster. In Peru, thirty clusters of seven households were selected at random using health districts maps from both urban and rural zones, for a total of sixty clusters. A sample size of 210 households for each area was chosen as per LQAS, plus 30% additional households to account for missing data. For both countries, random selection was done by proceeding to the third house on the left from the previous participant whenever possible. There were no recorded instances of participation refusal; however when a family was absent from the home the surveyors proceeded to an additional house to the left. Mothers were interviewed in privacy of their homes with no other members of the household present whenever possible. Immunization information was obtained from the child’s vaccination card. If a vaccination card was not available, the survey was completed leaving the vaccine information blank. For this analysis, children in whom vaccination card information was absent or who were younger than 6 weeks, and therefore ineligible for the targeted vaccines, were excluded.

Data from the Guatemala RNA was entered using Teleform® software (Cardiff, USA), and for the Peru RNA using RedCap® (Vanderbilt University, TN, USA). Both data sets were de-identified at export and no personal information was available to the investigators for this analysis.

2.3. Definition of vaccination delay

The primary endpoint of this analysis was the timeliness of immunization categorized as delayed or not delayed for each
vaccine. The interval for immunization was calculated comparing the date of each vaccination administration with the date of birth. In accordance with previous studies, vaccination delay was defined as receipt of vaccine greater than 28 days after recommended age according to the recommended national immunization schedule in each country for all doses of Penta and the MMR dose [24]. Guatemala and Peru immunization programs follow a 2, 4 and 6 month primary schedule providing Penta and polio; in addition to rotavirus and pneumococcal vaccines at 2 and 4 months. The rotavirus vaccine was introduced in Peru in January 2009 and in Guatemala in February 2010 and age-restriction windows were in place according to the manufacturer’s package insert that the first dose be administered before 15 weeks of age, and the last dose by 32 weeks. Therefore, for rotavirus vaccine, a delay was defined as the first dose given past 15 weeks of age, and the last dose administered later than age 32 weeks. Because of the timing of the RNA relative to introduction of the rotavirus vaccine, a larger sample of children eligible for rotavirus vaccination was available in Peru. The first MMR is recommended at 12 months of age in both countries since measles and rubella have been nearly eliminated from the region.

2.4. Variables related to vaccination delay

Independent variables included were gender of child, birth year cohort, number of children in household, maternal age, maternal education, and food insecurity. Maternal education level was classified as primary if mothers had completed up to the 6th grade, secondary if completed through 12th grade, and advanced if a post high school degree was obtained. A “none” category was used for

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**Fig. 1.** Cumulative distribution of 3 primary doses of Penta (DTwP-HBV-Hib) vaccine in children <5 years of age in Guatemala and Peru.
mothers who had never completed any formal schooling. Food insecurity was measured using 4 of the survey questions adapted from the Household Food Insecurity Access Scale (USAID 1987, Washington DC, USA) that assessed on a 1–3 Likert measure the status of food availability in each mother’s family. These questions were scored and 0–4 classified as food secure and 5–12 as food insecure.

2.5. Statistical analysis

Proportions were used to describe the basic characteristics of the populations and to estimate vaccination status. Proportions for the primary outcome (delayed or not) for all Penta doses and MMR were all >10%. Therefore a log-binomial regression was used to test associations between variables and the dependent factors and to generate relative risks [25]. Due to the limited number of children receiving rotavirus in Guatemala, it was not modeled. All regression models were adjusted for the random effects of community within each country; therefore, community was not tested independently with any primary outcome. Due to the limited number of children available for various demographic characteristics and primary outcomes, only univariate associations were performed, as a multivariate analysis would not have provided a stable estimate. All analyses were conducted using SAS (version 9.3, SAS Institute, Cary, NC, USA).

3. Results

RNA surveys were conducted in Guatemala between September 30 and October 3, 2011 and in Peru from July 1 to July 2012. Among the eight hundred and thirty households surveyed: 283 (34.1%) were from Guatemala and 547 (65.9%) from Peru. There were 1057 children <5 years in those households; 391 (36.9%) from Guatemala and 670 (63.1%) from Peru. Of these children, 246 (29.6%) without a vaccination card were excluded from the analysis. Therefore, 811 children were included; 313 (38.6%) from Guatemala and 498 (61.4%) from Peru.

Table 1 provides baseline demographic characteristics of children and mothers. The mean age of children in Guatemala was 3.0 years, with 161 (51.6%) children having been born before 2009. The mean number of children in household was 3.8 with mean maternal age 28.0 in Guatemala. Only 90 (29.4%) Guatemalan mothers had completed education beyond primary school, and 217 (69.3%) mothers reported moderate to severe food insecurity. In Peru, the mean age of children was 2.3 years and mean maternal age was 28.4 years. The mean number of children in household was 3.3 and 117 (23.8%) children in Peru were born before the year 2009. Completion of secondary or advanced education was reported in 355 (72.0%) mothers in Peru and food insecurity was reported in 200 (40.2%) households.

3.1. Immunization status of children

Fig. 1 shows the cumulative proportion of children who received on-time vaccination for the Penta vaccine by dose. Approximately half of infants in Guatemala (n = 163, 54.3%) and two thirds in Peru (n = 316, 66.8%) completed their first dose of Penta vaccine on time. There was a significant increasing trend in the proportion of children delayed for each subsequent dose of Penta vaccine in both Guatemala and Peru (p < 0.0001). As shown in Fig. 2, the cumulative proportion of children with delayed immunization >28 days from recommended age increased from 45.7% of Penta 1 to 77.4% of Penta 3 in Guatemala and from 33.2% of Penta 1 to 59.9% of Penta 3 in Peru. MMR vaccination was administered on time in 58.2% of children in Guatemala and 44.3% of children in Peru.

For rotavirus, of those children eligible for rotavirus vaccine, 23 (41.1%) infants in Guatemala and 48 (14.2%) infants in Peru received their first dose after the recommended age of 15 weeks; and 8 (21.1%) and 14 (5.4%) infants, respectively, received the last dose of vaccine past 32 weeks of age.

3.2. Variables related to vaccination delay in Guatemala and Peru

Table 2 shows the factors evaluated for association with vaccination delay. In Guatemala, there were no significant associations for late administration of the Penta series. Late administration of MMR vaccine was associated with advanced maternal age (RR = 1.13, p < 0.05), and male gender was protective for delay in MMR vaccination (RR = 0.70, p < 0.05). For each additional child in the household above the mean of 3.8 children, there was a 7% increased risk of late administration of MMR vaccine (RR = 1.07, p < 0.05).

In Peru, birth year cohort before 2009 was significantly associated with late administration of all Penta vaccines and MMR (p < 0.001). Lower maternal education level was associated with late administration of Penta 1 (RR 1.39, p < 0.05) and Penta 3 (RR 1.25, p < 0.05). Increased number of children in the household beyond the mean of 3.3 was associated with late administration of Penta 2 (RR 1.06, p < 0.05), Penta 3 (RR 1.05, p < 0.05) and MMR (RR 1.07, p < 0.05). Food insecurity was also observed to be linked to on-time receipt of Penta 3 (RR = 0.83, p < 0.05).

4. Discussion

Our findings demonstrate the feasibility of using RNA surveys (LQAS or cluster-sample based) to detect high rate of delays in childhood immunizations in both Guatemala and Peru. The data from RNA surveys in different areas of Latin America can be used in the future as a system to monitor not only vaccine coverage and completeness, but also possible factors that influence failures and delays to vaccine children. Although the traditional measures of childhood vaccination coverage (e.g. Penta 3 by 12 months of age, or MMR by 24 months) provide information on the proportion of children up-to-date based on recommended schedules, they do not reveal the degree of immunization delays [26]. Therefore, an age-appropriate vaccination measure is a better indicator of vaccination status in a specific population that could allow immunization programs to reach unimmunized children [27].

Other methods used to evaluate vaccination timely and the risk factors for delays include the use of active surveillance programs [24]; prospective studies [28], and case-control studies [29]. However, most of these methods are personnel and cost intensive or require good immunization registry databases that are linked to demographic and health care information. Adapted from the
Table 2
Unadjusted associations with late administration (>28 days) of vaccines in (a) Guatemala and (b) Peru.

<table>
<thead>
<tr>
<th>Country and variable</th>
<th>Level</th>
<th>Penta, dose 1 Relative risk, 95% CI</th>
<th>Penta, dose 2 Relative risk, 95% CI</th>
<th>Penta, dose 3 Relative risk, 95% CI</th>
<th>SPR (MMR) Relative risk, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(A) Guatemala</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Gender of child</td>
<td>Male</td>
<td>0.91 (0.72, 1.16)</td>
<td>0.98 (0.84, 1.15)</td>
<td>0.99 (0.88, 1.12)</td>
<td>0.70 (0.52, 0.96)</td>
</tr>
<tr>
<td></td>
<td>Female (ref.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of children in HH</td>
<td>(per additional 1 child)</td>
<td>1.01 (0.96, 1.06)</td>
<td>1.00 (0.97, 1.04)</td>
<td>0.97 (0.94, 1.00)</td>
<td>1.07 (1.02, 1.12)</td>
</tr>
<tr>
<td>Mother’s age (years)</td>
<td>(per additional 5 years)</td>
<td>1.02 (0.95, 1.09)</td>
<td>0.98 (0.93, 1.04)</td>
<td>0.94 (0.90, 0.99)</td>
<td>1.13 (1.06, 1.21)</td>
</tr>
<tr>
<td><strong>(B) Peru</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Education</td>
<td>Primary</td>
<td>1.39 (1.06, 1.83)</td>
<td>1.20 (0.97, 1.49)</td>
<td>1.25 (1.05, 1.48)</td>
<td>1.15 (0.93, 1.42)</td>
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<tr>
<td></td>
<td>Secondary/advanced (ref.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Food security</td>
<td>Food insecure</td>
<td>1.00 (0.76, 1.32)</td>
<td>0.85 (0.69, 1.05)</td>
<td>0.83 (0.69, 0.99)</td>
<td>0.98 (0.80, 1.20)</td>
</tr>
<tr>
<td></td>
<td>Food secure (ref.)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Cohort</td>
<td>Early cohort (&lt;2009)</td>
<td>1.95 (1.33, 2.84)</td>
<td>1.55 (1.28, 1.86)</td>
<td>1.48 (1.27, 1.73)</td>
<td>1.57 (1.30, 1.89)</td>
</tr>
<tr>
<td></td>
<td>Late cohort (≥2009)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of children in HH</td>
<td>(per additional 1 child)</td>
<td>1.04 (0.98, 1.11)</td>
<td>1.06 (1.01, 1.11)</td>
<td>1.05 (1.03, 1.08)</td>
<td>1.07 (1.04, 1.09)</td>
</tr>
<tr>
<td>Mother’s age (years)</td>
<td>(per additional 5 years)</td>
<td>0.95 (0.87, 1.04)</td>
<td>1.00 (0.94, 1.06)</td>
<td>0.99 (0.94, 1.05)</td>
<td>1.03 (0.97, 1.10)</td>
</tr>
</tbody>
</table>

* p < 0.05.
† p < 0.001.

Disaster preparedness and response experience, RNAs have been applied to rapidly evaluate health priority needs for program response and evaluation [30–32]. The inclusion of immunization information and household, environmental and socio-economic data could be a powerful resource to explore potential factors that influence lagging immunization coverage in certain populations.

As a result, our analysis found several factors to be associated with vaccination delays, including lower maternal educational status, advanced maternal age, and increased number of children in the household. Previous studies have looked at age-appropriate vaccination, and found delays in immunization to be associated with similar factors [33–35]. In India, immunization delays were linked to increased family size, number of children <5 years old, maternal education, socio-economic status, and distance from the health center [36]. One study from Argentina found that for DTwP and HepB vaccinations, delays were associated with later place in the birth order, children whose caregivers had not completed primary school, and residence within a central zone of the city [37]. The observed association of lower maternal education and immunization delay has been supported by numerous studies. This finding may be driven by the ability to generate a more complete knowledge of immunizations with an advanced education [38].

The observation that more children received timely vaccinations in Peru if born during or after 2009 could be attributed to the “Threshold Program”, which was implemented by the Peruvian government with the help of the Millennium Challenge Corporation in June of 2008. This thirty-five million dollar grant targeted immunization of rural children and assisted the Ministry of Health in strengthening vaccination program management and outreach [39]. Additionally, the national introduction of both rotavirus and pneumococcal vaccinations in 2009 may have resulted in changes in the national vaccination strategy that increased coverage and opportunity for immunization [40].

The delayed administration of rotavirus vaccine in Guatemala and Peru was to be expected when deploying a vaccine having age restrictions in LMICs. Age-restrictions, while aimed to minimize the risk of intussusception, may preclude children from completing the vaccination series in LMICs where access and opportunity for vaccination is problematic [41]. In Brazil, four years after rotavirus vaccine was introduced, vaccine coverage for two doses of rotavirus vaccine at 1 year of age was only 83% as compared to 98.4% for DTP-Hb2; a coverage gap that was perceived to be due to age restrictions [42]. A benefit-risk model was developed by the Centers for Disease Control and Prevention to address rotavirus vaccine age-specific guidelines. This model predicted that by removing age restrictions there would be 47,200 fewer rotavirus deaths worldwide and only 294 additional intussusception deaths, for an incremental benefit-risk ratio of 154 fewer deaths for every one death caused by vaccine related-intussusception [14]. In January 2013, WHO recommended that countries could use a more lenient age for completing the rotavirus series by 24 months of age, encouraging them to focus on early vaccine administration [43].

There are several limitations of the present study. First, the RNAs were designed to evaluate the maternal-child health status of the communities, and not specifically to study risk factors for immunization timeliness. Therefore, if risk factors for immunization delays are to be elucidated, investigators and program evaluators will need to make use of best epidemiological practices of risk-factor analysis. RNA is not a validated method to draw conclusions on risk factors, but is a way to generate hypotheses that could be tested in case-control or immunization registry cohort studies. Second, we were only able to include children with the vaccination card in our analysis, resulting in exclusion of a third of children and we made no attempts to extrapolate data to the excluded households, even when some children were reported to have received immunizations, but their card was unavailable. This introduces a selection bias to our findings, as households without a vaccination card may be different from households that keep the vaccination card.

Third, these data sets reflect only the timeliness of immunizations in two less-developed regions of Guatemala and Peru, and may not be representative of the national immunization program coverage levels for each country. As previous studies have shown, the proportion of those vaccinated and the impact of the vaccines may differ between distinct regions within a country [27]. The study could not account for the impact of availability of vaccines at government clinics in both countries that may influence the timely completion of vaccine schedules. As it was shown in Peru, the younger cohorts had better completion rates after an optimized immunization strategy was used.

Additionally, the sample size was not calculated to estimate differential effects, but we can infer that the larger sample size in Peru contributed to more associations than in Guatemala. Finally, our limited sample size prevented the use of a multivariate regression model and consequently we cannot comment on the presence of potential confounders.
5. Conclusion

RNA is a quick and effective tool to evaluate vaccine coverage and possible risk factors for immunization delay. This study demonstrates that if a set of core variables and factors can be identified and confounders controlled, RNAs can shed light on population determinants of lower vaccine coverage and timeliness. High rates of delays in childhood immunizations in both Guatemala and Peru appear to be related to maternal, family and program access factors. Improving vaccination coverage in countries that have already reached high rates of immunization requires tools to identify age-appropriate immunization strategies that can overcome the reasons associated with delayed immunizations.

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Author's contributions

EJA and KKD conceptualized and designed the study. EJA, KKD, CC, HH and SB participated in the collection of data. EJA, KKD, JD, AF and SB were responsible for analysis and interpretation of data. KKD, JD, AF and EJA collaboratively wrote the manuscript. All authors read and approved the final version.

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Conflict of interest: All the authors have declared that they have no competing interests.

References


