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Monitoring and addressing determinants of vaccine utilization in low and middle income country settings: parental attitude scales and vaccine reminder interventions

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Abstract

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By Aaron Stuart Wallace

To protect against vaccine-preventable diseases, which are leading causes of childhood mortality in several low and middle income countries (LMIC), infants are recommended to receive at least three doses of diphtheria-tetanus-pertussis containing vaccine (DTPcv). In several countries, a substantial proportion of children receive only the first DTPcv dose, leaving them vulnerable to illness.

Despite concerns that parental hesitancy may contribute to incomplete vaccination, little work has occurred in LMICs to develop tools to monitor hesitancy trends. Additionally, lack of parental awareness of future visits is a common determinant of incomplete vaccination. However, little is known about the effects and costs of interventions designed to remind parents of future vaccination visits in LMICs.

In dissertation aim 1, we developed a scale to assess parents' hesitancy about childhood vaccination among a sample of 373 respondents in Ghana. Our final valid and reliable scale was composed of three parental attitude domains: *vaccination benefits*, *vaccine safety & efficacy*, and *past vaccination behavior*. Parents who scored higher on the scale were more likely to have a child with incomplete and delayed vaccinations.

In aim 2, we implemented a cluster-randomized trial in 90 health facilities of Indonesia to test the effectiveness of two interventions designed to remind parents of future vaccination visits. In each intervention, children received and kept a home-based vaccination record; in one intervention group, an appointment reminder sticker was placed on the record. A higher proportion of children in the reminder-sticker group received a timely vaccination; however, by the end of 7 months, vaccination rates were similar across all groups.

In aim 3, we examined the costs of the Indonesia reminder interventions and the cost-effectiveness of the sticker intervention group. The costs of each intervention where both low at about $0.50 per targeted child; for the reminder-sticker group, the cost-effectiveness ratio was below the costs of similar strategies Indonesia uses to improve timely completion of childhood vaccinations.

Taken together, these studies provide robust evidence for future development of tools and strategies designed to monitor and address why children remain incompletely vaccinated in low and middle income country settings.

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Thanks you to my parents for all the support and love they have given me my entire life. The opportunities they have presented to me and the freedom to let me roam my own path have led me to a blessed place in my life. My parents have both come from very different, diverse and humble origins; each have instilled in me the value of hard work, perseverance and valuing both the process and end of every journey. I also thank my grandparents, both passed and alive; particularly my Grandma Garcia, who has always been an inspiration for how to lead a humble yet rewarding life.

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CHAPTER 1: BACKGROUND AND SIGNIFICANCE

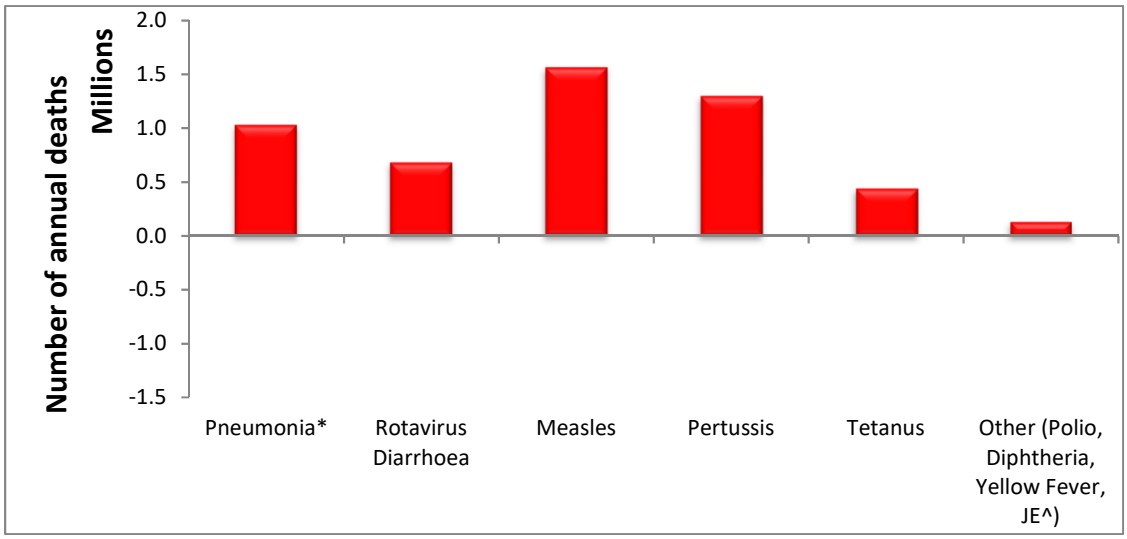
Pre-vaccine burden of vaccine preventable diseases

In the pre-vaccine era, an estimated five million deaths occurred annually due diseases which are now largely preventable by vaccines [1]. Measles sickened an estimated 90% of persons globally by the age of 15 prior to development and use of a measles vaccine; similarly, nearly all children developed pertussis in the pre-pertussis vaccine era [1, 2]. Many of these diseases have substantial case fatality rates estimated to result in high numbers of deaths in the absence of vaccination[1]. Without vaccination, it is estimated that, two million people would die from measles infection and 1.3 million from pertussis infection (Figure 1). Another 1.5 million individuals would also die from complications of pneumonia and rotavirus diarrhea which are now largely preventable by vaccines currently being introduced worldwide[3, 4]. An additional 1 million deaths would occur in the absence of vaccinations against tetanus, diphtheria, yellow fever and polio. Many of these deaths occurred in those under 5 years of age; for instance, in 2002, vaccine-preventable diseases were estimated to cause 40% of deaths in <5 year olds [1, 5].

Although not all vaccine-preventable diseases have high mortality rates in the absence of vaccination, many also cause serious health complications among a substantial proportion of those infected. For instance, it is estimated that 90% of all children in the developing world were infected with polio virus annually and 1% developed paralysis, equal to approximately 1 million children annually[1, 6]. Measles infection can lead to blindness, hearing loss, and swelling of the brain leading to intellectual disability[2, 6]. Pertussis complications include swelling of the brain, apnea and convulsions, while tetanus complications include pneumonia,

blood clots and difficulty breathing. Diphtheria complications include heart muscle damage, nerve damage, lung infection and paralysis in a minority of those who are infected.

Figure 1.1: Estimated number of annual deaths from vaccine-preventable diseases in the absence of a vaccine against the respective disease; WHO Burden of Disease and Disease Control Priorities Projects, 2008



**vaccine preventable component caused by Streptococcus pneumoniae, Haemophilus influenzae type b*
^ Japanese Encephalitis

The Expanded Programme on Immunization

The World Health Organization's Expanded Programme on Immunization (EPI) began in 1974 with the goal of ensuring that all children benefit from life-saving vaccines[7]. When EPI began, the minimum recommended childhood vaccination schedule for all countries included a dose of Bacillus Calmette-Guérin vaccine (BCG) at birth, three doses of Diphtheria-Tetanus-Pertussis vaccine (DTP), three doses of polio vaccine (POL), and one dose of measles-containing vaccine (MCV) (**Table** 1).

Table 1.1: Childhood Vaccination Schedule Recommended by the World Health Organization and Used by Most Low and Middle-Income Countries in the 1970s and 1980s

Vaccine	Birth	6 weeks	10 weeks	14 weeks	9 months
Bacillus Calmette-Guérin vaccine (BCG)	BCG				
Diphtheria, Tetanus, Pertussis vaccine (DTP)		DTP1	DTP2	DTP3	
Polio vaccine (POL)		POL1	POL2	POL3	
Measles-containing vaccine (MCV)					MCV

Since the launch of EPI and original recommended vaccination schedule, additional vaccines were developed and incorporated into the World Health Organization (WHO)-recommended childhood schedule[8]. These include Hepatitis B vaccine (HepB), a pentavalent version of DTP-containing vaccine which also includes Hepatitis B and Haemophilus influenzae type b (Penta), inactivated polio vaccine (IPV), a rubella vaccine (RV), pneumococcal vaccine (PCV) and rotavirus vaccine (RV). Additional regional vaccines of interest include Yellow Fever vaccine (YF) and Japanese Encephalitis vaccine (JE).

Routine delivery of these vaccinations is generally conducted through a network of primary healthcare facilities (known as fixed delivery points), outreach delivery points within communities far from fixed points and mobile delivery points (vehicle or boat-based) which are more than 24 hours away from fixed points[9]. Since vaccines are seen as among the most cost-effective interventions for reducing childhood mortality and morbidity, vaccine delivery systems have received substantial investment since the launch of EPI[10]. As routine immunization programs have evolved, coverage has continued to grow such that the routine immunization system has also served as a foundation for the development of many low and middle-income countries' (LMIC) primary healthcare systems [11, 12].

Routine vaccination coverage is a key marker of immunization system performance; coverage is defined as the proportion of the target population that is reached for a specific vaccine in a given time period. Multiple immunization system goals, with associated coverage targets and benchmarks, were established since the start of EPI.

Global immunization goals and strategies

In 2003, WHO and UNICEF developed the Global Immunization Vision and Strategy (GIVS), which included the goal of reaching and sustaining 90% national vaccination coverage in all countries by 2015 [13]. This goal was reiterated in the Global Vaccine Action Plan 2011-2020, which also calls on countries to attain 80% vaccination coverage in all districts by 2020[14]. As vaccination coverage has increased, goals for certain vaccine-preventable diseases have also been set, with a desire to control, eliminate or eradication the disease on question. One of the initial VPDs for which global eradication goals were set was polio[15].

In 1988, the Global Polio Eradication Initiative was launched with the goal to eradicate polio by 1990[15]. Although this goal was missed, global polio incidence continues to decrease, with only 12 wild polio cases reported in 2017[16]. The current goal is to eradicate polio by 2018. Elimination goals also exist for measles. In 2012, the alliance of global agencies who drafted the Global Vaccine Action Plan set a goal to eliminate measles in five of six WHO regions by 2020[17]. Partner agencies developed a 10-year Global Measles and Rubella Strategic Plan in 2011 outlining key steps and activities to achieve the latter goal[18]. The activities in the Plan include strengthening routine vaccination services such by reducing the number of children who start but fail to complete all recommended vaccinations. Currently, all regions now have a measles elimination plan and target elimination year, including the African region, which adopted 2020 as the target year.

Control and elimination goals also exist for other VPDs. In the Western Pacific region, a hepatitis-B control goal aims to reduce the prevalence of hepatitis B infection to <1% of young children by 2017 using a birth dose of HepB vaccine and HepB-containing vaccines, such as the pentavalent vaccine used in most LMICs [19]. Many of these disease control, elimination and eradication goals were developed based on the relatively strong immunization system performance that many countries have achieved since the start of EPI, the highly efficacious nature of the vaccines in use, and the ongoing disease burden which continues to occur from these various VPDs.

Global routine immunization performance and impact

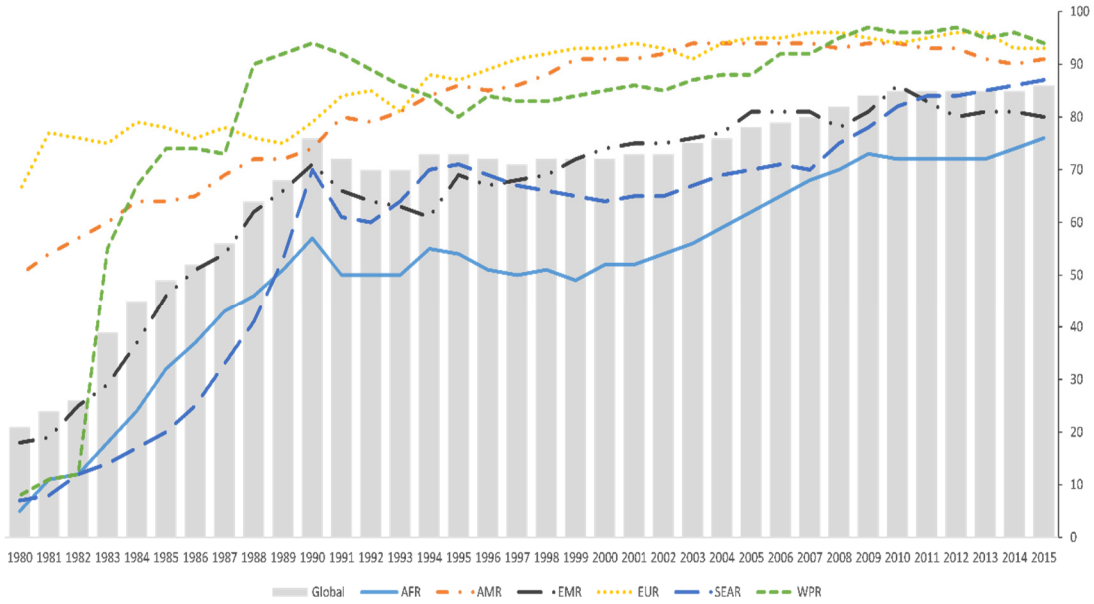
Coverage with the 3rd dose of DTP vaccine (DTP3) among children in their first year of life is a key indicator of immunization program performance [9, 10, 14]. Based on WHO and UNICEF estimates of vaccination coverage, global coverage with DTP3, BCG, polio vaccine and measles vaccine increased from <5% when EPI was established in 1974 to ≥85% by 2015. Estimated coverage for DTP3, the first dose of measles-containing vaccine (MCV1) and the third dose of polio vaccine (Pol3) has remained at 84%-86% since 2010. Estimated global coverage with BCG was 88% in 2015, slightly decreased from 89% in 2014. Estimated global coverage of the 2nd routine dose of measles-containing vaccine (MCV2), which is now integrated into the routine immunization system in 82% of countries, was 43% by the end of the second year of life and 61% when older age groups were included. This is an increase from 39% and 58% respectively in 2014.

WHO and UNICEF derive national coverage estimates through an annual country-by-country review of all available data, including administrative and survey-based coverage.

Administrative coverage is the number of vaccine doses administered to those in a specified target age group divided by the estimated target population. Countries report administrative coverage annually to WHO and UNICEF. Vaccination coverage is calculated as the percentage of persons in a target age group who received a vaccine dose. During vaccination coverage surveys, a representative sample of households with children in a specified target age group (e.g.12–23 months) are visited. Dates of vaccination are transcribed from the child's home-based record or are recorded based on caregiver recall. WHO/UNICEF estimates of national immunization coverage are revised annually and adjusted retrospectively to incorporate newly available data. Countries' annual reports to WHO and UNICEF also include information on introductions of new vaccines into their routine immunization systems. For selected vaccines introduced since EPI's inception, countries were categorized by their 2015 vaccine introduction status, World Bank income classification based on 2015 per capita incomes, and eligibility in 2016 for support from Gavi, the Vaccine Alliance.

116 million children were vaccinated for DTP3 in 2015 (Table 2), and DTP3 coverage among children aged <12 months ranged from 76% in the WHO African Region (AFR) to 94% in the WHO Western Pacific (WPR) region. National DTP3 coverage estimates varied between 16% and 99% and the national DTP 1-3 dropout rates varied between 0% and 61%. 126 (65%) of 194 WHO member states achieved ≥ 90% national DTP3 coverage. National DTP3 coverage was 80-89% in 34 countries, 70-79% in 12 countries and < 70% in 22 countries. Among the 19.4 million children worldwide who did not receive 3 DTP doses during the first year of life, 7.6 million (39%) lived in just three countries (India [17%], Nigeria [15%] and Pakistan [7%]) and 11.7 million (60%) lived in 10 countries (India, Nigeria, Pakistan, Indonesia, Philippines, Democratic Republic of the Congo, Iraq, Ethiopia, Ukraine, Angola). 12.8 million (66%) did not receive the first DTP dose, and 6.6 million (34%) started, but did not complete, the 3-dose series.

Figure 1.2: Global and regional coverage of the third dose of Diphtheria-Pertussis-Tetanus vaccine (DTP3), 1980 - 2015



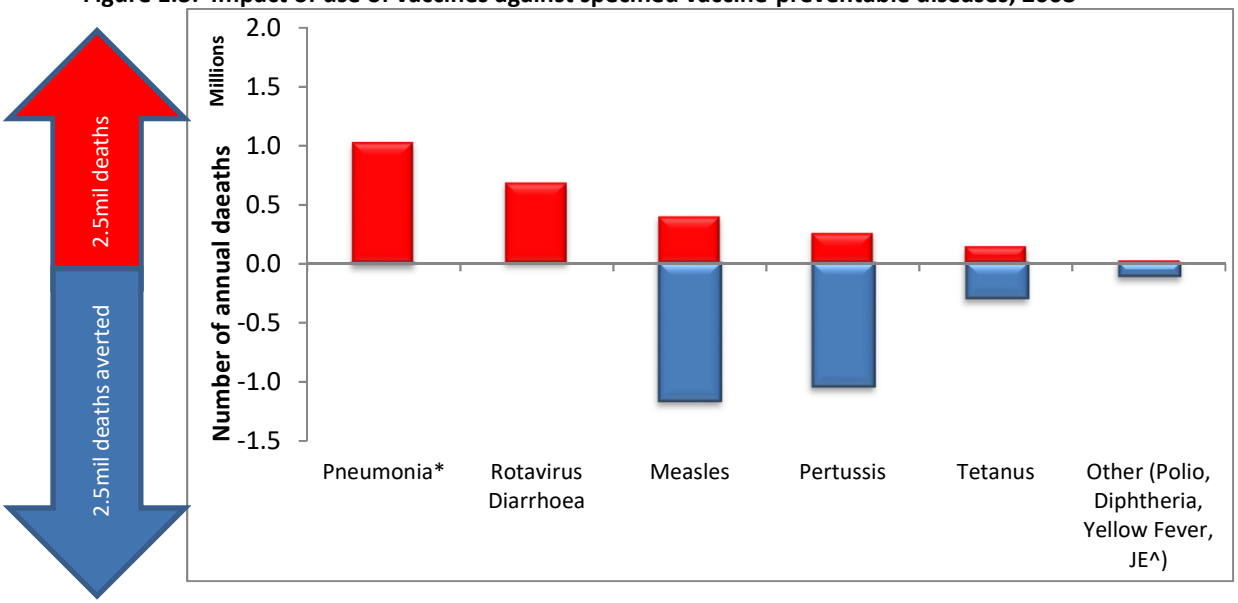
Lower income countries reported the lowest DTP3 coverage estimates, and countries that were not eligible for support in 2016 from Gavi, The Vaccine Alliance, because their per capita incomes were too high outperformed the 54 countries eligible for Gavi support by about 10% for DTP3 coverage in 2015 (Figure 1, Figure 2). Of the 10 countries with lowest 2015 DTP3 coverage (Equatorial Guinea (16%), Ukraine (23%), South Sudan (31%), Syrian Arab Republic (41%), Somalia (42%), Central African Republic (47%), Guinea (51%), Liberia (52%), Chad (55%)) almost all are in conflict or economic turmoil. Only 54 (28%) countries achieved ≥ 80% DTP3 coverage in every district, and 21 countries reported that more than 10% of districts had DTP3 coverage <50%.

Similarly to DTP3 coverage, MCV1 coverage varied between 74% - 96% by region and between 20% - 99% by country. Whilst 119 (61%) countries achieved the 2012-2020 Global Measles and Rubella Strategic Plan goal for 2015 of ≥ 90% national MCV1 coverage, 51 of these

countries were high income countries. Only 5 (16%) of 31 low income countries achieved the same goal.

Immunizations are now estimated to avert between 2 and 3 million deaths annually each year (**Figure** 3)[1]. However, 2-3 million more deaths could still be averted with the inclusion of all recommended vaccines in all national programs, and increases in vaccination coverage across all countries.

Figure 1.3: Impact of use of vaccines against specified vaccine-preventable diseases, 2008



Data: World Health Organization and Disease Control Priorities Project 2: Burden of Disease estimates

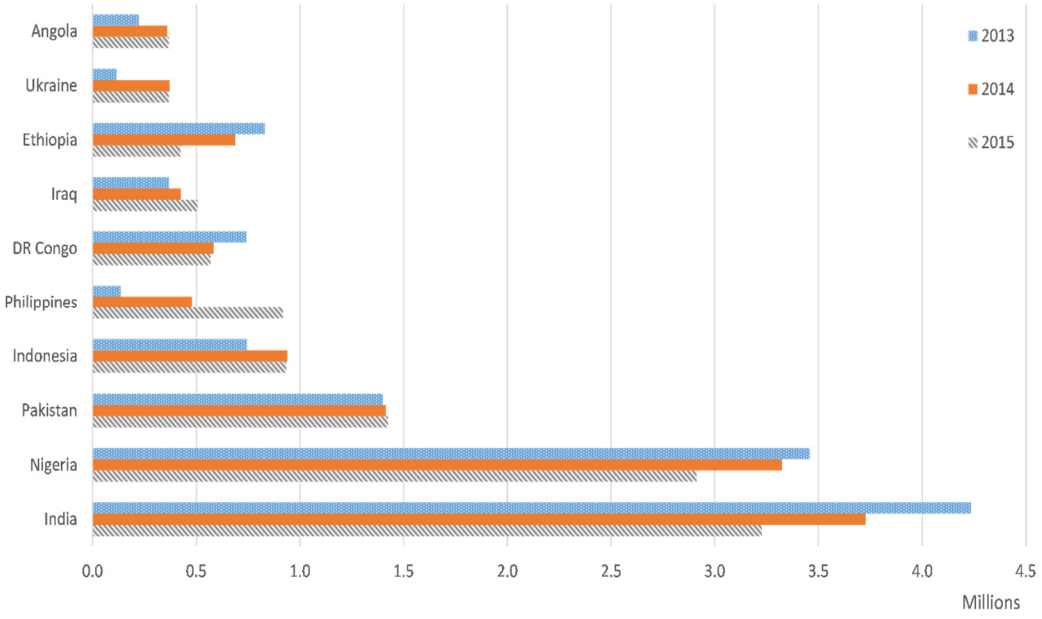
Top countries with lowest routine vaccination performance

In 2015, an estimated 19.4 million children were unvaccinated with a third dose of DTP-containing vaccine. 60% of these children live in the top ten countries with the most number of children unvaccinated against DTP3 (Figure 4). For the past several years, Nigeria, Pakistan, India, Indonesia, Democratic Republic of Congo and Ethiopia have remained constants on the top-10 list of countries with most number of children unvaccinated against DTP3[20, 21]. Philippines and Iraq have been included in this list since 2012 while Angola and Ukraine joined

the top-10 list in 2015. In 2014, South Africa and Uganda were among the top-10, but both dropped due to Angola and Ukraine's substantial decreases in DTP3 vaccination coverage in 2015. During the 2013-2015 period, Ethiopia, Nigeria and India continue to improve the proportion of children vaccinated with DTP3 whereas Ukraine, Philippines and Angola have seen substantial decreases in the proportion vaccinated with the third dose of DTP vaccine.

Indonesia, a setting for two aims of this dissertation, encompasses 4% of the world's unvaccinated children, and is ranked at #8 among the top-10 countries with most unvaccinated based on DTP3 vaccination status.

Figure 1.4: Top ten countries with most unvaccinated children in 2015 based on DTP3 vaccination status



Key immunization program monitoring indicators

A series of monitoring indicators are commonly used by health sector staff and global health stakeholders to assess immunization system performance and provide insight into possible areas of weakness. Three program indicators most frequently used to qualitatively

assess program performance are: Access, timeliness and utilization [9, 14, 22-24]. Each of these indicators has quantitative monitoring measures which are routinely monitored at all levels of the health system. These indicators and their associated monitoring measures are described below.

Access

Access is defined as the ability of a health system to provide access to vaccination series and is an indication of initial use of vaccination services[9, 21]. Access is commonly measured using coverage of the first dose of DTP vaccine (DTP1) as it is one of the first vaccines administered to a child in the location where they should receive the rest of their recommended childhood vaccinations.

Timeliness

Timeliness is defined as receipt of a vaccination at the recommended age per a country's national vaccinations schedule [25-28]. Generally, countries will have a buffer period after the recommended age, whereby a vaccination is still considered timely. For instance, if measles vaccination is recommended at 9 months of age in a country, a timely dose is any that is given within one week after 9 months of age. Timeliness is an indicator of compliance to the recommended vaccination schedule. Timeliness is also an indication of the quality of communications between parents and health workers, ability of parents to reach vaccination services on a regular basis and ability of health workers to bring services closer to hard to reach communities on a regular basis.

Utilization

Utilization is defined as the ability of a health system to ensure that children who are reached with a first vaccination dose in a series (e.g. the 3-dose DTP vaccination series) are also

reached with the final dose in that series. Utilization can be measured by comparing the proportion of children who receive the first dose in a vaccination series (e.g. DTP1) with the proportion of children who receive the third dose in a vaccination series (e.g. DTP3) during a defined period of time (e.g. over a 1-year period). Utilization is an indicator of the continuity of use of vaccination services by parents, level of parental satisfaction with vaccination services, and quality of communications between parents and health workers about the need for and benefits of a child receiving all recommended vaccinations. Utilization is commonly measured through use of a vaccine dropout rate which is described further below.

Monitoring vaccine utilization

Health sector staff measure vaccine utilization by measuring the proportion of children who received the last dose in a vaccination series among those children who received the first dose in a vaccination series. A vaccination dropout rate is one commonly used measure of the proportion of children who did not receive the last dose in a vaccination series among those children who did receive the first dose in a vaccination series [9, 29-31]. Those children who fail to complete a vaccination series after receiving the first dose in a series are considering "drop-outs"[21] since they have dropped out of the recommended vaccination schedule.

To calculate a vaccination dropout rate, one uses the following formula:

$$\frac{(\%\ of\ target\ pop\ receiving\ 1st\ dose\ in\ series) - (\%\ of\ target\ pop\ receiving\ last\ dose\ in\ series)}{(\%\ of\ target\ pop\ receiving\ 1st\ dose\ in\ series)}$$

As an example, if one were to calculate a dropout rate for the DTP series, the formula to use is:

$$DTP\ 1-3\ Dropout\ rate\text{:}\ \frac{(DTP1\ coverage) - (DTP3\ coverage)}{(DTP1\ coverage)}$$

These formulas are considered “crude” dropout rates since the coverage values used in the formulas are aggregate, population-level measures, thus the dropout rate may not necessarily equal the actual proportion of children who received DTP1 vaccination but have failed to return for DTP3 vaccination. However, this formula is used by health workers as it is a relatively simple formula to calculate and uses information that is already gathered on a monthly basis in most LMIC settings. A vaccination dropout rate is generally calculated by health facility and district staff on a monthly basis to provide insight into vaccine utilization trends and identify potential issues with utilization [29-31].

An alternative method for calculating the dropout rate is to calculate the proportion of children who received the last dose in a vaccination series among those who had received the first dose in a vaccination series. This formula will yield the same value as the formula described above. An example of this formula using the DTP series is shown below:

DTP 1 -3 Dropout rate: [100% - ((DTP3 coverage) / (DTP1 coverage))]

Vaccine utilization determinants

Immunization program staff monitor both access to and utilization of all recommended vaccinations because determinants of service access may differ from determinants of service utilization[32]. Being able to identify if a problem is primarily an access issue or utilization issue can help program staff determine the most appropriate solutions to implement to improve overall vaccination coverage levels as well as prioritize use of limited resources for improving service performance.

Commonly identified determinants of vaccination service access generally are related to health system characteristics, such as health worker availability, vaccine availability, routine provision of vaccination sessions (where vaccines are administered) and distance between health facility and communities being served [32-34]. Other common determinants of access include various socioeconomic characteristics of the beneficiary such as level of maternal education, religious or cultural identity and household income level. These characteristics can influence other aspects related to vaccination access, including lack of awareness of the availability and benefit of vaccinations as well as distance from health facilities.

Commonly identified determinants of utilization of vaccination services are frequently related to household demand for vaccination services. Factors which can influence utilization include the quality of the interaction between a health worker and the parent, parent-perceived quality of facility conditions, parent's lack of awareness of future vaccinations for one's child and level of parental hesitancy about vaccines and vaccination services [35-38].

Vaccine hesitancy: a determinant of utilization

The topic of vaccine hesitancy has emerged in over the past ten years as a key area of research due to increasing concern and evidence about the potential effect of hesitancy on vaccination coverage levels. Although concerns about vaccines have existed since the era of the first smallpox vaccine, the phrase "vaccine hesitancy" wasn't well used until the late 2000s in published scientific literature[39]. Vaccine hesitancy can be described as a state of unease about the decision to either be vaccinated or have one's children vaccinated[40]. Recent studies suggest that as VPD incidence decreases, fewer parents see the severe effects of these VPDs and may instead become more concerned with potential side effects of vaccinations, quality of vaccination services and source of the vaccination services, hence leading to increasing levels of

hesitancy in the population [41-43]. Vaccine hesitancy is attributed to several factors ranging from both personal beliefs about vaccination to contextual characteristics such general government distrust or rumors about vaccine safety issues [40, 41, 44, 45]. In a recent systematic review of studies identifying individuals' and communities' vaccination concerns (an even broader term than vaccine hesitancy) in LMICs, the main reported concerns stemmed from perceptions of vaccination harms, program distrust and health system unfriendliness[35].

Although much anti-hesitancy intervention work is currently ongoing, as of yet, little evidence is available about the effect of interventions to address these underlying issues leading to vaccine hesitancy and concern among parents[40]. However, published evidence about the association of parental hesitancy level with vaccination status of the child indicates a need for routine surveillance of vaccine hesitancy trends as a prompt for developing hesitancy interventions. Currently, however, no work has occurred on ways to routinely survey vaccine hesitancy trends in LMICs, but such work could include development of a valid and reliable parental hesitancy scale.

Examples of measuring vaccine hesitancy trends

Recent examples exist of efforts to either monitor vaccine hesitancy trends or develop tools that can be used to identify vaccine hesitant individuals who may be more likely to delay or not vaccinate one's child. Nearly all these documented efforts to measure and/or monitor vaccine hesitancy are located in high income countries. For instance, in Canada and the United States, a series of studies have examined the utility of creating a vaccine confidence scale designed to identify parents who are hesitant about vaccines and may consequently choose to either delay or refuse vaccines for their child [46-52]. One notable example of a survey which

included low-income countries and assessed vaccine confidence included four questions on vaccine importance, safety, effectiveness and religious compatibility[53, 54]. While the latter survey included 67 countries, its topical scope related to vaccine hesitancy was narrow and did not include an objective to develop a hesitancy scale, nor evaluate how parental attitudes towards vaccination relate to the child's vaccination status. Since 2010, a small number of examples of vaccine hesitancy scales developed in high income settings were published.

Developed in 2011 by Opel and colleagues, the Parents Attitudes about Childhood Vaccines Survey (PACV), incorporates 15 survey items and 3 latent factors: vaccine safety & efficacy, general attitudes and behavior [46, 47, 55]. In their approach to designing the scale, the researchers initially began with a review of previous studies which had examined the association of specific survey questions with various vaccination outcomes such as intention to vaccinate one's child or child's vaccination status. Their initial survey included 27 items and 4 latent factors. They assessed reliability and validity of the scale among a cohort of parents and children in a US-based healthcare system located in Seattle, Washington. They comparing the scale score to a child's vaccination status to determine the predictability of the score (i.e. a higher score translated to higher parental hesitancy) and reported that the higher score was associated with greater likelihood of delayed vaccinations. A follow-up prospective study examined the predictive ability of the PACV scale score on the child's vaccination status and reported similar results as the earlier cross-sectional study[55]. The setting for the prospective study was also in Seattle; the authors noted that their study population predominantly included white, married mothers who had household incomes >$75,000, limiting the generalizability of the results and conclusions regards use of this scale in populations with substantially difference socio-demographics.

Additional examples exist of scales developed to assess hesitancy against specific vaccines targeting specific age groups. In 2014, Gilkey and colleagues released a scale (the Vaccine Confidence Scale) that was designed to measure the confidence of parents in adolescent vaccines across diverse populations in the United States [50, 52]. Their resulting 8-question scale measured three latent factors: vaccination harms, benefits and trust. Although their analysis was unique in assessing the utility of the scale across multiple socioeconomic characteristics known to be associated with a child's vaccinations status, they did not contextually validate the scale with the vaccination status of the adolescent. Another study, published in 2016, also released a scale (The HPV Attitudes and Beliefs Scale – HABS) assessing Canadian parents' confidence in the HPV vaccine[51]. This scale included 9 latent factors: vaccination benefits, threats, influence, harms, risk, affordability, communication, accessibility and general vaccination attitudes. Compared to the previous study by Gilkey, a greater number of parental attitudes and beliefs were incorporated into the HABS, which the authors believed could provide greater insight into beliefs distinctively related to HPV vaccine and allow researchers to assess additional attitudes and beliefs related to HPV vaccination decision-making.

Standardized scales such as the ones described above have a variety of benefits as opposed to ad-hoc scales or questionnaires for assessing a characteristic such as a parent's hesitancy towards vaccinations. In particular, standardized scales have been shown to be more reliable than ad-hoc scales or questionnaires[56]. A scale is generally a composite measure, composed of several items that have some type of logical or empirical structure to them. The items, or questions, that are used to create the scale, have been identified from a list of several possible questions and winnowed down to a set of questions that are considered the most reliable and valid for measuring the topic of interest [57].

Reliability refers to how consistent individuals' responses are to specific questions. Generally, one should expect similar people to respond in a similar manner when evaluating the same issue. Reliability is generally measured using Cronbach's alpha, which is a method for measuring how similar grouped survey items are to one another in measuring a latent factor within the surveyed population. The value ranges from 0 (low internal reliability) to 1 (high internal reliability); generally a score above 0.70 indicates acceptable internal reliability. Validity refers to how well the scale score measures what the researcher has intended it to measure. For instance, if one is most interested in a child's vaccination status as a key outcome, then a vaccine hesitancy score for a parent should have a correlation with the child's vaccination status.

A key gap among these various vaccine hesitancy scales is no evidence of applicability and use in low and middle income country settings. Scales can have limitations to their generalizable use since their psychometric properties may differ across different cultural groups[57]. These limitations can exist in the interpretations of words, questions, instructions, or the general meaning of a set of items, such that the items in the scale may no longer represent the same latent factor or construct. Hence, the accuracy of interpretation is compromised. Adapting the use of such a scale may require going back to a version with more survey items so as to determine which survey items are associated with one another and what latent factors may exist in this new population.

Improving vaccine utilization: Parental reminder strategies

A variety of interventions are available to remind parents to ensure they bring one's child back to a health facility for future vaccinations. These interventions are commonly

described as parental reminder/recall systems[58]. They generally include some form of parental education provided by the healthcare provider which can include information on dates of future vaccinations, benefits of bringing one's child for future vaccinations, overview of the recommended childhood vaccination schedule and overview of vaccine safety and possible side effects following immunization. Parental reminders can take on several forms, including letters or postcards to patients, person-to-person telephone calls, computerized phone messages, combinations of postcards and phone, community outreach, and reminders for healthcare providers alongside parents[58].

Evaluations of parental reminder strategies have generally shown a very positive effect on vaccination uptake, with a recent review indicating that parental reminders can increase coverage by 57% for certain vaccines[58]. However, nearly all findings from this 2005 Cochrane review of parental reminder strategies are documented from high-income country settings. In the 2008 update to this previous Cochrane review, the authors found no direct evidence of how effective reminder interventions are in low and middle-income countries, although they reiterated the findings of a strong effect seen in high income country settings. Additional Cochrane review updates examining the evidence on effectiveness of interventions to increase vaccination coverage in low and middle-income countries indicated the low number of high-quality study designs conducted in these settings (n=14)[59, 60]. One study, from Pakistan, was included that examined the effect of a reminder intervention on vaccination coverage [61, 62]. The review authors indicated that reminders may increase coverage in low-income country settings, however, the evidence was of low-certainty due to the lack of available data and identified issues of study bias in the single included paper. The review authors also noted that only one study incorporated information on intervention costs and no study included an analysis of cost effectiveness of the evaluated intervention.

In a 2015 review of the effect of interventions targeted at parents to improve early childhood uptake, Harvey et. al. identified 28 randomized controlled trials (RCTs) on parental reminder, recall or education interventions, the majority (16/28) of which were in based in the US; only 5 were based in a low or middle-income country setting (2 in Pakistan, 1 each in Nepal, Ghana, and India)[63]. Thirteen of the studies evaluated the impact of a parental reminder; eleven were postal-based reminder and two were telephone reminders. Based on the limited data, the authors concluded that use of postal reminders should be included as part of the standard of care for immunization delivery. The four low/middle income country studies reviewed by Harvey et al included one study examining use of home visit referrals by community health workers in Ghana, postnatal health education to mothers in Nepal and India, and redesign of home-based health records (e.g. vaccination cards) combined with facility-based health education in Pakistan. In all but Nepal, receipt of the intervention significantly improved uptake of vaccinations.

The use of the home-based record (HBR) as a parental reminder was examined by Usman and colleagues in urban and rural settings of Pakistan as a strategy to improve vaccine utilization[61, 62]. In Pakistan during the early 2000s, DTP1-DTP3 dropout was estimated at 11-13%. This study was designed as a cluster randomized controlled trial, with four study groups:

- parents in study group 1 received a redesigned HBR that included a very visible date on the front of the card describing when the next vaccination for one's child was due as a reminder for the parent to return to the clinic;
- parents in study group 2 received health facility-based education about the benefits of vaccination;
- parents in study group 3 received both the redesigned HBR and the facility-based education;

- parents in the control group received routine care

The outcome of interest was complete uptake of DTP2 and DTP3 vaccinations by the end of the 90-day follow-up period. For the urban-based study, in the standard care group, 55% of children completed DTP3, whereas DTP3 coverage in Study groups 1, 2 and 3 were 69%, 65% and 74%, respectively. All were significantly higher than the control group coverage level at the end of 90 days. For the rural-based study, results were similar: the standard care group reported 39% DTP3 coverage, whereas study groups 1, 2, and 3 were at 66%, 61% and 67%, respectively at the end of 90 days. The authors concluded that use of either redesigned HBRs or facility-based education could have a positive effect on completion of the DTP vaccination series among those who had initially started the series. No information was provided on the costs or cost effectiveness of these interventions in the Pakistani setting. The use of a home-based records as the basis for a parental reminder strategy appears promising based on this Pakistan-based study but needs additional evidence from other LMIC settings.

Feasibility of home-based records as a parental reminder for vaccination

The use of a home-based record (HBR) as a parental reminder in a low or middle income country setting as compared to other parental reminder interventions may provide a number of unique benefits. Globally, WHO recommends that health workers provide parents with an HBR for their child as it provides the details of all health services the child has received[64]. It also allows the healthcare provider to also know which services the child has received, so that they do not receive redundant services. For instance, if a parent uses multiple health facilities for health services, a well-documented HBR can act as the information bridge for services the child has received, to help notify the provider of services for which the child is eligible. The latter is

particularly critical in low resource settings where health system-based records are paper-based or are not shared across health facilities.

The HBR is used for a variety of purposes other than as a record of services received. These other purposes include validating vaccination status during vaccination coverage surveys, reducing missed opportunities for vaccination by using the HBR to screen for eligible vaccinations during any health facility visit, and through using the HBR as a parental reminder[64]. In many low and middle income country settings, vaccination coverage surveys are conducted on a routine basis to provide an estimate of the proportion of children who have received all recommended vaccines in a country. The HBR is the main information tool used for validating a child's vaccination status. Without the HBR, surveys must rely upon parental recall of vaccination received which introduces substantial bias to the estimate; generally parents tend to under-estimate the number of vaccinations received. In some surveys, health facility vaccination records may be used, however this is also challenging since facility health records in many resource-poor locations also have accuracy issues due to poor record-keeping.

Ideally, the HBR is used as a reminder for the parent to bring the child for future vaccinations. The presence of the HBR at home acts as a physical reminder of vaccination, and the dates when previous vaccinations were received is included in the HBR for a parent to view to they can calculate the next date of vaccination for their child. However, challenges exist to using the HBR as a reminder. In certain settings, health workers may not allow the parents to keep the HBR at home, for fear of damaging or losing the HBR[64]. Instead, the HBR is kept at the health facility where its usefulness as a parental reminder is nullified. Additionally, HBR supply may be inadequate due to poor supply planning by national or sub-national health sector staff, so parents never receive an HBR. Lastly, the design of the HBR may make it difficult for a

parent to easily identify when they should bring the child in for a future vaccination since HBR do not generally have a place to write the date for the next vaccination visit.

The HBR may be suitable as a key element of a national parental reminder strategy that could be rapidly implemented at scale in limited resource settings such as those found in many low and middle income countries. It is already widely used in many countries and strongly linked to vaccination services. Yet, beyond the card-based parental reminder trial conducted in Pakistan [61, 62], no additional evidence is available about the costs and effects of using the HBR as a parental reminder. Additionally, the Pakistan studies only examined the effect on coverage at the end of a 90-day period and used trained study personnel to implement the intervention. The effect of the reminder may be different if measured if implemented by healthcare providers; the latter are the ones who would need to implement an HBR-based reminder strategy if it were brought to scale in a country. Additionally, the effect of an HBR-based reminder may be different if measured over a longer period of time, e.g. 6-12 months, i.e. the reminder effect could fade as time progresses from the last vaccination visit. These latter issues are key knowledge gaps that should be addressed in future studies.

Key knowledge gaps

Monitoring utilization: Developing vaccine hesitancy scales for use in developing country settings

Vaccine hesitancy is of growing interest and concern across all countries, although research is limited in low and middle income countries compared to the rapidly growing research base in high income country settings. In high income settings, research has linked vaccine hesitancy to vaccination status; in particular as a factor correlated with incomplete utilization of recommended vaccinations. In high income country settings, a limited number of

examples exist of scales to monitor vaccine hesitancy trends. No standardized hesitancy scales have yet been developed in a low or middle income country setting. Standardized scales are highly preferable to ad-hoc tools and require a thorough development process, evaluating the reliability and validity of their use in specific contexts. The lack of a standardized scale developed for a low or middle-income country setting is a critical limitation to routine surveillance of vaccine hesitancy trends in these countries and is of particular importance as hesitancy may be playing a more prominent role as a bottleneck to high utilization of vaccination services in LMIC settings.

Using parental reminders to improve vaccine utilization in developing country settings

Evaluating strategies to improve vaccine utilization in low and middle income countries is also a critical research area for global immunization efforts. Parental reminders may be an important strategy for improving utilization as measured by completion of recommended vaccination series in the first year of life and more timely administration of recommended vaccinations. However, little evidence is available to sufficiently determine the type of effect of parental reminders in low or middle countries[58, 60]. In particular, the long-term effect of the reminder as implemented by those who would be providing the reminder at-scale (i.e. the healthcare provider) is currently unknown. Home-based records (HBRs) may provide an opportunity for designing a parental reminder strategy since all children should ideally receive an HBR when they start receiving health services, including vaccinations. A redesigned HBR as part of an HBR-based parental reminder strategy could lead to improved vaccine utilization which would lead to better immunity against vaccine-preventable diseases, lower disease

incidence and satisfy the multiple vaccine-preventable disease elimination and eradication goals that currently exist worldwide.

Evaluating the cost-effectiveness of parental reminders to improve vaccine utilization

In the recent Cochrane review of studies aimed at assessing interventions designed to improve vaccination coverage in low and middle income country settings, none of the 14 reviewed studies provided any information on costs of implementation[60]. Documenting the costs of parental reminder interventions is a critical component of the information needed for program managers in resource-limited settings when choosing which strategies to use to improve vaccination service access and utilization levels. Documenting both costs and effects also allows for a calculation of the cost effectiveness of such interventions. As health program managers in resource-limited settings seek additional funds from both internal and external partner agencies and departments, inclusion of cost effectiveness data becomes critical, yet is currently a missing link in many epidemiological studies of health interventions.

Dissertation aims

In this dissertation, we addressed these latter knowledge gaps by evaluating and designing strategies to measure and improve utilization of recommended vaccinations in two resource-limited settings: Ghana and Indonesia. In Am 1, we developed a reliable and valid scale to measure the attitudes of Ghanaian parents towards vaccination services which can be included as a module in surveys evaluating vaccine hesitancy and in routine surveillance of vaccine hesitancy trends in low income country settings. We will conduct primary data collection for developing this scale through a household-based survey of 373 randomly sampled

households in a rural area of Ghana. In Aim 2a, we analyzed data from a 7-month, three-group, cluster-randomized controlled trial in a semi-urban area of Indonesia to measure:

1) The effect of healthcare providers giving an HBR to all parents of vaccine-eligible children and allowing the parents to keep the HBR at home, on DTP3 vaccination status among children who received DTP1 by end of the study follow-up period;
2) The effect of healthcare providers giving a HBR to all parents of vaccine-eligible children, allowing the parents to keep the HBR at home, and using a redesigned HBR that incorporates a large reminder sticker with the date of the next vaccination on the front of the HBR, on DTP3 vaccination status among children who have received DTP1 by end of the study follow-up period.

In Am 2b, we evaluated the effect of each of the two previously described interventions on time to receipt of DTP3 vaccination among children who received DTP1 vaccination. In Aim 3, we evaluated the costs of the two HBR-based parental reminder interventions under evaluation in the Indonesia vaccination reminder trial and calculate the cost effectiveness of these interventions to help assist program managers in deciding which strategies to use for improving utilization of all recommended childhood vaccinations.

CHAPTER 2: AIM 1 MANUSCRIPT

Title: The Global Vaccine Acceptance Scale: Development of a valid and reliable survey to assess parents' beliefs and attitudes about childhood vaccines and their association with vaccination uptake and delay in Ghana

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Keywords: vaccine hesitancy, vaccine acceptance, Ghana, vaccination delay, factor analysis

Abstract

Background: Childhood vaccinations are a key intervention for reducing global childhood mortality and morbidity from multiple diseases. Parents' attitudes and beliefs in vaccination influence a child's vaccination status and are important to understand for shaping vaccination demand interventions. Outside of selected high-income countries, little research has focused on developing a psychometric scale to measure parents' attitudes towards vaccinations and how they are associated with childhood vaccination status. This study details the development of the Global Vaccination Attitudes Scale (GVAS) in Ghana.

Methods: We conducted a survey of 373 randomly selected households with children aged 12-35 months of age from Northern Region, Ghana. Parents answered 22 vaccination behavior and belief questions and provided the child's vaccination status. In exploratory factor analysis to assess GVAS content validity, we used parallel analysis using polychoric correlations, very simple structure, scree plot and percent variance explained to guide the number of factors to extract. Principal axis factor analysis (PAF) was used for factor extraction. Internal consistency reliability of the scale was assessed using reliability estimates based on Mislevy and Bock reliability and McDonald's Omega statistic. Criterion validity of scale and sub-scales was assessed against a child's receipt of recommended vaccinations by 12 months of age and child's vaccination delay, using number of days undervaccinated for recommended vaccinations by 12 months of age.

Results: Exploratory factor analysis of GVAS responses resulted in 11 of 22 questions removed due to loadings <0.30 and a 5-factor structure with subscales for vaccine-preventable disease awareness, vaccine benefits, past behavior, vaccine safety and efficacy, and trust. The structure accounted for 69% of the common variance and Mislevy & Bock scale reliability estimates and omega statistic values were >0.73 for all sub-scales. Criterion validity analysis indicated children

were 50% (95% confidence interval [CI]: 37%, 68%) less likely to be completely vaccinated and 86 (95%CI: 28, 143) days under-vaccinated for every 1 point increase in a parent's scale score, compared to those that were completely vaccinated or not delayed for any vaccines, respectively. Criterion validity for each separate subscale score indicated similar trends and directions of association as the overall scale, however, CI for both VPD awareness and trust subscales, the measures of association with vaccination status included the null value. The final recommended scale had 3 factors representing vaccine benefits, past behavior and vaccine safety and efficacy.

Discussion: The most parsimonious and recommended version of the GVAS necessitated dropping several questions previously proposed for use in low & middle-income country settings to identify vaccine-hesitant parents. Replicating this study in several country settings will provide additional needed evidence on GVAS structure and provide useful information to further characterize how parents' attitudes and beliefs towards vaccination vary across countries.

INTRODUCTION

Globally, childhood vaccination has contributed to a dramatic decline in morbidity and mortality associated with vaccine preventable diseases (VPD). However, global vaccination coverage has stalled in recent years, with concerns raised about the role of parents' beliefs in vaccination as a contributor [35, 65, 66]. To further drive vaccine demand, interest has risen in developing methods to characterize parents' vaccination beliefs[53, 67]. These methods could be used in routine monitoring of vaccine confidence trends across multiple countries and for developing more targeted approaches to address parents' concerns about vaccination.

Multiple researchers in the USA and Canada have developed scales designed to measure parents' attitudes towards vaccination by categorizing attitudes into distinct areas of concern. In 2011, Opel and colleagues published the Parental Attitudes towards Childhood Vaccination scale (PACV) which had four psychometric domains: beliefs about vaccine safety and efficacy, immunization behavior, attitudes about vaccine mandates, and trust [46, 47]. In the USA and Canada, multiple scales to measure parental concerns about childhood vaccines and adolescent vaccines have been released since 2010, including the Vaccine Confidence Scale (VCS) to assess adolescent vaccination beliefs of US parents and the human papillomavirus (HPV) attitudes and beliefs scale (HABS) to assess HPV vaccination beliefs of Canadian parents [50, 51, 68-70]. In 2015, the World Health Organization convened a vaccine hesitancy working group which recommended a series of questions, largely based on the PACV, to screen for vaccine hesitant parents[67]. To date, no validated and reliable scales have been developed in any low or middle-income countries, leaving a knowledge gap in tools to measure and understand the influence of

parents' vaccination-related attitudes, beliefs and knowledge on childhood vaccination outcomes in these settings.

Multiple studies in low and middle income country settings have highlighted caregivers' concerns about vaccination and their variations across geographical and cultural settings. Such concerns include perceptions of harmful effects from vaccination, mistrust in vaccination programs and fear of potential side effects from vaccination[35]. Such concerns include perceptions of harmful effects from vaccination, mistrust in vaccination programs and fear of potential side effects from vaccination. Few studies have concretely identified associations between these concerns and the child's vaccination status. Creating a valid and reliable tool to monitor, screen and identify parents with concerns about vaccination is a critical step for countries seeking to make evidence-based decisions about vaccine demand creation strategies. Our objectives for this study were to assess the content validity of a scale designed to measure parents' attitudes towards vaccination in Ghana, determine scale reliability, and evaluate concurrent criterion validity of the scale through two outcomes: child's vaccination status by 12 months of age and child's vaccination delay.

METHODS

Scale development: Identify measures

To identify the measures for the GVAS module, we conducted a review of existing vaccination attitude scales and recommendations for measuring parental attitudes towards vaccination. We also developed de novo questions (n=6) based on discussions with immunization professionals who work on vaccine demand interventions in African countries. In total, 22 questions (10 of Likert scale format; 12 of Yes/no/Do not know format) were incorporated into the GVAS module (Table 2.1).

Data collection: Survey design and participants

To collect GVAS module data, we designed and implemented a cross-sectional, household-based survey in Northern Region, Ghana. The primary intent of the survey was to estimate regional measles 2nd dose vaccination coverage as part of another project; we incorporated our GVAS module into this survey. In the survey, we randomly selected 373 households with children aged 12-36 months to assess the child's vaccination history, sociodemographic characteristics, and parent's vaccination beliefs via the GVAS module. All households completed the GVAS module.

Scale development: Construct validity assessment

To evaluate construct validity, we used exploratory factor analysis (EFA) to analyze the Ghana dataset. In EFA, we used principal axis factor extraction (PAF) with a polychoric dispersion matrix, as this is recommended for analyzing ordinal data collected via Likert-type scales or variables that have few categories such as dichotomous items [71, 72]. EFA based on a Pearson correlation matrix is known to lead to underestimation of the strength of relationships

between variables with few categories, with reduced factor loadings compared to EFA based on a polychoric correlation matrix[71], generally because Pearson correlations assume that the underlying variables are continuous. Exploratory factor analysis and reliability assessment were analyzed using a combination of the R *psych* package, MPlus 8, and FACTOR 10 software[73, 74]. For factor rotations, we used promax, an oblique rotation, since we hypothesized some correlation between factors[75], although there is consensus that use of similar oblique rotation procedures (e.g. promin, oblimin) would likely yield similar results[76].

Prior to EFA, we examined the skewness and kurtosis of each GVAS response item; excessive kurtosis can be used as further evidence of the need to use a polychoric correlation matrix[72]. To assess whether the sample size was sufficient to conduct EFA, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Barlett's test of Sphericity were evaluated. The KMO sampling adequacy value varies between 0 and 1, with values >0.60 generally indicating adequacy of the data for EFA, whereas a significant finding for the test of Sphericity can indicate rejection of the null hypothesis that the correlation matrix is an identity matrix [77], which can be interpreted that at least some of the variables are correlated and hence the data is adequate for EFA.

To determine the number of factors to extract, parallel analysis (using FACTOR software with minimum rank factor analysis and polychoric correlations and MPlus), very simple structure (using R), scree plot (using R and MPlus), and proportion of variance explained (in R and MPlus) were used. The final selection of number of factor to extract was based on review of the results from the latter extraction methods alongside theoretical coherence of factors and simplicity of the factor loadings. Bentler's simplicity index and the loading simplicity index were used to assess the level of factor loading simplicity, essentially a measure of how well each item loads onto a single factor versus multiple factors. To determine which items loaded onto each factor,

we used a cutoff of 0.30. We tested the goodness of fit of the explanatory model using goodness of fit index (GFI), which ranges between 0 and 1, with values in excess of 0.9 considered an indication of adequate model fit, and the root mean square of residuals.

Reliability assessment

To assess reliability and internal consistency of the derived factor solution, we used the Mislevy & Bock reliability estimate. This estimate is equivalent to the square of the correlation between a single factor score (derived from the values of the items that loaded into that factor) and the true score on the latent variable that the factor is representing [78]. In other words, it reflects the percent of variance in the factor scores explained by the latent variable; a value closer to 1 is desirable. We also examined Cronbach's coefficient alpha and McDonald's Omega statistic. The Omega statistic is preferable to use for skewed data and has been showed to be more robust than the alpha statistic for measuring closer to true reliability in these situations[79]. Additionally, the alpha statistic assumes equal factor loadings across items loading onto a factor to properly estimate the true reliability; if this is not the case, then alpha will underestimate reliability[80].

Criterion validity assessment: vaccination outcomes

To evaluate the relationship between parental attitudes and childhood vaccination outcomes, we used separate regression models to assess the association between the mean scale score and two separate outcomes: non-vaccination by 12 months of age and vaccine delay up to 12 months of age. We used generalized estimating equation (GEE) models to examine

non-vaccination as a dichotomous outcome for any vaccine, as well as for MCV1 and penta3 vaccines specifically.

We used GEE models to examine vaccine delay as a continuous outcome for the combined series of measles-containing vaccine 1st dose (MCV1), Pentavalent vaccine 3-dose series, oral polio vaccine (OPV) 3-dose series, rotavirus vaccine (RV) 2-dose series and pneumococcal vaccine (PCV) 3-dose series, as well as for MCV1 and penta-3 vaccines alone. Vaccine delay was defined as number of days under-vaccinated, per the method developed by Luman [28]. In brief, the number of days under-vaccinated was calculated by determining the age at which a child received each examined vaccine dose and comparing it to the recommended age (in days) on the 2014-2016 Ghana vaccination schedule, accounting for minimum dose intervals and minimum age (supplemental table 2.5). If the child received a dose >4 days before the minimum acceptable age or interval for the vaccine, the dose was too early and not counted. If the child received a dose beyond the recommended age, we calculated the difference between the child's age at vaccination and the latest age in which it should be received (generally a 31 day buffer period for a timely vaccination). If the child did not receive a vaccine, then we calculated the difference between the maximum age of interest (365 days) and the latest age in which it should have been received. If a child received a dose late in a multi-dose series (i.e. Penta-1 late), the calculation of days under-vaccinated for the next dose was based the end of the minimum interval period and an additional 31 days buffer. Records were excluded if a vaccination was indicated but date of vaccination was either not included or was inconsistent with the date of birth or if the child was missing date of birth.

To explore the influence of each scale factor, we re-ran the non-vaccination and vaccine delay outcome models using each factor. Models controlled for the following demographic factors that prior research indicates are associated with under-vaccination in Ghana and

elsewhere: mother's age, child's gender, mother's education level, and child's birth order. Due to the clustered survey design, we accounted for the primary sampling unit as a repeated effect in the GEE models. In our modeling analyses conducted using SAS 9.3, we report the frequencies, means, percentages and odds ratios with 95% confidence intervals.

RESULTS

Sample characteristics

373 parent-child pairs were surveyed. Among the 373 sampled children aged 12-36 months, 176 (47%) were female, 197 (53%) were male, 80 (22%) were first-born, and 201 (54%) were aged 12-23 months (Supplemental Table 2.6). All 373 caregivers responded to the 22 GVAS items. The mean age of mothers was 28.9 years (n=106 did not respond), 261 (70%) had never attended school, 40 (11%) had only a primary education and 70 (19%) had a secondary or higher education. Educational attainment was slightly higher among fathers as 146 (39%) had a primary or greater educational level. The majority (N=214, 57%) of mothers were farmers/laborers as were fathers (N=270, 72%). The majority of households were Muslim (N=195, 52%), followed by Christian (N=137, 37%) or Traditionalist (N=37, 10%). Among children, 371 (99%) indicated receipt of at least 1 vaccination and 353 (95%) had vaccination cards. To analyze vaccination delay, multiple records were excluded due to lack of sufficient information on vaccination dates. 279 records (75%) were usable for delay analysis across all vaccines, 344 records (92%) for penta-3 vaccination delay, and 353 (95%) for mcv-1 vaccination delay.

Factor analysis

The distribution of scale items was examined visually using histograms and multivariate tests for skewness and kurtosis were conducted. One variable was dropped due to lack of sufficient data for each response category. There was evidence of asymmetry: values for skewness were >|1| for 14 items, and excess kurtosis was indicated for 16 items. The multivariate test of skewness was not statistically significant (p=1.00), but the test of kurtosis

was significant (P <0.0001), further indicating the need to use a polychoric correlation matrix for EFA. Sampling adequacy tests indicated suitability of the data for EFA as the KMO measure of sampling adequacy was 0.58 and Bartlett's test of Sphericity was statistically significant (X^2 = 749.9, P <0.0001).

The results from parallel analysis using MRFA extraction and polychoric correlation indicated extraction of six factors. Very simple structure analysis, using PAF extraction, polychoric correlation and promax rotation, also indicated 5 factors. Visual assessment of the scree plot indicated between 4 and 6 factors, and Kaiser criterion indicated 3 eigenvalues above 1.00. We chose to run EFA with 4 to 6 factors extracted.

The 5-factor model included 11 items, with two loading per factor for all except the 5th which had 3 items load greater than 0.30 (Table 2.2). The 4-factor model included the same first four factors and same 8 items loading onto each factor. A 6-factor model included a factor where only 1 item loaded greater than 0.30. Based on the items which loaded onto each factor in the 5-factor model, we chose to name the factors as: VPD awareness, benefits, past behavior, efficacy and safety, and trust.

Model fit, simplicity and reliability

The measure of fit between this model and the observed covariance matrix was evaluated with the goodness of fit index (GFI) and the value of 0.90 indicated an acceptable model fit. The RMSR value of 0.1087 also indicated acceptable model fit was slightly higher than the expected mean value of 0.0518. Using Bentler's simplicity index value (0.96) and loading simplicity index (0.93), both indicated the 5-factor model to be an acceptable structural solution.

Mislevy and Bock reliability estimates for all 5 factors were >0.73; the factor, or sub-scale, with the lowest reliability was trust (Table 2.2). McDonald's omega coefficient values showed similar values, with all >0.78. Cronbach's alpha coefficients were >0.60 for the VPD awareness, benefits and behavior subscales; efficacy and safety was 0.54 and trust was 0.41. Dropping any items from the trust subscale failed to improve any internal reliability measures.

Criterion validation analysis: Vaccination receipt

A one-point increase in a caregiver's full scale score was associated with an odds ratio of 0.58 (95% confidence interval [CI]: 0.41, 0.80) for the odds of a child receiving a penta-3 vaccination, indicating decreased likelihood of penta-3 vaccination as a caregiver's full scale score increased (Table 2.3). In separate analysis of each subscale, the benefits domain showed the strongest association (odds ratio [OR]: 0.09; 95% CI: 0.02, 0.39) whereas VPD awareness showed the weakest association (OR: 0.94; 95% CI: 0.54, 1.64) with penta-3 vaccination. Trust also showed a null association, although the OR point estimate was strong (OR: 0.43; 95% CI: 0.07, 2.38). Receipt of measles 1st dose and of all vaccines showed similar patterns as those reported for Penta-3 receipt. Four-factor and three-factor scales which did not include the VPD awareness domain (dropped in 4-factor and 3-factor) and the trust domain (dropped in 3-factor scale) showed stronger associations with the odds of receipt of each assessed vaccination outcome compared to the 5-factor scale (Table 2.3).

Criterion validation analysis: Vaccination delay

For every 1 point gain in a caregiver's full scale score, children were 11.1 (95% CI: 3.7, 18.4) more days under-vaccinated for Penta-3 compared to children who received a timely penta-3 vaccination (Table 2.4). In separate analysis of each subscale, the benefits domain showed the strongest association (101.0 days undervaccinated; 95% CI: 51.3, 150.6) whereas

VPD awareness showed the weakest association (-1.0 days undervaccinated; 95% CI: -12.9, 10.8). Past behavior and trust also showed a null association. For every 1 point gain in the caregiver's full scale score, children were 5.6 (95% CI: 2.2, 8.9) more days undervaccinated for MCV1 compared to children who received a timely MCV1 vaccination. Separate subscale analyses indicated associations between days undervaccinated for MCV1 and VPD awareness. Days undervaccinated for all vaccines showed associations with the benefits, past behavior and safety and efficacy domains and null associations for VPD awareness and trust.

Characteristics of recommended scale

The 3-factor scale with six items that included the benefits, past knowledge, and vaccine safety and efficacy domains showed the most consistency in terms of significance of sub-scale associations with assessed vaccination outcomes. Mislevy and Bock reliability estimates and omega coefficients were >0.80 for these three factors in this scale and factor loadings were ≥0.45 for all six items.

DISCUSSION

In our study of Ghanaian parents of children aged 12-35 months, we were able to develop a contextually valid and internally reliable scale for parental attitudes and beliefs towards vaccination which was highly predictive of the child's vaccination status and number of days undervaccinated. The psychometric domain, *vaccination benefits*, showed a strong association with the latter vaccination outcome indicators which could be the basis for a short-form version of this scale. We identified one new domain not seen in previous scales, *VPD awareness*, which may be unique to settings where VPDs are still commonly seen in the community, however, it was not associated with most vaccination outcome indicators. In our study, the trust domain was not associated with any assessed vaccination outcomes which could indicate the priority the trust domain has in comparison to other factors which Ghanaian parents consider in the vaccine decision-making process. Several items proposed for use in vaccine hesitancy screening tools for global use or used in other high-income country-based scales failed to load onto any factors in this setting, but replicating such research will help further inform recommendations for use of these items.

In comparison to other scales for assessing parental attitudes towards childhood vaccination, four out of five of our GVAS domains showed similarities with the domain structures of the vaccine confidence scale (VCS) and the parental attitudes towards childhood vaccines scale (PACV). The VCS was developed using existing behavioral questions inserted into the US national immunization survey, whereas the PACV was developed from review of previous parent attitude and belief surveys in the US and then through data collected from a convenience survey in Seattle, Washington. The two items in our beliefs domain closely overlap two of the items which compose the beliefs domain in the vaccine confidence scale (VCS), although one of

the items in our vaccine safety and efficacy domain is also listed in the beliefs domain of the VCS[50, 52]. The two items in our vaccine efficacy and safety domain overlap and are derived from the same domain found in PACV scale[55]. In our scale, we did face challenges in naming the benefits domain and the safety and efficacy domain as the items within each generally appear to overlap from a wording perspective. However, we chose not to eliminate either domain or merge them as none of our factor analyses ever indicated these items were all together strongly associated with only one factor. Additionally, from a wording perspective, there are key differences, as both items in the benefits domain start with "I believe…" and were *Yes/No/Don't know* formats, whereas the two items in the safety and efficacy domain were statements using a Likert scale format. Lastly, our two VPD awareness domain items are de novo, although, they have overlap to items in the *threats* domain of an 8-domain HPV attitudes and beliefs scale developed in Canada[51].

Our overall scale score was associated with both child's vaccination status and days undervaccinated, the latter a measure of vaccination delay, while three of five factors were consistently associated with both of these outcomes. These finding compare favorably to other scales. In the PACV study, the overall scale was associated with vaccination delay, although each domain was not assessed separately against vaccination status[47]. In an adapted version of the PACV for adolescent vaccinations, the two-domain scale score was not associated with vaccination status[70]. Analyses of the VCS indicated the overall score was associated with vaccination status but only one of the three VCS domains was associated with delay [52, 81]. Similar to our finding that the trust domain was not associated with vaccination outcomes, the VCS also reported that the trust domain was not associated with vaccination refusal, status or delay in their US-based population[81].

Multiple studies cite trust in the health system and healthcare provider as a key component of ensuring high vaccination demand and uptake[82]. In our survey, the three items which compose our trusts domain all had very high (>96%) agreement from caregivers, indicating high trust. One possible explanation is that in this high trust environment, trust does not act as a bottleneck to vaccination, rather, other beliefs become more important determinants of vaccination status. A similar finding from the VCS concerning the trust – vaccination outcome association mirrors our findings [52]. A methodological explanation for the lack of trust-vaccination outcome association is a lack of statistical power; nearly all providers reported high trust. Consequently, odds ratios had large confidence intervals despite point estimates which were far from the null for this latter association.

The identification of the VPD awareness domain was unique from previous scales and this may be due, in part, to the context within which developed this scale. Both items in this domain ask about a caregiver's experience with VPDs; we developed these items on the basis of the *availability heuristic*, which is used in the context of vaccinations to describe how a caregiver perceives the probability of a vaccine-preventable infection based upon the availability/ease of recalling relevant past examples[83]. In Ghana, however, because vaccination coverage has been high for several years, most VPDs are actually relatively uncommon; for instance, in 2016, 32 measles cases occurred, although >1600 happened in 2012 and >10,000 as late as 2002. Measles vaccination delay was the one outcome which did show an association with the VPD awareness domain, with one explanation being that measles is a very visible disease, with a vaccine that has been in the schedule for several years, compared to the other vaccines and VPDs. A suggestion for future research is to consider including these VPD awareness items to assess their criterion validity in other settings, particularly those with higher VPD burden.

Replicating our study in other settings is desirable to ensure a fuller picture of how such scales may need to vary in domain structure and item specification. We developed our scale by starting mainly with questions derived from scales used in high-income countries or suggested, but not tested yet, for global use. However, a systematic review of studies conducted to assess caregiver attitudes and beliefs towards vaccination in low and middle-income countries would be useful to generate a listing of items that could be evaluated for their inclusion into another scale development exercise. Future studies should increase the sample size to allow for more precise estimates during the criterion validity steps and also allow for exploratory and confirmatory factor analysis, which would provide additional evidence on the applicability of the scale. Additionally, future research should incorporate a prospective study whereby the predictive criterion validity of this scale is assessed. For program managers and others developing caregiver-based vaccination coverage surveys or vaccination demand interventions and have an interest in incorporating a short list of caregiver beliefs questions, consider using the items under our benefits, efficacy and safety, and/or behavior domains which all showed strong associations with the measured vaccination outcomes. Program managers may also consider suggesting that the items from our benefits domain be considered for routine national household surveys such as demographic health surveys and multiple indicator cluster surveys, such that these surveys provide information on behavioral determinants of vaccination status alongside the usual socioeconomic determinants of vaccination status.

Our study is subject to certain limitations. The survey was cross-sectional, so information for the scale and for vaccination status was collected at the same time, thus our criterion validity was limited to concurrent rather than predictive validity. Our sample size was sufficient for EFA, but we could not split the sample into two sets to also do CFA, which could have further strengthened our results. However, we plan to incorporate CFA into our next

study. For the vaccination status outcome, we did incorporate both card-based and caregiver recall information so we could utilize the entire dataset, so caregiver recall could have some misclassification of vaccination status. However, card retention was very high, so only 20 of the 373 children had recall-based information and in a sub-analysis, vaccination status of children with only recall-based information did not differ from children with card-based information. Our days undervaccinated analysis only used card-based information, so confidence in classification of the analysis is high, although we excluded records where dates of vaccination appeared incorrect, so our sample size did decrease somewhat, thus have some effect on the precision of our estimates. Lastly, we originally planned to use a 5-level Likert scale for Likert formatted questions which could have provided more precision on agreement level fore respondents. However in our initial piloting of these questions in Ghana and similar settings, respondents generally found 5-level scales confusing, thus we reverted to a simpler design.

CONCLUSION

Understanding the caregivers' beliefs and attitudes that drive acceptance of childhood vaccination is critical for the success of any immunization program. Our study is the first to document development of a valid and reliable scale to assess caregiver attitudes and beliefs towards vaccination and show a high level of association of the scale score with child's vaccination status in a low or middle income country setting. This scale could be used for routine monitoring of caregiver attitude and belief trends, evaluation of the effect of caregiver-based interventions to improve quality and coverage of vaccination services, and informing the design of demand-based strategies to improve vaccination uptake. As vaccine hesitancy trends potentially continue to rise globally, development of such tools as this scale become increasingly important to both understand those trends and act to ensure these trends do not counteract the benefits that vaccination affords to all children when they are protected against disease.

Tables and Figures

Table 2.1: Questions used in Global Vaccination Attitudes Scale module in household survey of parents of children 12-35 months of age, Ghana 2016

Question	Style	Source
Children get more vaccinations than are good for them	A/NS/D	[46, 84-86]
Healthy children do not need immunizations	A/NS/D	[46]*
Vaccination does more good than harm	A/NS/D	[46]*
It is better for a child to develop immunity by getting sick than to get a vaccination	A/NS/D	[46] 21, 25
A parent should be allowed to selectively choose the vaccines which she believe her child needs	A/NS/D	[46]*
It is better for a child to receive two injectable vaccinations in 1 visit rather than 1 injectable vaccination in 2 visits	A/NS/D	[46] 21
Many of the illness which vaccinations prevent are severe	A/NS/D	[46] 3,19
When a parent refuses to vaccinate a child, it harms the entire community through risk of disease	A/NS/D	New
People in this community have expressed concerns that a child might have a serious side effect from a vaccination	A/NS/D	[46, 87]*
Following the nationally recommended vaccination schedule is a good idea for a child	A/NS/D	[46]*
If the national immunization policy states that 2 injectable vaccines should be given in the same arm/leg would you allow it?	Y/DK/N	New
I believe vaccines are safe	Y/DK/N	[52]
I believe vaccines protect my child from vaccine preventable disease.	Y/DK/N	[52]
Have you personally seen someone with either polio, pneumonia, measles or whooping cough?	Y/DK/N	New

Do you know of someone in your family or community who had either polio, pneumonia, measles or whooping cough?	Y/DK/N	New
Have you ever delayed having your child get a vaccination for reasons other than illness or allergy?	Y/DK/N	[46, 88]
Have you ever decided not to have your child get a vaccination for reasons other than illness or allergy?	Y/DK/N	[46, 88]
If you had another infant today, would you want your infant to get all recommended vaccinations?	Y/DK/N	[46, 88]
Do you know the location where you can have your child vaccinated?	Y/DK/N	New
Do you know the days and times when vaccination services are offered in your community?	Y/DK/N	New
Are you able to discuss any concerns you have about vaccinations with your child's healthcare provider?	Y/DK/N	[46, 84, 89, 90]
Do you trust the information that you receive from your local healthcare worker about vaccinations?	Y/DK/N	[46, 89, 90]

A/NS/D = Agree/Not sure/disagree; Y/DK/N = Yes/do not know/no

*Indicates the source question was modified for the Ghana scale

Table 2.2: Factor loadings for development of 5-factor scale version of the Global Vaccine Acceptance Scale, Ghana 2017

		Standardized factor loading				
Item	Item mean (SD)	VPD Awareness	Benefits	Past behavior	Efficacy & safety	Trust
Have you personally seen someone with either polio, pneumonia, measles or whooping cough?	1.58 (0.04)	0.93				
Do you know of someone in your family or community who had either polio, pneumonia, measles or whooping cough?	1.71 (0.04)	0.93				
I believe vaccines are safe	0.03 (0.01)		0.93			
I believe vaccines protect my child from vaccine preventable disease.	0.03 (0.01)		0.95			
Have you ever delayed having your child get a vaccination for reasons other than illness or allergy?	0.48 (0.04)			0.89		
Have you ever decided not to have your child get a vaccination for reasons other than illness or allergy?	0.32 (0.04)			0.78		
Vaccination does more good than harm	0.24 (0.03)				0.85	
Many of the illnesses which vaccination prevent are severe	0.19 (0.02)				0.45	
If you had another infant today would you want your infant to get all recommended vaccinations?	0.07 (0.02)					0.55
Do you trust the information that you receive from your healthcare worker about vaccinations?	0.05 (0.01)					0.54
Following the nationally recommended vaccination schedule is a good idea for my child	0.04 (0.01)					0.66
Omega coefficient		*0.94*	*0.99*	*0.86*	*0.92*	*0.78*
Alpha coefficient		*0.78*	*0.87*	*0.64*	*0.54*	*0.41*
Mislevy & Bock reliability		*0.90*	*0.94*	*0.85*	*0.80*	*0.73*

Factor loadings <0.30 not shown and items which failed to load onto any of the five factors not listed in table

Table 2.3: Association of Global Vaccination Acceptance Scale score and sub-scale scores with child's receipt of listed vaccination(s); cross-sectional survey in Northern Region, Ghana, 2017

				Factor sub-scale				
			Complete scale (11 items)	VPD Awareness (2 items)	Benefits (2 items)	Past behavior (2 items)	Efficacy & safety (2 items)	Trust (3 items)
Vaccine(s)	Received	n (%)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
All vaccines[1] (n=373)	Yes	299 (80%)	0.56 (0.43, 0.72)	0.77 (0.50, 1.18)	0.16 (0.04, 0.64)	0.64 (0.45, 0.92)	0.32 (0.19, 0.55)	0.69 (0.15, 3.22)
	No	74 (20%)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Penta-3[2] (n=373)	Yes	337 (90%)	0.58 (0.41, 0.80)	0.94 (0.54, 1.64)	0.09 (0.02, 0.39)	0.65 (0.40, 1.04)	0.34 (0.17, 0.66)	0.43 (0.07, 2.38)
	No	36 (10%)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
MCV-1[3] (n=373)	Yes	316 (85%)	0.50 (0.37, 0.68)	0.98 (0.62, 1.55)	0.12 (0.03, 0.50)	0.50 (0.33, 0.75)	0.32 (0.18, 0.58)	0.43 (0.09, 1.93)
	No	57 (15%)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.

Definitions: 1. All vaccines includes 3-dose oral polio vaccine series, 3-dose pentavalent vaccine series, 3-dose pneumococcal vaccine series, 2-dose rotavirus vaccine series and 1st dose of measles-containing vaccine. 2. Penta-3 = 3rd dose of the pentavalent vaccine series. 3. MCV-1 = 1st dose of the measles-containing vaccine. OR = odds ratio. CI = confidence interval. VPD = vaccine-preventable disease. Ref. = reference level for the given measure of association.

Table 2.4: Association of Global Vaccination Acceptance Scale score and sub-scale scores with child's delay in vaccinations received as measured by days undervaccinated through 12 months of age, Ghana 2017

Vaccines	Delayed n (%)	Mean days under-vaccinated[4] (95% CI)	Beta coefficient: days undervaccinated (95% CI)					
			Complete scale	VPD Awareness (2 items)	Benefits (2 items)	Past behavior (2 items)	Efficacy & safety (2 items)	Trust (3 items)
All vaccines[1] (n=279)	262 (94%)	382.4 (294.7, 468.1)	85.5 (28.2, 142.8)	12.0 (-103.3, 127.4)	1230.9 (768.4, 1693.3)	116.0 (0.1, 232.2)	214.7 (46.2, 383.1)	303.3 (-174.8, 781.5)
Penta-3[2] (n=344)	113 (33%)	110.6 (91.9, 129.4)	11.1 (3.7, 18.4)	-1.0 (-12.9, 10.8)	101.0 (51.3, 150.6)	7.0 (-5.1, 19.0)	23.4 (5.3, 41.4)	31.2 (-16.3, 78.7)
MCV-1[3] (n=353)	314 (89%)	51.3 (47.7, 54.8)	5.6 (2.2, 8.9)	6.5 (1.3, 11.7)	19.1 (-3.3, 41.5)	4.6 (-0.5, 9.8)	4.1 (-3.9, 12.1)	-11.4 (-32.7, 9.9)

Definitions: 1. All vaccines includes 3-dose oral polio vaccine series, 3-dose pentavalent vaccine series, 3-dose pneumococcal vaccine series, 2-dose rotavirus vaccine series and 1st dose of measles-containing vaccine. 2. Penta-3 = 3rd dose of the pentavalent vaccine series. 3. MCV-1 = 1st dose of the measles-containing vaccine. 4. Days undervaccinated calculated only among the proportion who were delayed, as the number of days a child had not received the given vaccine(s) after the end of the buffer period that determines a timely vaccination, using the 2016 Ghana vaccination schedule for recommended age of vaccination, with a 30-day buffer period after that age. CI = confidence interval. VPD = vaccine-preventable disease.

Figure 2.1: Flowchart of methodology used to develop the Global Vaccination Attitudes Scale and key outcomes of each step, Ghana 2017


Identify measures
•Review of previous research on scales to assess parents' vaccination-related attitudes, beliefs and knowledge
•Development of de novo scale measurement items based on past experience
•Outcome: 22 measure items identified for use in survey
Collect data
•Cross sectional survey of 373 parents of children aged 12-35 months in Northern Region, Ghana
•Parents interviewed using scale measurement items, questions on child's vaccination dates/status
•Outcome: Data from 373 parent-child pair interviews collected for use in scale development
Assess construct validity
•Exploratory factor analysis
•Determine number of factors to extract using a combination of : Parallel analysis, VSS, MAP, scree plot, % variance explained, and theory underlying previous scales
•Assess factor loadings for measurements to retain with each factor; retain items which load at >0.30 for a factor
•Outcome: Contruct validated 5-factor scale with 11 measurement items
Assess reliability
•Assess internal reliability / consistency
•Mislevy & Bock reliability estimate, McDonald's omega coefficient & Cronbach's alpha coefficient
•Outcome: 5-factor scale with 11 items has adequate reliability and construct validity measures
Assess criterion validity
•How well does total scale score measure the concurrently collected information on child's vaccination status (vaccination receipt and vaccination delay)
•Identify if any factor scores (i.e. sub-scale scores) are not significantly associated with with child's vaccination status
•Outcome: 3-factor scale with 6 items has adequate criterion validity measures
Final scale
•Selection based construct validity, reliability and criterion validity results
•Outcome: Validated and reliable 3-factor scale with 6 items

SUPPLEMENTAL TABLES, FIGURES AND DESCRIPTIONS

Supplemental Table 2.5: Parameters for defining vaccination delay and days under-vaccinated up to 12 months of age

Vaccine	Age of early vaccination (days)	Earliest age for a valid vaccination (days)	Age of late vaccination (days)	length of buffer period (days)	Maximum number of days under-vaccinated
Penta1, PCV1, RV1, OPV1	≤38	42	>69	31	296
Penta2, PCV2, RV2, OPV2	≤66	70	>97	31	268
Penta3, PCV2, OPV3	≤94	98	>125	31	240
Measles1	≤248	252	>279	31	86
All vaccines	NA	NA	NA	NA	2412

*

Descriptive results of Ghana survey sample

Among all children, 337 (90%) had received Penta-3, 316 (85%) had received MCV-1, and 299 (80%) had received all vaccines. Among those with sufficient data for assessing vaccination delay, 33% were delayed for Penta-3, 89% were delayed for MCV-1 and 94% were delayed for any vaccine. Among those delayed for Penta-3 and MCV-1, the mean days undervaccinated was 36.3 (standard deviation [SD] =78) and 45.7 (SD=34), respectively. Across all vaccines, the mean days undervaccinated was 358 (SD=696).

Children of mothers who did not attend school were less likely than children of mothers with primary or secondary educational attainment to receive Penta-3 vaccination (88% versus 92% and 98%, respectively). Similarly, children of parents following a Traditionalist religion were less

likely than Christian and Muslims to have received Penta-3 vaccination (81% versus 92% and 90%, respectively). Firstborn children were slightly more likely to have received Penta-3 versus later-born children (93% versus 90%), as were female children compared to male children (93% versus 88%).

Among interviewed caregivers, 20% indicated they had seen an individual with either polio, pneumonia, measles or whooping cough and 13% knew of someone in their family or community who had one of the latter diseases. Nearly all (99%) knew the location of vaccination and days/times of vaccination (94%). Nearly all believed vaccines to be safe (97%), although 22% indicated that people in their community had expressed concerns possible side effects from vaccination. Although nearly all (97%) believed that following a nationally recommended vaccination schedule is a good idea and 96% would want to have any future children get all recommended vaccinations, 22% and 15% had indicated either ever delaying or ever deciding not to have a child receive a vaccination for reasons other than illness or allergy. A slight majority (57%) of caregivers said they were able to discuss concerns about vaccination with their local healthcare provider, although nearly all (97%) trusted the information they received about vaccination from the provider. A sizeable minority (23%) believed that healthy children did not need immunizations and expressed concerns about the number of vaccinations provided, with 41% agreeing that children get more vaccinations than are good for them and 23% disagreeing that children should get two injectable vaccinations in 1 visit rather than one per visit.

Supplemental Table 2.6: Descriptive characteristics of parents and children interviewed for development of Global Vaccination Acceptance Scale, Ghana, 2017

Characteristic		N (%)
Child's age		
	12-23 mo.	201 (54%)
	24-36 mo.	172 (46%)
Child's sex		
	Female	176 (47%)
	Male	197 (53%)
Child's birth order		
	first child	80 (22%)
	second or more	293 (79%)
Child has vaccination card		
	Yes	353 (95%)
	No	20 (5%)
Child ever received vaccination		
	Yes	371 (99%)
	No	2 (1%)
Parents' religion		
	Christian	137 (37%)
	Muslim	195 (52%)
	Traditionalist	37 (10%)
	None	4 (1%)
Mother's age (years)	mean (SD)	28.9 (6.6)
	N missing	106
Mother's education		
	Never attended school	261 (70%)
	Primary education	40 (11%)
	Secondary or post-secondary education	70 (19%)
Mother's occupation		
	Farmer/Laborer	214 (57%)
	Artisan/trader/merchant	68 (18%)
	Housewife	32 (9%)
	Other	59 (16%)
Father's education		
	Never attended school	218 (59%)
	Primary education	41 (11%)
	Secondary or post-secondary education	105 (28%)
Father's occupation		
	Farmer/Laborer	270 (72%)
	Artisan/trader/merchant	48 (13%)

Civil servant	26 (7%)
Other	29 (8%)

CHAPTER 3: AIM 2 MANUSCRIPT

Title: Home-based records and vaccination appointment stickers as parental reminders to reduce vaccination dropout in Indonesia: a cluster randomized controlled trial

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Keywords: vaccine hesitancy, vaccine acceptance, Ghana, vaccination delay, factor analysis

Abstract

Introduction: Little evidence exists about the effectiveness of strategies to reminder caregivers when to bring children back for future vaccinations in low and middle-income country settings. We evaluated the effectiveness of two reminder strategies based on home-based vaccination records in Indonesia.

Methods: In this cluster-randomized controlled trial involving children, 90 health facilities were randomly assigned to either a control group or one of two intervention groups: 1) home-based record-only group, where healthcare providers ensured any child without a home-based record during a vaccination visit received one to keep at home between visits, or 2) group, where providers placed future vaccination appointment reminder sticker placed on the front of home-based record+sticker the home-based record and ensured provision of home-based records. The primary outcome was receipt of the third dose of diphtheria-tetanus-pertussis containing vaccine (DTPcv3) by end of 7 months (analyzed using generalized estimation equations [GEE]), and secondary outcome was receipt of a timely DTPcv3 dose (analyzed with GEE and cox proportional hazards models), among children who had received DTPcv1.

Results: In intention to treat analysis, neither intervention group had significantly different DTPcv3 coverage compared to the control group (RR=0.94, 95% CI: 0.87, 1.02 for Home-based record-only group; RR=0.97, 95% CI: 0.90, 1.04 for Home-based record+sticker group) by study end. However, Home-based record+sticker group children were 50% more likely to have received a DTPcv3 vaccination (RR=1.46, 95% CI: 1.02, 2.09) within 60 days of DTPcv1 vaccination, compared to children in the control group. Home-based record-only group children were 5% more likely to do so (RR=1.05, 95%CI: 0.71, 1.55). Per protocol analyses showed similar

but slightly stronger effects for DTPcv3 timeliness for the Home-based record+sticker group compared to control group.

Discussion: In this setting, the use of the reminder stickers had an immediate effect on coverage by improving the proportion of children who received a timely DTPcv3 dose, however this effect waned and did not change the proportion of children who received DTPcv3 over an extended period. Coupling the use of reminder stickers with strategies to address other reasons while children do not return for future vaccination visits need further exploration.

INTRODUCTION

A variety of interventions are available to remind parents to ensure they bring one's child back to a health facility for future vaccinations. These interventions are commonly described as parental reminder/recall systems and are considered a key demand generation tool available to healthcare providers [58]. Parental reminders can take on several forms, including letters or postcards to patients, person-to-person telephone calls, computerized phone messages, combinations of postcards and phone, community outreach, and reminders for healthcare providers alongside parents[58]. Evaluations of parental reminders show a positive effect on vaccination uptake, with two recent systematic reviews indicating that they can increase vaccination coverage by 4-20% [58]; however, nearly all reviewed reminder evaluations were set in high-income countries [59, 60].

In the 2015 systematic review of parental reminder studies, Harvey et. al. identified 13 randomized controlled trials (RCTs) of parental reminders; eleven were postal-based reminder and two were telephone reminders [63]. The majority of the reviewed studies were in based in the US; two were based in a lower-middle income country, Pakistan [63]. The Pakistan-based studies assessed the feasibility of using a future vaccination appointment date sticker on the child's home-based record (home-based record) or vaccination card and found that this strategy improved coverage of the third dose of diphtheria-pertussis-tetanus-containing vaccine (DTPcv3) by 10-20%. Although these studies have promising results, they were both of short duration (3 months) and the interventions were implemented by study personnel rather than healthcare providers. As highlighted by the systematic reviews and the two Pakistani studies, additional evaluation of home-based record-based parental reminder strategies is needed in other low and middle-income country settings to better understand their possible benefits.

The World Health Organization (WHO) has long recommended that all children globally should receive an home-based record to ensure the caregiver is aware of the services the child has and has not received; consequently their use is ubiquitous worldwide[64]. Use of a parental appointment sticker placed on the home-based record could be a simple strategy to ensure parents return promptly for the next recommended childhood vaccination. Yet in some countries, the proportion of caregivers who receive or are allowed to keep the child's home-based record at home can be quite low which may limit their effect as a parental reminder of future vaccinations. In Indonesia, for instance, only 41% of children aged 12-23 months surveyed in 2012 had an home-based record present during the household-based interview even though 71% indicated their child had received at least one recommended vaccination[91].

Since little evidence exists about the effectiveness of home-based record-based reminders in low and middle-income countries despite their promise from results in several high-income countries, we implemented a cluster randomized control trial in Indonesia designed to estimate the effect of the following two simple and low-cost parental reminder interventions on completion and timeliness of the 3-dose DTPcv series: 1) ensure parents receive an home-based record to keep at home and are provided a vaccination appointment reminder sticker on the home-based record at each childhood vaccination visit, and 2) ensure parents an home-based record to keep at home.

METHODS

Study Design, Recruitment and Randomization

We used a cluster-randomized controlled trial (cRCT) design to measure the effect of each intervention, randomizing at the health facility level into one of three study groups. Five districts in West Java province Indonesia (Cianjur, Cirebon, Kota Bundung, Kota Depok and Sukabumi), were purposively chosen using the following criteria: (a) no known or anticipated activities in the district to improve vaccination service utilization, (b) no scheduled communication messages promoting home-based record ownership, and (c) a sufficiently large estimated target population to support study sample size requirements. The study intervention period began on January 1 2016 and lasted 7 months.

All public health facilities which provided vaccinations within these districts were included in the study sampling frame. Facility eligibility criteria included government-owned (public), regularly providing vaccination services, and having an estimated number of annual births ≥360. The initial sampling frame contained 264 public health facilities; two were omitted due to no information on number of annual births and 32 were omitted due to the number of annual births being <360. To reduce possible confounding by district, we first stratified the facility sampling frame by district, then within each district, we randomized six facilities to each study group using simple random sampling for a total of 30 randomized facilities per group.

All children who received DTPcv1 in a study health facility in January 2016 and had this vaccination recorded on the facility vaccination register were eligible for inclusion in the study. Based on the target populations <1 year of age for the 90 study facilities, we estimated that 3600 children would be included in the study. Consent for participation in the study was received from the district health management teams and facility officer-in-charge prior to

randomization. This study was approved by the institutional review boards of the University of Indonesia and US Centers for Disease Control and Prevention (CDC).

Intervention Procedures

For healthcare provider orientation to the interventions and provision of intervention materials, we used a cascading approach that would mimic how Indonesia introduces a new health intervention, so that our study outcome measurements would best reflect intervention effectiveness. The cascade approach started with an orientation of national, province and district health management staff, and partner organizations (UNICEF and CDC) in October 2016. After this orientation, the province and district health teams were instructed to orient intervention health facilities and provide intervention materials prior to January 2016.

In home-based record-only study group health facilities, healthcare providers were instructed to provide a home-based record to a caregiver of a child anytime the caregiver had not yet received a home-based record or had forgotten to bring the home-based record to the vaccination visit. The provider was instructed to tell the parent to keep the home-based record at home and remember to bring it back at the next vaccination visit. All children coming for vaccination were eligible for this intervention.

In the home-based record+sticker intervention health facilities, healthcare providers followed the same home-based record provision rules as those in the home-based record-only study group. Additionally, they were instructed to affix a future vaccination visit reminder sticker to the front of the home-based record during a vaccination visit for child still due for a future vaccination, write the date of the next vaccination visit on the reminder sticker, and explain the purpose of the sticker to the caregiver. All children coming for vaccination were

eligible for this intervention. In control study group health facilities, healthcare providers followed their usual practice for vaccination reminders, home-based record provision and home-based record storage location.

Outcomes

The primary outcome of interest was child-level receipt of DTPcv3 prior to the end of the study. Vaccination status was determined by retrospective review of the health facility vaccination register. At study end, trained data collectors visited each study facility and abstracted the complete vaccination record for each child that had received DTPcv1 in January 2016. Information abstracted were: child's gender, child's dates of birth and all vaccinations received.

Our second outcome of interest was DTPcv3 vaccination timeliness. To calculate timeliness of a DTPcv3 vaccination, we used two methods: (a) receipt of DTPcv3 within a certain timeliness period after DTPcv1, and (b) time to DTPcv3 vaccination or end of intervention period. We created a binary variable for each child which indicated receipt of DTPcv3 56-60 days after DTPcv1, as 56 days is the minimum recommended spacing between these doses. We also created additional binary variables indicating receipt of valid DTPcv3 within 70 days of DTPcv1 and within 90 days of DTPcv1. For time to DTPcv3 vaccination or end of study, we created a variable defined as the number of days between DTPcv1 vaccination and either DTPcv3 vaccination (event) or end of study (censoring). The latter variable was used in survival analyses.

Statistical Analysis

To calculate our a-priori sample size, we made the following assumption: (a) DTPcv3 coverage in control groups was 70%, based on 2014 coverage information in study districts, (b) 40 children per facility, based on average target population of children <1 year of age,(c) intraclass correlation coefficient of 0.10, based on recent household surveys, (d) alpha of 0.05, and (e) power of 80% to detect an absolute increase of 11% in the proportion of children receiving DTPcv3 in the intervention versus control study group (based on results from previous reminder studies showing 10-35% coverage increase). The target sample size was 30 facilities per group.

Prior to any analysis, we examined the dataset for any invalid or missing dates of birth, invalid dates of DTPcv vaccination and invalid doses. Invalid dates of birth and vaccination were identified by examining if any dates of DTPcv vaccination came before the dates of birth. If these occurred, we reconciled if feasible and excluded those which could not be reconciled. Invalid doses were defined as those doses where the minimum interval between DTPcv doses was <28 days. For all analyses, only valid DTPcv dose data were used.

Intention to Treat Analysis

Our primary analyses were intent to treat, with individuals analyzed according to the group with which their facility was randomized. We modeled binary and continuous outcomes using generalized estimating equations (GEE) with a log link function to calculate risk differences and risk ratios with 95% confidence intervals (CI). A cluster effect for facility, with an exchangeable correlation structure, was included in the model. Covariates used in the model were child's gender (male/female), age of child at DTPcv1 vaccination date (in days), hepatitis B birth dose vaccination status prior to receipt of DTPcv1 (yes/no), and child's home district.

We modeled time to DTPcv3 vaccination using a cox proportional hazards model to calculate hazard ratios with 95% CI. A cluster effect for facility was included in the model alongside previously covariates. The calculation of survival time started at the day of DTPcv1 to the day of DTPcv3 vaccination or end of study period. SAS version 9.3 and SAS-callable SUDAAN were used for analysis of data.

Per-Protocol Analysis

To assess adherence to the intervention, staff at each intervention health facility were surveyed at the end of the study to provide information on when they received intervention materials (reminder stickers and additional home-based records) and their acceptance and use of the interventions. A-priori, a decision was made that if it was determined that intervention materials had arrived after the start of the intervention period, a per-protocol analysis would be conducted whereby intervention facilities would be reclassified into the appropriate study group and the various analyses redone as per the previous methods.

Post-Hoc Analyses

In a post-hoc analysis, we re-analyzed our primary and secondary outcomes of interest using ITT among only those children who had received a second dose of DTPcv (DTPcv2), under the theory that intervention facility healthcare providers would be more experienced with the interventions and thus adhering better to the intervention protocols.

RESULTS

Of the 3633 records abstracted from health facilities, 17 were discarded (12 from Group 1 facilities and 5 from Group 2 facilities) due to invalid vaccination data. Vaccination records from 3616 children in 90 health facilities were analyzed (Figure 3.1). Most baseline indicators appeared balanced across study groups, however, children in the Home-based record-only study group were generally older (87 days of age versus 77-79 days) and less likely to have received BCG vaccination (90% versus 95%) at baseline compared to children in the other two groups (Table 3.1).

During healthcare provider interviews, multiple intervention providers indicated receipt of intervention materials (cards and/or stickers) after the presumed start of the intervention on 1/January. Due to this finding, we reclassified facilities based on whether or not they had received intervention materials before January and re-analyzed the results per protocol. Among the 30 Home-based record+sticker intervention facilities, 7 were reclassified as Home-based record-only and 3 were reclassified as control. Among the 30 Home-based record-only facilities, 11 were reclassified as control.

Primary Outcome

By the end of the study, there was no significant difference in the proportion of Home-based record+sticker group children who had received DTPcv3 vaccination (77%) compared to control group (81%) (RR=0.97, 95% CI: 0.90, 1.04) nor in the proportion of Home-based record-only group children who had received DTPcv3 (74%) compared to control group (RR=0.94, 95% CI: 0.87, 1.02) (Table 3.2).

Under per protocol analysis, there was still no significant difference in the proportion of Home-based record+sticker group children who had received DTPcv3 vaccination (77%) compared to control group (78%) (RR=0.99, 95% CI: 0.98, 1.09) nor in the proportion of Home-based record-only group children who had received DTPcv3 (74%) compared to control group (RR=0.96, 95% CI: 0.88, 1.05) (Table 3.3). Using a modified per protocol analysis approach where intervention facilities were not reclassified into the control group if they had not started the intervention by January 2016, the results were virtually the same as the intention to treat analysis (supplementary table 3.1).

Secondary Outcomes

However, home-based record+sticker group children were nearly 50% more likely to have received a valid DTPcv3 vaccination with 60 days of DTPcv1 vaccination (DTPcv3 coverage at 60 days=32%) compared to children in the control group (23%); (RR=1.46, 95% CI: 1.02, 2.09). Home-based record-only group children were 5% more likely to do so, although this was non-significant (DTPcv3 coverage at 60 days=24%), (RR=1.05, 95%CI: 0.71, 1.55) (Figure 3.2). This timeliness effect for the Home-based record+sticker group children appeared transitory as by 90 days after DTPcv1 vaccination, the likelihood of DTPcv3 vaccination compared to control group children was nearly equal (61%), (RR=0.99, 95% CI: 0.96, 1.03). Survival analysis results indicated similar trends; Home-based record+sticker group children had a 9% greater likelihood of time to DTPcv3 vaccination within 60 days (HR: 1.09, 95% CI: 0.96, 1.22) compared to control group children whereas there was no difference in time to DTPcv3 vaccination within 60 days between Home-based record-only children and control group children (HR: 0.99, 95% CI: 0.89, 1.09).

Compared to ITT results, under per protocol analysis, the Home-based record+sticker intervention showed a significant and stronger effect on the proportion of Home-based record+sticker group children who received a more timely DTPcv3 vaccination compared to control group children. 13% (95% CI: 2%, 24%) more Home-based record+sticker children received DTPcv3 within 60 days of DTPcv1 (coverage=37%) compared to control group children (coverage=24%) and 10% (95%CI: 1%, 22%) more within 70 days (57% versus 47%) (Figure 3.3). By 100 days, the proportion was equal (69%), (RD: 0%, 95% CI: -9%, 8%) between these groups, again indicating a transient timeliness effect from the Home-based record+sticker intervention. Survival analysis results indicated timeliness effects that were also stronger compared to ITT results. Home-based record+sticker group children were 23% more likely have a more timely DTPcv3 vaccination within the follow-up period compared to control group children (HR: 1.23, 95% CI: 1.11, 1.37). Per protocol survival analysis indicated Home-based record-only group children were 11% more likely to receive a more timely DTPcv3 vaccination compared to control group children (HR: 1.11, 95% CI: 1.02, 1.22).

In a post-hoc analysis among only children who received DTPcv2 (n=3088, 85% of total), children in the Home-based record+sticker group were significantly more likely to receive a more timely DTPcv3 vaccination (HR: 1.31, 95% CI: 1.18, 1.45); additionally, children in the Home-based record-only group were also more likely to receive a more timely DTPcv3 vaccination (HR: 1.16, 95% CI: 1.05, 1.27). However, by the end of the study, children across all three study groups were nearly equally likely to receive DTPcv3 vaccination (RR for Home-based record+sticker group: 1.03, 95% CI: 0.98, 1.07; RR for Home-based record-only group: 0.99, 95% CI: 0.93, 1.04).

Healthcare provider acceptability

The healthcare providers in the Home-based record+sticker group were generally very positive about use of reminder stickers to bring caregivers back for the next vaccination as they felt it helped remind parents of vaccination since it was on the front of the home-based record and was easy to implement. However, in both intervention groups, only 33% of providers supported providing new home-based record to caregivers without an home-based record and approximately 45% of each group did not provide new home-based record if the parent forgot the card.

DISCUSSION

Children of parents who attended facilities that provided sticker-based reminders of future vaccination appointments were more likely to have a more timely DTPcv3 vaccination, however, the effect was modest and transient since it result in higher DTPcv3 coverage by the end of the 7 months. Providing a new home-based record to parents of children who came without a home-based record did not have any effects on vaccination coverage or timeliness; a majority of providers indicated resistance in implementing this strategy which likely hindered the effect. The reminder sticker strategy may be a consideration if packaged with other interventions designed to improve parents' knowledge and demand for vaccination.

Our results differ from the two home-based record-based sticker reminder studies based in Pakistan that reported a positive effect of the intervention on completion of the DTPcv series [61, 62]. A number of study characteristic differences may explain why our results differ. Our study was longer (7 months versus 3 months), we used healthcare providers to implement the interventions whereas trained study personnel implemented the interventions in Pakistan, we included 90 health centers versus 5 in Pakistan, our final control group DTPcv3 coverage was high (81%) versus 55% for the control group in Pakistan, and a number of our intervention facilities experienced a lag in intervention startup whereas no reported lag occurred for the Pakistan study.

One factor that may explain why control group health facilities eventually caught up to the same level of coverage as the Home-based record+sticker intervention facilities is the use of a strategy in Indonesia known as sweeping. Although it is not meant to be a core strategy for vaccinating children, sweeping occurs every quarter and is acts as a short vaccination campaign run by facility and community-based health workers to catch up all children < 12 months of age

who failed to return for vaccination at a health facility or outreach vaccination site. The 2012 Indonesia program review cited this strategy as unsustainable and urged the government to focus on investments into fixed and outreach-based vaccination as more sustainable strategies. It is possible that the sweeping activities succeeded in catching up those children who were missed, while in the Home-based record+sticker intervention group, those children who would have been vaccinated through sweeping instead ended up coming to the facility due to the effect of the sticker as a reminder of the next vaccination visit. Another possible explanation for the effect of the sticker on a more timely vaccination but not on increased vaccination coverage is the timing of the sticker as a reminder since it was provided at least 28 days prior to when the next visit would occur. The period between a reminder and the event for the reminder may dilute the reminder effect, particularly if the sticker-enhanced home-based record is not stored in visible location in the household. Other reminders that are provided immediately prior to the visit could have more effect, such as a phone-based text message to the parent one week prior to the visit or a mailed postcard received by the parent just prior to the visit.

The sticker and home-based record are designed to address a parent's lack of awareness about when to bring the child back for vaccination, however lack of knowledge about future visits is only one determinant of why children are incompletely vaccinated. For instance, a parent may be concerned about fever the child may have after vaccination, particularly if they have not been informed that this can be a normal response, and this reaction may result in their refusal to allow the child to receive any more vaccinations, whether or not they are reminded by the sticker and home-based record [82, 88, 92]. A recent immunization drop-out study by UNICEF Indonesia revealed that 70% of surveyed mothers of incompletely vaccinated children thought that fever after vaccination was not normal; additionally 60% had an unfavorable

opinion about vaccination services received. Both of these factors can lead to incomplete vaccination and would be challenging to solve through use of sticker and/or home-based record alone.

Our study has a number of limitations. We did identify exposure misclassification since a series of intervention group facilities did not start the intervention during the expected timeline; we addressed this limitation through per protocol analysis. However, as we only used facility-based vaccination records, we were restricted to individual-level covariate data already routinely collected through this system, thus in the per-protocol analysis, we could not control for other covariates commonly included in such analyses, such as maternal education, birth order of child, parents' income status and ethnicity. Additionally, we did not have information at an individual level about whether a parent who attended an intervention facility actually received the specified reminder so it is possible that even our per-protocol analysis may have under-estimated the interventions' effects. Lastly, the control group coverage was about 10% higher (70% versus 81%) than we had assumed in our sample size calculations for seeing a desired effect size of >11%; we would have needed to increase the number of facilities to 150 to have this same level of precision.

Our study has several strengths. We designed our study to closely mimic an effectiveness study and with scalability in mind by ensuring that health workers implemented the intervention rather than study staff. We further minimized involvement of study staff by using a cascade-style training approach where district health teams oriented health workers to the interventions, as is typical for roll-out of these types of interventions in Indonesia and many other countries. Additionally, our per-protocol analysis of DTPcv3 coverage and timeliness and sensitivity analysis among only Penta2 recipients largely mirrored our ITT analysis.

Despite our findings of no effect on DTPcv3 coverage, further replication of this study, particularly in low-income countries with limited immunization program resources, would be useful to ensure a full picture of the effects of these interventions. In any future research, including a follow-up survey of parents exposed to such reminder interventions would be useful to understand how they use home-based records in the home. The use of stickers and home-based records as reminders may also need to be included into an integrated healthcare provider – caregiver communications package designed to ensure parents receive adequate information on the benefits of vaccination, the likelihood of side effects and adverse events following immunization and how they should respond, when and where to return for future vaccination visits, and the use of an appointment reminder sticker on the home-based record.

CONCLUSIONS

The combined use of the home-based record and an inexpensive appointment reminder sticker placed on the front of the home-based record led to mild improvement in the timeliness of DTPcv3 vaccination among our intervention group compared to standard practice. Although substantial research is focused on assessing the effect of more expensive vaccination appointment reminder options (such as text messages and voice messages), additional efforts are still needed to examine the effects of simple, easily deployable reminder options in resource-limited settings where logistical hurdles to deploying more sophisticated options exist. Further understanding the benefits and limits of such simple reminder options (like the reminder stickers) in other low and middle-income country settings will provide valuable information to program managers considering the multiple options available for ensuring children continue to return and complete all recommended vaccinations.

Figures and Tables

Figure 3.1: CONSORT diagram

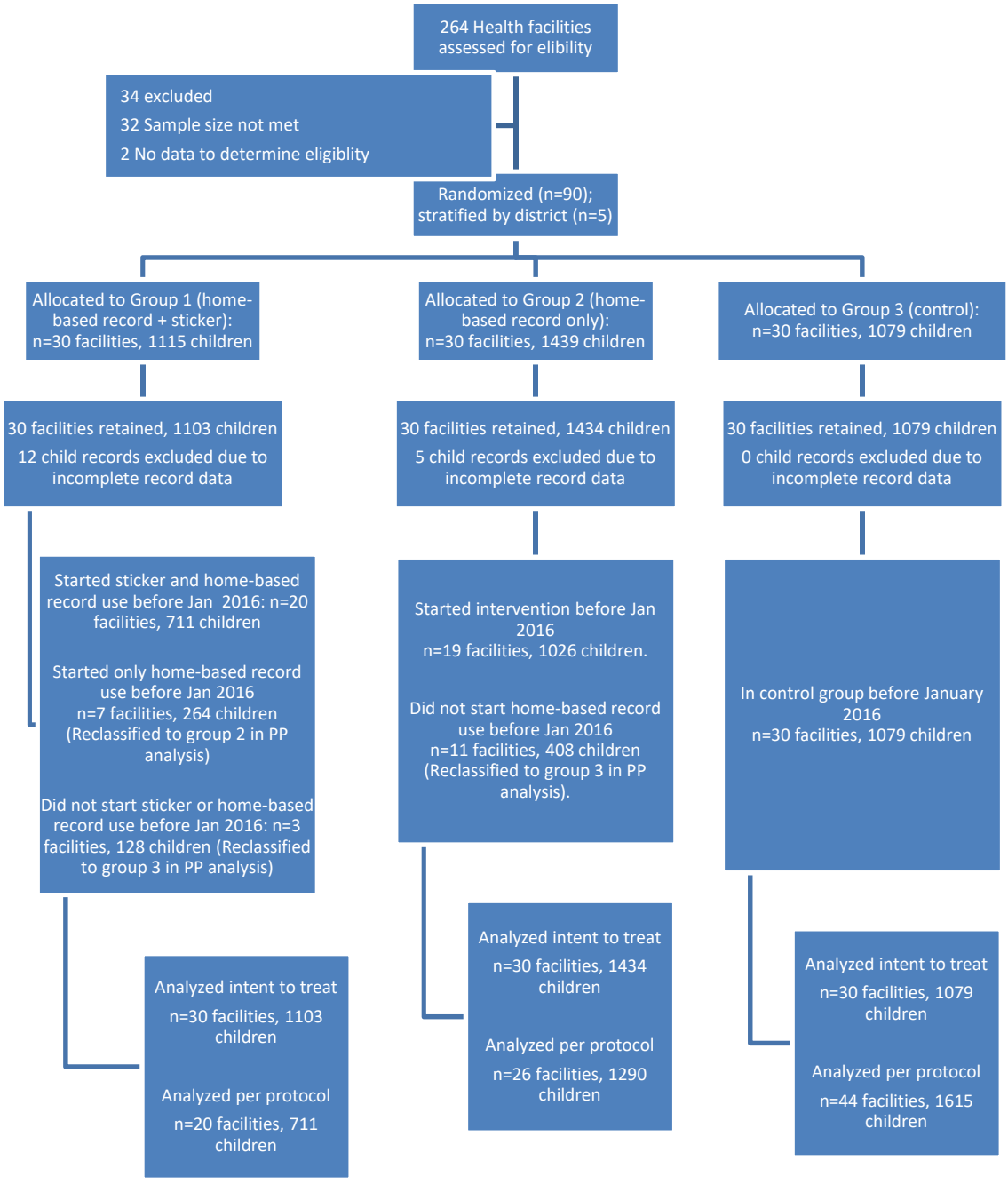


Table 3.1: Characteristics of study participants and sites among study groups for parental reminder intervention, Indonesia 2015-2016

Characteristic	Total	Study group		
		Card and appointment sticker (Group 1)	Card-only (Group 2)	Standard practice (Group 3)
Number of vaccination records	3616	1103	1434	1079
Child's home district, % (95% CI)				
1	9 (3, 15)	10 (0, 20)	7 (0, 16)	10 (0, 22)
2	33 (20, 46)	34 (11, 57)	34 (10, 58)	31 (9, 53)
3	26 (14, 38)	26 (7, 45)	29 (6, 52)	23 (4, 41)
4	11 (5, 18)	10 (0, 19)	14 (1, 28)	9 (0, 19)
5	20 (11, 30)	20 (4, 36)	16 (1, 30)	27 (5, 48)
Child's gender, % (95% CI)				
Male	49 (47, 51)	48 (46, 51)	49 (46, 52)	50 (46, 53)
Female	51 (49, 53)	52 (49, 54)	51 (46, 54)	51 (47, 54)
Mean age of child at Penta1 vaccination, days (95% CI)	82 (77, 87)	79 (74, 83)	88 (75, 100)	77 (73, 81)
Mean age of child at end of follow-up period, days (95% CI)	282 (277, 287)	279 (274, 284)	288 (275, 300)	277 (273, 280)
Penta1 vaccination date available in child's record, % (95% CI)				
Yes	100 (100, 100)	100 (99, 100)	100 (100, 100)	100 (100, 100)
No	0 (0, 0)	0 (0, 1)	0 (0, 0)	0 (0, 0)
Child's BCG vaccination status, % (95% CI)				
Yes	93 (90, 95)	95 (91, 98)	90 (83, 97)	95 (92, 98)
No	7 (5, 10)	5 (2, 9)	10 (3, 17)	5 (2, 9)

CI = Confidence interval; BCG = bacille Calmette-Guerin vaccine; Penta = Pentavalent vaccine, containing diphtheria, tetanus, pertussis, hepatitis B and Haemophilus influenzae type b vaccines;

Table 3.2: Intention to treat analysis of DTPcv3 vaccination and timeliness by study group in parental reminder for childhood vaccination study, Indonesia 2015-2016

	Group 1: Home-based record and appointment sticker			Group 2: Home-based record only			Group 3: Control (Reference)
Intervention effect	RR or HR (95% CI)	RD (95% CI)	DTPcv3 coverage	RR or HR (95% CI)	RD (95% CI)	DTPcv3 coverage	DTPcv3 coverage
DTPcv3 vaccination by end of 200-day study period	0.97 (0.90, 1.05)	-0.04 (-0.12, 0.03)	77%	0.94 (0.87, 1.02)	-0.07 (-0.14, 0.01)	74%	78%
DTPcv3 vaccination within 60 days of DTPcv1	1.46 (1.02, 2.09)*	0.09 (0.01, 0.20)*	32%	1.05 (0.71, 1.55)	0.01 (-0.10, 0.11)	24%	23%
DTPcv3 vaccination within 70 days of DTPcv1	1.02 (0.82, 1.26)	0.02 (-0.09, 0.14)	55%	0.85 (0.68, 1.05)	-0.05 (-0.17, 0.06)	47%	52%
DTPcv3 vaccination within 90 days of DTPcv1	0.98 (0.83, 1.17)	0.00 (-0.12, 0.11)	61%	0.84 (0.73, 1.03)	-0.08 (-0.19, 0.03)	53%	61%
Time to DTPcv3 vaccination over 200 day study period	1.00 (0.91, 1.10)[1]	N.A.	N.A.	0.95 (0.86, 1.04)[1]	N.A.	N.A.	N.A.

Models for calculating effect include covariates for child's BCG vaccination status, age at DTPcv1 vaccination, gender, district, and facility (cluster variable). Control group is reference for all measures of association.

CI = Confidence interval; RR = Risk ratio; HR = hazard ratio; RD = Risk difference; DTPcv = vaccine containing diphtheria, tetanus, pertussis, hepatitis B and Haemophilus influenzae type b antigens; DTPcv1 = 1st dose of DTPcv vaccine; DTPcv3 = 3rd dose of DTPcv vaccine; N.A. = Not applicable to given intervention effect.

* = Confidence intervals do not include the null value; 1 = listed value is a hazard ratio, otherwise all other values in given column are risk ratios;

Table 3.3: Per protocol and sub-group analyses of DTPcv3 vaccination and timeliness by study group in parental reminder for childhood vaccination study, Indonesia 2015-2016

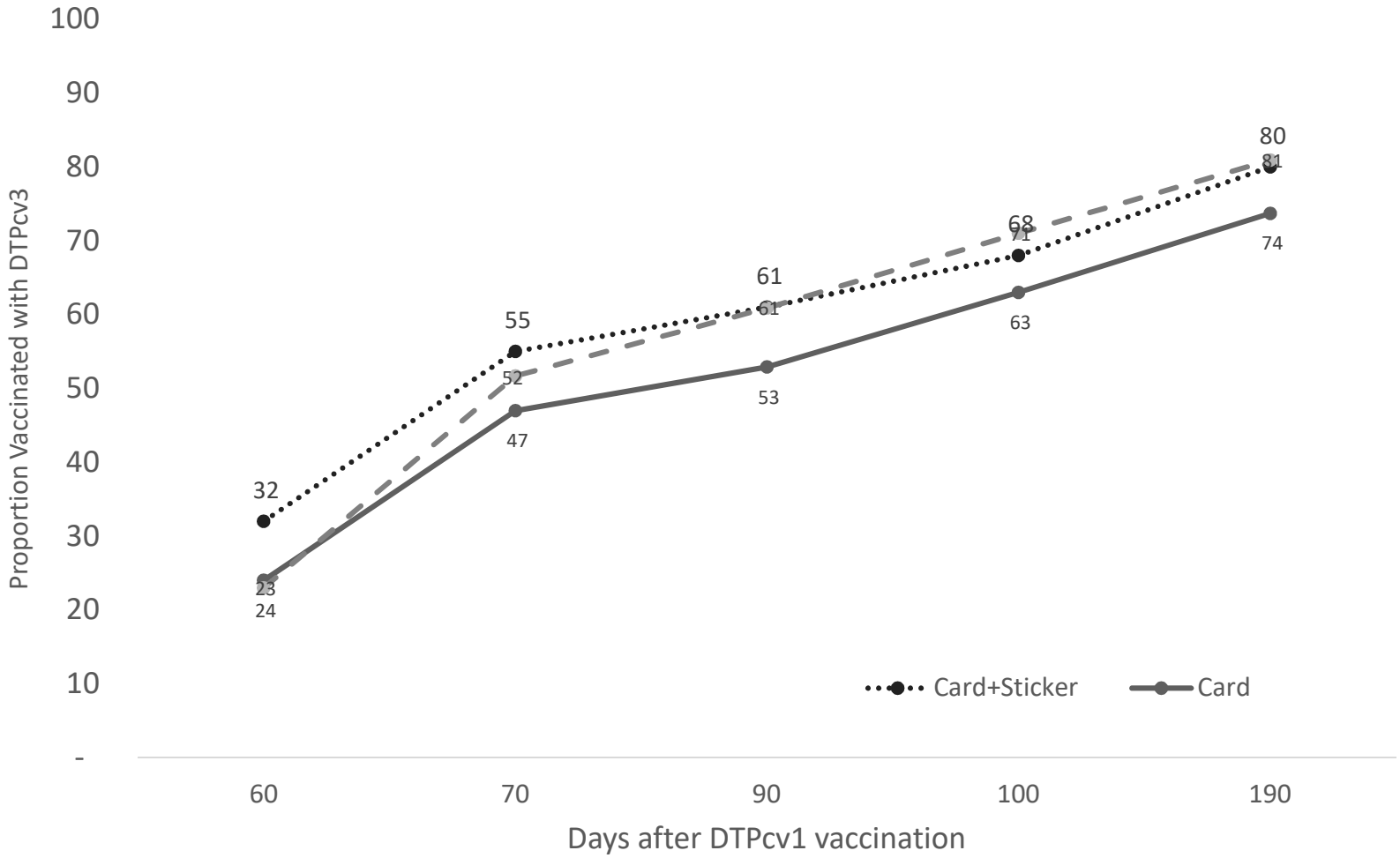
		Group 1: home-based record and appointment sticker			Group 2: Home-based record-only			Group 3: control (Reference)
Population	Intervention effect	RR or HR (95% CI)	RD (95% CI)	DTPcv3 coverage	RR or HR (95% CI)	RD (95% CI)	DTPcv3 coverage	DTPcv3 coverage
PP groups	DTPcv3 vaccination by end of 7-mo study period	0.99 (0.97, 1.09)	-0.02 (-0.10, 0.06)	77%	0.96 (0.88, 1.05)	-0.06 (-0.14, 0.03)	74%	78%
	DTPcv3 vaccination within 60 days of DTPcv1	1.64 (1.16, 2.33)*	0.13 (0.02, 0.24)*	37%	1.16 (0.81, 1.65)	0.03 (-0.06, 0.13)	28%	24%
	DTPcv3 vaccination within 70 days of DTPcv1	1.24 (1.02, 1.51)*	0.11 (0.01, 0.22)*	57%	0.93 (0.74, 1.16)	-0.03 (-0.15, 0.08)	47%	43%
	Time to DTPcv3 vaccination within 7-mo study period	1.23 (1.11, 1.37)*[1]	N.A.	N.A.	1.11 (1.02, 1.22)*[1]	N.A.	N.A.	N.A.
ITT groups	Time to DTPcv3 vaccination within 7-mo study period (CP method)	1.17 (1.06, 1.28)*[1]	N.A.	N.A.	1.04 (0.95, 1.15)[1]	N.A.	N.A.	N.A.
Penta-2 only[2]	DTPcv3 vaccination by end of 7-mo study period	0.99 (0.94, 1.04)	N.A.		0.97 (0.92, 1.10)[1]	N.A.		
	DTPcv3 vaccination within 60 days of DTPcv1	1.52 (1.07, 2.15)*[1]	0.12 (0.01, 0.23)	55%		0.03 (-0.08, 0.14)	39%	35%
	Time to DTPcv3 vaccination within 7-mo study period	1.05 (0.95, 1.16)	N.A.	N.A.	0.97 (0.89, 1.07)[1]	N.A.	N.A.	N.A.

Models for calculating effect include covariates for child's BCG vaccination status, age at DTPcv1 vaccination, gender, home district, and facility (cluster variable).
CI = Confidence interval; RR = Risk ratio; HR = hazard ratio; RD = Risk difference; DTPcv = vaccine containing diphtheria, tetanus, pertussis, hepatitis B and Haemophilus

influenzae type b antigens; DTPcv1 = 1st dose of DTPcv vaccine; DTPcv3 = 3rd dose of DTPcv vaccine; N.A. = Not applicable to given intervention effect; CP method = survival analysis method using the counting process approach whereby participant time is classified based on when their assigned facility actually started a given intervention; PP group = per protocol reclassification of study groups; ITT = intention to treat classification of study groups

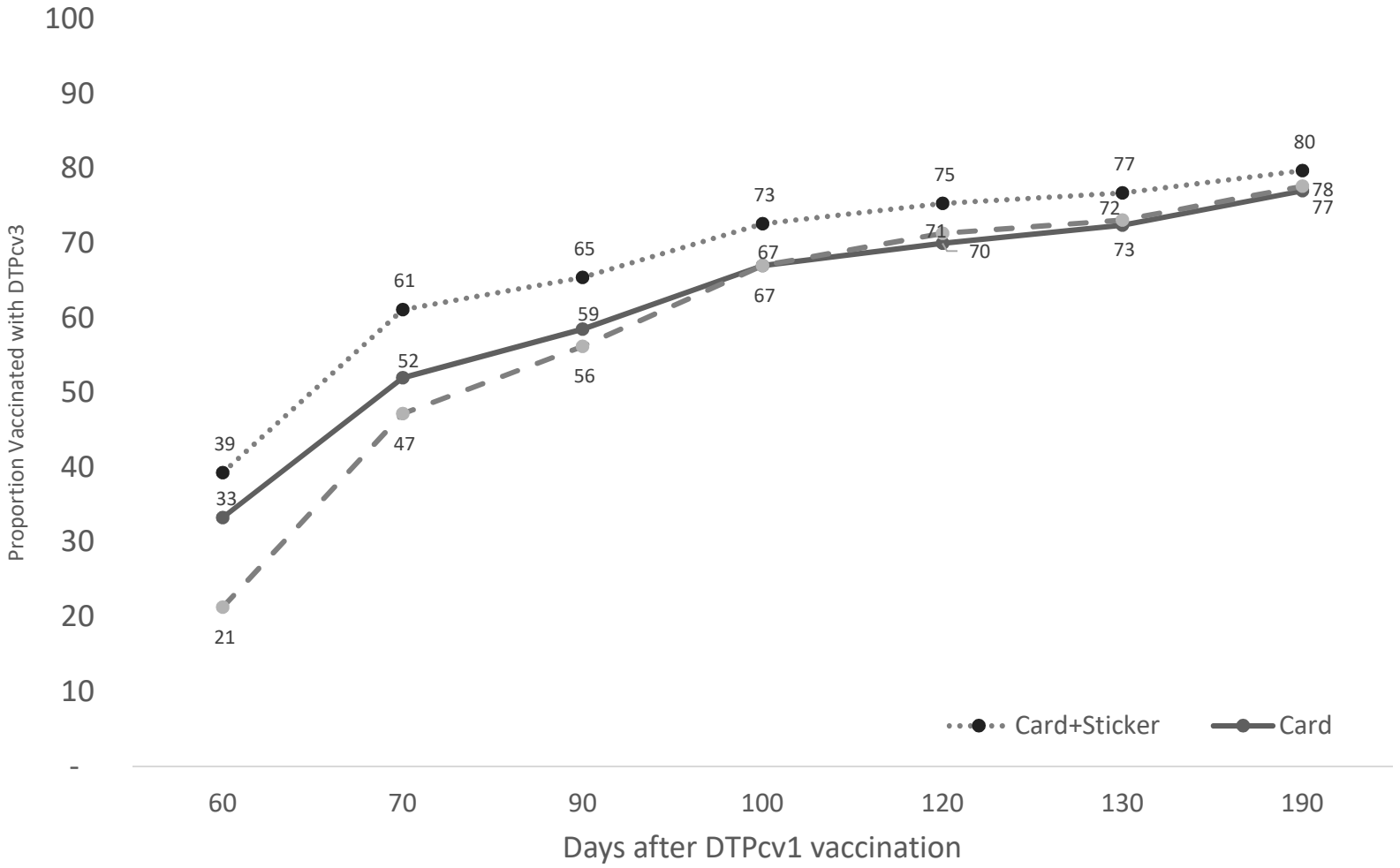
* = Confidence intervals do not include the null value; 1 = listed value is a hazard ratio, otherwise all other values in given column are risk ratios; 2 = population sub-group that includes only participants that received DTPcv2 vaccination

Figure 3.2: Intention to treat analysis of time to DTPcv3 vaccination by study group, Indonesia 2015-2016



DTPcv = Vaccine containing diphtheria, tetanus, pertussis, hepatitis B and Haemophilus influenzae type b antigens; DTPcv1 = 1st dose of DTPcv vaccine; DTPcv3 = 3rd dose of DTPcv vaccine

Figure 3.3: Per protocol analysis of time to DTPcv3 vaccination by study group, Indonesia 2015-2016



DTPcv = Vaccine containing diphtheria, tetanus, pertussis, hepatitis B and Haemophilus influenzae type b antigens; DTPcv1 = 1st dose of DTPcv vaccine; DTPcv3 = 3rd dose of DTPcv vaccine

SUPPLEMENTAL INFORMATION

Section 1: Alternative analysis methods

To further explore how results could vary based on the chosen modeling method, we re-ran all dichotomous outcome models using a generalized linear mixed model (GLMM) and alternating logistic regressions model (ALR).Under the GLMM approach, facility was treated as a random effect with an exchangeable correlation structure and district location of the child was also treated as a random effect within which facilities were clustered. Under the ALR approach, facilities were a cluster variable, nested within districts which were also considered a cluster variable. Similar analyses using GLMM and ALR methods did not change any observations about intervention effects as reported using the GEE approach (data not reported).

Using a counting process approach which incorporated the intervention start-up lag by facility, Home-based record+sticker group children were 17% more likely to receive a more timely DTPcv3 vaccination (HR: 1.17, 95% CI: 1.06, 1.28) compared to control group children and Home-based record-only group children were 11% more likely to receive a more timely DTPcv3 compared to control group children (HR: 1.11, 95% CI: 1.02, 1.22).

CHAPTER 4: AIM 3 MANUSCRIPT

Title: Costs and cost-effectiveness of child vaccination cards and vaccination appointment reminder stickers as strategies to remind parents of future childhood vaccination visits in West Java Province, Indonesia

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ABSTRACT

Introduction: Limited evidence is available about the costs and cost-effectiveness of parental reminders for vaccination in low and middle-income country settings, despite their promise in results from studies in high-income countries. We aimed to evaluate the costs and cost effectiveness of two home-based record (HBR) reminder interventions in Indonesia.

Methods: Using a randomized controlled trial with two intervention groups and a control group, we calculated the incremental direct and indirect health sector costs of a intervention where healthcare providers distributed an HBR to any age-eligible child who did not have one and allowed the parent to keep the HBR at home (HBR-only group); and an intervention which included the same provision of the HBR, plus use of an future vaccination appointment reminder sticker placed on the front of the HBR (HBR+sticker group). Using results on the interventions' incremental effects on timely receipt of the third dose of diphtheria-tetanus-pertussis containing vaccine (DTPcv3), we calculated an incremental cost of a timely vaccination for an additional child as our incremental cost effectiveness ratio (ICER) for the HBR+sticker group only. ICER sensitivity analyses incorporated intervention effect ranges based on per protocol analysis results and ongoing costs only.

Results: The HBR-only intervention cost $593 ($0.41 per targeted child), with 43% of costs for startup and 57% for ongoing activities. The HBR+sticker intervention cost $774 ($0.70 per targeted child) with 25% of costs for startup and 75% for ongoing activities. In the base-case cost-effectiveness scenario, 99 additional children received a timely vaccination for an ICER of $7.80 for the HBR+sticker group. Sensitivity analyses showed an ICER range of $3.51 to $7.80. Using only direct costs, the ICER ranged between $2.30 and $5.11.

Discussion: Compared to the current financing per child for vaccination in Indonesia, the base-case ICER was relatively high, largely due to the mild effect of the HBR+sticker intervention. However, the ICER sensitivity ranges made the use of the HBR+sticker intervention a much more competitive option. Documenting similar reminder studies ongoing in Indonesia and elsewhere would provide useful comparisons for assist decision-makers with efficiently using limited program resources.

INTRODUCTION

Since the rapid global expansion of national immunization programs starting in the 1970s, vaccine preventable disease (VPD) mortality and morbidity has dramatically decreased worldwide [9]. However, in multiple countries, VPDs continue to be a leading cause of childhood mortality because of barriers to vaccine access and utilization. In these high VPD burden countries, substantial external investments are made to support immunization system strengthening, vaccination introductions and general health systems strengthening. For instance, donors invested US$1.3 billion in 71 low and middle-income country immunization programs via the Gavi Alliance in 2016.

A challenge to ensuring sufficient return on local and external investments is a lack of high quality data on costs, effects and cost-effectiveness of many interventions used or suggested for use to improve vaccination coverage in low and middle-income countries [43, 59, 60, 93-95]. A 2016 review of these latter interventions identified only 14 studies using a more rigorous randomized trial study design, and only one documented intervention costs [60]. The 2016 review pointed to multiple promising interventions that needed further research to fill evidence gaps in costs and cost-effectiveness to better inform immunization program investments. One such promising intervention with limited evidence is the use of reminders to ensure parents bring children back for future vaccination visits.

Parental reminders for vaccination are designed to ensure that children who start a country's recommended vaccination schedule also complete all the recommended vaccinations. Example reminder strategies include sending letters or postcards about an upcoming vaccination visit to the child's home, automated calling to the parent, home visits, and text messages sent to a parent's phone. Recent studies from Pakistan showed encouraging results

with the use of parental reminders to improve DTPcv3 coverage, however, no data were provided on costs or cost-effectiveness. In Indonesia, a high proportion of children are estimated to start the recommended vaccination schedule, but fail to complete all recommended vaccinations. As a middle-income country, Indonesia is largely ineligible for Gavi funding and has limited government funding to support the immunization program. Hence, an evidence-based decision for prioritizing investment into interventions to improve vaccination coverage requires information on both interventions costs and effects.

To improve understanding of the costs and cost-effectiveness of parental reminders for vaccination in low a middle-income country settings, we conducted a field trial of two strategies, one based on ensuring children receive a home-based record (HBR) and another based on a vaccination appointment reminder sticker placed on the HBR. The objectives of the study were to calculate the incremental costs of implementing these two parental reminder interventions in West Java Province, Indonesia and the incremental cost-effectiveness of these two interventions.

METHODS

A complete description of the project methodology can be found in our earlier paper describing the effectiveness of the two parental reminder interventions on various vaccination outcomes [96]. In brief, we randomized 30 health facilities to each of three study groups in West Java province, Indonesia. In study group 1 (HBR+sticker group), healthcare providers at each facility were trained to ensure they provided a home-based record (HBR), where the child's vaccination records are stored, to each parent that presented the child for vaccination and allowed the parent to keep the HBR at home between vaccination visits. If a parent brought the child for a vaccination and had misplaced the HBR, the healthcare providers were instructed to provide a new HBR. Secondly, at the end of each vaccination visit, the provider was instructed to place a reminder sticker with the date of the next vaccination visit on the front of the HBR. In study group 2 (HBR-only group), healthcare providers received the same intervention as in group 1, except they did not provide the reminder sticker. Study group 3 (control group) facilities represented the standard practice, with no intervention.

The enrolled children were all those who received the first dose of DTPcv (DTPcv1) in January 2016 in a study health facility. The study lasted 7 months and the main outcomes were receipt of the third dose of diphtheria-tetanus-pertussis containing vaccine (DTPcv3) by the end of the follow-up period and timeliness of DTPcv3 vaccination.

Costing Definitions

Economic costs were defined as the sum of direct and indirect costs. Direct costs were defined as the explicit costs incurred by the health sector to purchase and transport materials or to pay for training-related expenses such as room rental or staff per diems. Indirect costs were defined as the value of the best alternative forgone by the health sector due to implementing

the intervention. Example indirect costs include the value of health sector staff time spent implementing the intervention. An incremental cost effectiveness ratio is defined as the ratio of the change in cost between an intervention group and the control group (i.e. the incremental cost) to the change in effect between an intervention group and the control group (i.e. the incremental effect). All costs were converted to US dollars using the 2016 exchange rate of 13,308 Indonesian rupiah to 1 US dollar [97].

Incremental cost analysis

Each intervention was costed from a health sector perspective using the activity-based costing (ABC) method (Figure 4.1). The ABC method follows a linear approach whereby to reach an outcome of interest (for example, a vaccinated child), intervention activities to reach this outcome are identified, resources are assigned to each identified activity, cost per resource is calculated, which allows for calculating cost per activity, which finally allows for calculating cost per intervention. The costing time horizon was the study period, 7 months.

We calculated the incremental direct and indirect costs needed to implement each intervention in study groups 1 and 2; we did not cost any study group 3 activities. We identified the following activities to cost: staff training, materials, materials transport, and facility-level implementation (Table 4.1). We also classified activities into those related to the startup phase of the intervention and those related to ongoing or long-term implementation. The cost of each activity was calculated in total and as a cost per targeted child. A targeted child was defined as a child who received DTPcv1 in each intervention group in the first month of the study. Data sources for calculating the incremental intervention costs were obtained from the study budget records, government salary records, UNICEF financial materials, and interviews with health

sector staff. Major costing inputs are summarized in table 2. Detailed costing calculations are available in supplemental tables 1 and 2.

Incremental effect analysis

The effect of each intervention (Table 4.2) is derived from our earlier effectiveness study [96]. Results from our effectiveness study indicated the only statistically significant measure of effect was DTPcv3 timeliness between the HBR+sticker group and the control group. Consequently, we used the timeliness measure, "DTPcv3 coverage by 60 days after DTPcv1 vaccination" as the measure of effect in our base-case cost-effectiveness scenario. We defined this indicator as a "timely DTPcv3" vaccination. The base-case scenario used the effectiveness results from the intention-to-treat method [96]. For calculating the incremental effect, we converted the original timely DTPcv3 measure from a risk difference measure into an absolute measure of the number of additional children vaccinated with a timely DTPcv3 in the HBR+sticker group. To do so, we multiplied the risk difference by the number of enrolled children (the intervention target) in the HBR+sticker group.

Cost-effectiveness analysis

To calculate the ICER, we divided the incremental cost of the intervention by the base-case incremental effect of the intervention. The ICER can be interpreted as cost incurred for every additional child reached with a timely DTPcv3 vaccination if the intervention were implemented compared to doing nothing. Since the HBR-only intervention did not show a significant incremental effects, we measured the ICER for only the HBR+sticker intervention. We performed ICER sensitivity analysis by varying the incremental intervention effect based on incremental effect confidence intervals then recalculating the ICER. We also used incremental

effect estimated from the per protocol approach to recalculate the ICER. Since the analysis horizon for this analysis was <1 year, we report undiscounted estimates for all scenarios. Lastly, we calculated a return on investment, using the number of additional children receiving a timely DTPcv3 vaccination for a given amount of money invested in the intervention. In our analysis, we estimated this return on every USD100000 invested in the HBR+sticker intervention.

RESULTS

In the HBR+sticker and HBR-only study groups, 1103 and 1434 children, respectively, received DTPcv1 in January 2016. We estimated that 610 additional HBR were distributed during the study period in the HBR+sticker group and 790 additional HBR distributed in the HBR-only group based on an estimated percentage of children without HBR at each vaccination visit (Table 1). In the HBR+sticker group, 4068 stickers were used during the study period, based on the number of children enrolled at DTPcv1 at the start of the study and DTPcv2 and DTPcv3 coverage.

HBR-only intervention cost

In total, the HBR-only intervention cost was US$593 ($0.41 per targeted child), with 43% of the cost for startup and 57% for ongoing activities (Figure 4.2). Startup activity costs were 100% indirect while ongoing activity costs were largely direct (96%). Start-up activities were composed of trainings for both health facility and district-level health system staff ($0.18 per targeted child). Ongoing activities were largely composed of HBR purchase and transport costs ($0.23 per targeted child) and implementation of the intervention ($0.01 per targeted child); the bulk of these ongoing costs were direct due to purchase of the HBR.

HBR and sticker intervention cost

The HBR+sticker intervention cost was US$774 ($0.70 per child), with 25% of the cost for startup and 75% for ongoing activities (Figure 4.3). 85% of ongoing activities were direct (stickers, cards) and 15% were indirect (health worker time). Start-up costs were composed of trainings for both health facility and district-level health system staff ($0.18 per targeted child). Ongoing costs were largely composed of HBR and sticker purchase and transport costs ($0.45

per targeted child) and implementation of the intervention ($0.07 per targeted child); the bulk of these ongoing costs were direct due to the purchase costs of the cards and stickers.

Cost-effectiveness

In our base-case scenario, 99 additional children were vaccinated with a timely DTPcv3 compared to the control group, at an incremental total cost per additional child vaccinated of $7.80. Sensitivity analyses involving effect estimates from per protocol and DTPcv2 recipients showed a range of 33 to 221 additional children receiving a timely DTPcv3 vaccination in the HBR+sticker intervention group compared to the control group (Table 4.3). In these sensitivity analyses, the HBR+sticker intervention total cost per additional child vaccinated with a timely DTPcv3 ranged between US$3.51 and US$7.80. Using only the direct costs of the HBR+sticker intervention, the direct cost per additional child vaccinated with a timely DTPcv3 ranged between $2.30 and $5.11 (Table 4.3). Using only the direct costs that would be incurred by the government when investing into the intervention and the base case incremental effects, every $100,000 invested in the HBR+sticker intervention yielded 19,565 additional children vaccinated with a timely DTPcv3, with a sensitivity range of 652 to 41,304 additional children vaccinated with a timely DTPcv3 dose. Using the incremental effects from the per protocol analysis yielded a point estimate of 28,261 additional children vaccinated with a timely DTPcv3 dose, with a sensitivity range of 4,348 to 52,174, for every $100,000 invested in the HBR+sticker intervention.

DISCUSSION

In our study, the first to rigorously examine the costs and cost effectiveness of a parental reminder intervention for childhood vaccinations in a low or middle-income country setting, we estimated a relatively high ICER of $7.80 for the HBR+sticker intervention for the setting of Indonesia. The relatively high ICER was indicative of the relatively mild incremental effect that the HBR+sticker intervention had on receipt of a timely DTPcv3 vaccination. However, sensitivity analyses indicated an ICER as low as $1.48 using results from the per protocol analysis of incremental effect and including only direct costs, i.e. the additional out-of-pocket costs which the government would incur to implement the intervention. For the Indonesian government, which is already covering the indirect costs (i.e. staff salaries) incurred by the reminder intervention, the incremental direct cost-based ICER may be the most useful number for investment decisions. A key strength of this study was its prospective, randomized trial design which allowed for a detailed collection and tracking of intervention costs alongside minimized confounding and selection bias when estimating intervention effect.

Although the incremental effect of the HBR+sticker intervention was moderate, the cost of the HBR+sticker intervention was also relatively low when compared to a recent Gavi-funded intervention designed to reduce the number of children who failed to return for vaccination in 31 districts of Indonesia. The intervention cost was $36 per child who failed to return for vaccination compared to our baseline estimate of $14 per additional child reached with a timely DTPcv3 vaccination. This Gavi-funded intervention was built largely on a similar, widespread strategy used in Indonesia known as sweeping. The sweeping strategy requires health workers to use their health facility registers to identify those children who failed to return for a future vaccination visit, then visiting these communities and households to track those children

alongside community-based health staff. This strategy occurs every 1-2 months depending on funding availability and we theorized could be a reason why we observed similar vaccination coverage levels in our intervention groups and control group after a 7-month period but different vaccination timeliness results between the groups. Although the sticker+HBR intervention ICER may appear high, if it is able to accomplish the same level of effect on coverage as the sweeping strategy at a cheaper cost per child, then the sticker+HBR intervention becomes much more worth consideration for future support in the country. Additional efforts are needed to explore this comparison of costs between these strategies.

Although no other vaccination reminder intervention costing and cost-effectiveness studies were available to compare from low and middle-income country settings, examples are available from high-income countries. Several (n=8) cost-effectiveness reminder studies indicated wide variation in costs, largely due to variability in methods for calculating costs, items included in the costing analyses, different types of reminders used and the intensity of the reminders[58, 98-100]. Phone-based reminders were generally more costly than paper-based (letter, postcard) reminders, while costs increased depending on how many times a reminder was repeated (i.e. one SMS versus five SMS). Coupling our study results with similar results from costing and cost-effectiveness studies of phone-based reminders in Indonesia and similar settings would provide for a similar and useful comparison of the benefits and challenges of these different approaches to reminder implementation. Indonesia is also currently implementing an SMS-based parental reminder study which will include a cost-effectiveness component. SMS-based reminders have shown quite positive effects in multiple low and middle-income country settings, however a key hurdle is the cost and logistics for setting up such a system. A recent systematic review of SMS-based reminder studies in the African region

noted a cost range of 0.09USD-1.00USD per targeted child across three studies in Kenya, Nigeria and Zimbabwe, however none of the studies examined cost per additional child reached[101].

In our study, we documented that nearly 25% of the intervention costs were due to activities that we defined as “startup”, i.e. trainings for health sector staff to orient them on the intervention. It is likely that these start-up costs could be reduced through integrating the reminder intervention orientation into already planned health worker trainings which generally occur regularly in Indonesia. Since these startup activities could progress relatively quickly, focusing on direct costs and related cost-effectiveness ratios may be more useful for decision-makers with interest in considering expansion of these reminder interventions and the ability to provide long-term support. Since Indonesia’s immunization program does receive a variety of external funding that generally is short-term in nature, use of such a resource for these startup costs while using internal funding for the ongoing direct costs in the long term may be a creative mechanism for covering intervention costs.

Limitations and strengths to the study exist. This study setting is also moderately urban, so costs and effects may differ somewhat in a very rural setting. Another limitation is the relatively short follow-up period as this may have some impact on the observed effects of the interventions, i.e. health worker behavior tied to distribution of the HBR and use of the sticker may take longer than the follow-up period. An additional limitation to comparability is the use of an intermediate indicator as our measure of the intervention effect, rather than an outcome indicator such as disability adjusted life-years saved (DALYs). We chose the intermediate indicator for two reasons: it a more understandable measure of effect from the perspective of an immunization program manager and little evidence is available on the effect of improved DTPcv vaccination timeliness on outcomes such as lives saved or DALYs.

CONCLUSIONS

Several strategies used currently to improve vaccination coverage in low and middle income countries are not well grounded in strong evidence of effects nor costs, restricting the ability to adequately prioritize limited investments in immunization programs. Our study improves this evidence base by using a rigorous study design to assess the cost and cost-effectiveness of parental reminders for vaccination in Indonesia, a country of high priority for global vaccination efforts. Efforts are needed to ensure that research assessing the effectiveness of similar strategies also include costing and cost-effectiveness components to provide a well-rounded picture for key stakeholders who are intent on efficiently using limited resources to ensure all children promptly receive the complete schedule of recommended vaccinations.

TABLES AND FIGURES

Figure 4.1: Activity-based costing method framework used to cost two parental reminder interventions designed to improve vaccination coverage in West Java province, Indonesia

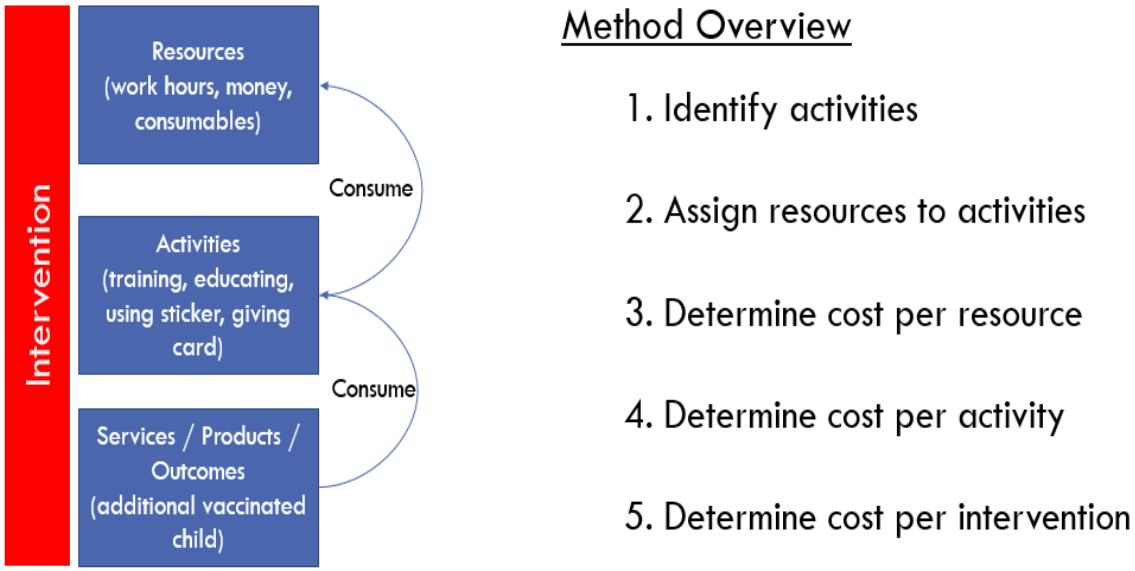

Table 4.1: Summary of key inputs and activities included in data collection for costing of two parental reminder interventions for improving vaccine utilization in Indonesia, 2016-17

Group	Activity	Direct resources/inputs	Indirect resources/inputs
Group 1: Home-based records and reminder sticker	Material purchases	HBR cost Number of additional HBR used Reminder sticker cost Number of stickers used Number of children vaccinated with DTPcv1 and DTPcv3	
	Materials transport	Transport cost for card Transport cost for sticker	
	Training	Number of province staff trained Number of district staff trained Number of health facility staff trained Training per diem Room rental cost Number of rooms rented Length of training	Staff salary by type Length of training
	Implementation		Staff salary by type Intervention length per caregiver
Group 2: Home-based records	Materials purchases	HBR cost Number of additional HBR used Reminder sticker cost Number of stickers used Number of children vaccinated with DTPcv1 and DTPcv3	

	Materials transport	Transport cost for card Transport cost for sticker	
	Training	Number of province staff trained Number of district staff trained Number of health facility staff trained Training per diem Room rental cost Number of rooms rented Length of training	Staff salary by type Length of training
	Implementation		Staff salary by type Intervention length per caregiver

Definitions: HBR= home-based record; DTPcv = diphtheria-tetanus-pertussis containing vaccine;

DTPcv1=1st DTPcv dose; DTPcv3=3rd DTPcv dose

Table 4.2: Inputs for estimating the costs of two interventions designed to remind parents to bring the child back for future vaccination visits, Indonesia 2016-2017

Input	HBR+sticker group	HBR-only group
Total children with DTPcv1 in January 2016	1103	1434
Estimated percentage of children without home-based record (HBR) at each DTPcv3 series vaccination visit	15%	15%
HBR and sticker buffer (additional records procured as a percentage of target population using the HBR to ensure that no HBR or sticker stockouts occur at a health facility level)	30%	30%
Number of HBR used during the study period	610	790
Stickers used during the study period (based on DTPcv2 and DTPcv3 coverage in HBR+sticker study group)	4068	NA
Sticker unit cost (USD)	0.04	NA
HBR unit cost (USD)	0.38	0.38
Transport cost as percentage of cost of materials transported	10%	10%
Facility health worker time spent to provide sticker (minutes)	0.5	NA
Facility health worker time spent to provide/check for HBR (minutes)	0.5	0.5
Facility health worker time spent for intervention training (minutes)	15	15
District health officer time spent for intervention training received and given (minutes)	75	75
Province health officer time spent for intervention training given (minutes)	60	60
National and province health officer time spent for consensus building workshop (minutes)	480	480
Difference in the proportion of children reached with a timely DTPcv3 vaccination (i.e. within 60 days of DTPcv1 vaccination date) between intervention group and control group, intention to treat analysis (95% confidence interval)	0.09 (0.01, 0.20)	0.01 (-0.10, 0.11)

Difference in the proportion of children reached with a timely DTPcv3 vaccination (i.e. within 60 days of DTPcv1 vaccination date) between intervention group and control group, per protocol analysis (95% confidence interval)	0.13 (0.02, 0.24)	0.03 (-0.06, 0.13)

DTPcv = Diphtheria-tetanus-pertussis containing vaccine; DTPcv2= 2nd dose of DTPcv; DTPcv3=3rd dose of DTPcv; HBR=home-based record; HBR= home-based record; USD=United States dollar;

Figure 4.2: Home-based-record-only study group intervention costs documented in study of parental reminders for vaccination, Indonesia 2016-17

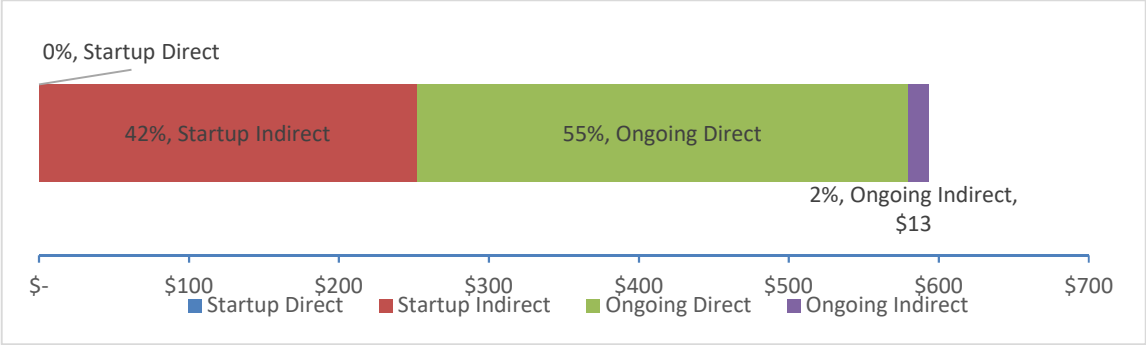

Figure 4.3: Home-based-record and reminder sticker study group intervention costs documented in study of parental reminders for vaccination, Indonesia 2016-17

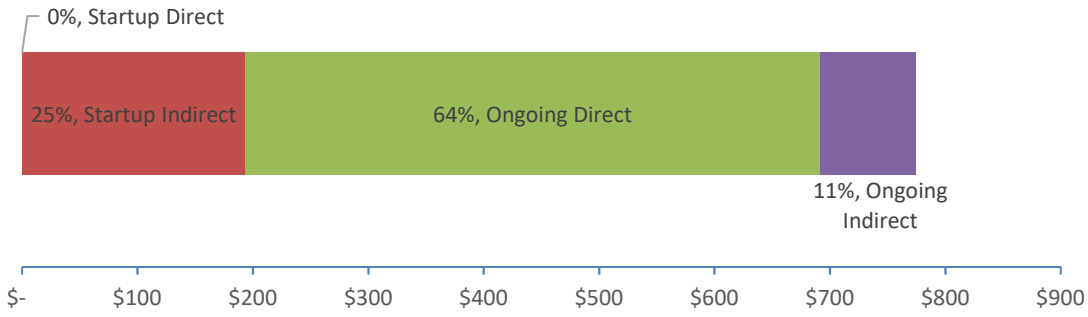

Table 4.3: Cost-effectiveness of HBR+sticker intervention included in a study to evaluate the effect of parental reminders for vaccination, Indonesia 2016-17

Analytic method	Outcome Indicator	Risk difference	Additional children up to date (UTD)	Cost per additional child UTD (sensitivity range)	Direct cost per additional child UTD (sensitivity range)
Intention to treat	DTPcv3 60 days after DTPcv1*	9% (0%, 19%)	99	$7.80 ($3.69, $233.99)	$5.11 ($2.42, $153.33)
Per protocol	DTPcv3 60 days after DTPcv1*	13% (2%, 24%)	143	$5.40 ($2.92, $35.10)	$3.54 ($1.92, $23.00)
	DTPcv3 70 days after DTPcv1*	11% (1%, 22%)	125	$6.21 ($3.19, $70.20)	$4.07 ($2.09, $46.00)
	DTPcv3 90 days after DTPcv1	3% (-7%, 14%)	33	$23.40 (-$10.03, $5.01)	$15.33 ($-6.57, $3.29)
Among DTPcv2 recipients only	DTPcv3 30 days after DTPcv2*	20% (8%, 31%)	221	$3.51 ($2.26, $8.77)	$2.30 ($1.48, $5.75)

1. Sensitivity range: results based on use of the 95% confidence intervals for intervention effects as reported in chapter 3

Supplemental Tables, Figures and Descriptions

Supplemental Table 4.5: HBR + Sticker intervention group detailed costs by activity and cost calculations

Summary Table of Initial Financial Costs

Cost Activity Category	Cost Activity Sub-Category	Item	Unit cost (IDR)	Quantity	Subtotal (IDR)	Subtotal (USD)	Unit Cost (USD)	Notes
Intervention : Health Cards								
Implement-ation	Materials	Health card	5,000.00	610	3,050,775.00	$229.26	$0.38	
	Transport Materials	Card transport	500.00	610	305,077.50	$22.93	$0.04	10% of unit costs
	Implementation time	Bidan - card	226.16	610	137,993.85	$10.37		Time spent checking if a new card is needed
Intervention: Sticker								
Implement-ation	Materials	Sticker	480.00	4068	1,952,496.00	$146.73	$0.04	
		Pen (1 per 1000 sticker)	2,000.00	60	120,000.00	$9.02	$0.15	at least 2 pen per facility (30 HF total in Group 1)
	Transport Materials	Sticker transport	48.00	4068	195,249.60	$14.67	$0.00	10% of unit costs
		Pen transport	200.00	60	12,000.00	$0.90	$0.02	10% of unit costs

	Implement-ation time	Bidan - sticker	226.16	4068	919,958.98	$69.13	$0.02	Time spent applying the sticker and explaining it
Setup (Sticker + Card)	Training	District officer (trainer)	40,709.15	30	1,221,274.56	$91.78	$3.06	Training from district to facility
		Bidan (trainee)	13,569.72	30	407,091.52	$30.59	$1.02	Training from district to facility
Cross-Intervention (costs shared by both HBR intervention and sticker+HBR intervention								
Setup	Consensus building	National staff (trainer)	1,302,692.86	2	2,605,385.72	$195.79	$97.89	Includes meetings, buy-in, interviews (labor time)
		Province staff (trainee)	868,461.91	1	868,461.91	$65.26	$65.26	Meetings between national and province
		Hotel room rental	5,000,000.00	1	5,000,000.00	$375.74	$375.74	Meetings between national and province

		Per diem	400,000.00	3	1,200,000.00	$90.18	$30.06	Meetings between national and province
	Training	Province staff (trainer)	108,557.74	5	542,788.69	$40.79	$8.16	Training from national to provincial
		District staff (trainee)	81,418.30	5	407,091.52	$30.59	$6.12	Training from provincial to district

MATERIALS COST RANGES

Other Information

Other sticker costs

Quantity	Total (IDR)	Cost/sticker (IDR)	Total (USD)	Cost/sticker (USD)
13500	10,000,000.00	740.74	$751.48	$0.06
55000	40,000,000.00	727.27	$3,005.91	$0.05

WAGE SCALES

Labor information

Worker type	Annual salary (IDR)	Yearly hours	Hourly wage (IDR)	Annual Salary (USD)	Hourly (USD)	

Bidan (facility-level health worker)	56,640,000	2087	27,139.43	$4,256.37	$2.04	
District officer	169,920,000	2087	81,418.30	$12,769.12	$6.12	
Provincial officer	226,560,000	2087	108,557.74	$17,025.50	$8.16	
National officer	339,840,000	2087	162,836.61	$25,538.25	$12.24	

Indonesia minimum wage scale

Location	Min monthly wage (IDR)	Date	Monthly Wage (USD)	
Jakarta	3,355,750.00	Q1 2017	$252.18	
Western Java	1,420,625.00	Q1 2017	$106.76	

HEALTH SECTOR TIME SPENT ON INTERVENTIONS

Activity	Worker type	Time spent (minutes)	Cost (IDR)	Cost (USD)
Provide sticker	Bidan (facility-level health worker)	0.5	226.16	$0.02
Provide/check card	Bidan	0.5	226.16	$0.02
Train Bidan for group 1	District officer	15	20,354.58	$1.53
Receive training for group 1	Bidan	15	6,784.86	$0.51

Train District for group 1	Province officer	60	108,557.74	$8.16
Receive training for group 1	District officer	60	81,418.30	$6.12
Consensus building workshop	Province officer	480	868,461.91	$65.26
Consensus building workshop	National officer	480	1,302,692.86	$97.89

Training expenses

Item	Cost (IDR)	Cost (USD)	Notes
Consensus building room rental 1-day	5,000,000	$375.74	At provincial level
per diem	400,000	$30.06	At provincial level

Supplemental Table 4.6: HBR-only intervention group detailed costs by activity and cost calculations

Summary Table of Initial Financial Costs

Cost Activity Category	Cost Activity Sub-Category	Item	Unit cost (IDR)	Quantity	Subtotal (IDR)	Subtotal (USD)	Unit Cost (USD)	Notes
Intervention: Health Cards								
Implemen-tation	Materials	Health card	5,000.00	790	3,951,675.00	$ 296.96	$0.38	
	Transport Materials	Card transport	500.00	790	395,167.50	$29.70	$0.04	10% of unit costs
	Implement-ation time	Bidan - card	226.16	790	178,743.71	$13.43		Time spent checking if a new card is needed
Setup	Training	District officer (trainer)	40,709.15	30	1,221,274.56	$91.78	$3.06	Training from district to facility
		Bidan (trainee)	13,569.72	30	407,091.52	$30.59	$1.02	Training from district to facility
Cross-Intervention (costs shared by both HBR intervention and sticker+HBR intervention								
Setup	Consensus building	National staff (trainer)	1,302,692.86	2	2,605,385.72	$195.79	$97.89	Includes meetings, buy-in, interviews (labor time)
		Province staff (trainee)	868,461.91	1	868,461.91	$65.26	$65.26	Meetings between national and province

		Hotel room rental	5,000,000.00	1	5,000,000.00	$375.74	$375.74	Meetings between national and province
		Per diem	400,000.00	3	1,200,000.00	$90.18	$30.06	Meetings between national and province
	Training	Province staff (trainer)	108,557.74	5	542,788.69	$40.79	$8.16	Training from national to provincial
		District staff (trainee)	81,418.30	5	407,091.52	$30.59	$6.12	Training from provincial to district

MATERIALS COST

Other Information

Other sticker costs

Quantity	Total (IDR)	Cost/sticker (IDR)	Total (USD)	Cost/sticker (USD)
13500	10,000,000.00	740.74	$751.48	$0.06
55000	40,000,000.00	727.27	$3,005.91	$0.05

WAGE SCALES

Labor information

Worker type	Annual salary (IDR)	Yearly hours	Hourly wage (IDR)	Annual Salary (USD)	Hourly (USD)	
Bidan	56,640,000	2087	27,139.43	$4,256.37	$2.04	
District officer	169,920,000	2087	81,418.30	$ 12,769.12	$6.12	

Provincial officer	226,560,000	2087	108,557.74	$17,025.50	$8.16	
National officer	339,840,000	2087	162,836.61	$25,538.25	$12.24	

Indonesia Minimum Wage scale

Location	Min monthly wage (IDR)	Date	Monthly Wage (USD)	
Jakarta	3,355,750.00	Q1 2017	$252.18	
Western Java	1,420,625.00	Q1 2017	$106.76	

HEALTH SECTOR TIME SPENT ON INTERVENTIONS

Activity	Worker type	Time spent (minutes)	Cost (IDR)	Cost (USD)
Provide/check card	Bidan (facility-level health worker)	0.5	226.16	$0.02
Train health worker for group 2	District officer	15	20,354.58	$1.53
Receive training for group 2	Bidan	15	6,784.86	$0.51
Train District for group 2	Province officer	60	108,557.74	$8.16
Receive training for group 2	District officer	60	81,418.30	$6.12
Consensus building workshop	Province officer	480	868,461.91	$65.26

Consensus building workshop	National officer	480	1,302,692.86	$97.89

Training expenses

Item	Cost (IDR)	Cost (USD)	Notes
Consensus building room rental 1-day	5,000,000	$375.74	At provincial level
per diem	400,000	$30.06	At provincial level

CHAPTER 5: CONCLUSIONS AND FUTURE DIRECTIONS

In this final chapter, we review the findings of the three studies and evaluate their implications within the context of programmatic efforts and implementation research to improve immunization programs. Our summary helps inform future research directions and provides suggestions for immediate application to immunization programs in country settings similar to Indonesia and Ghana.

Substantial efforts exist to improve the performance of immunization programs in low and middle income country settings. In the context of ensuring that children complete all recommended vaccinations in these settings, multiple challenges exist, including how best to ensure parents return with the child for future vaccination visits as well as monitoring parental attitudes towards vaccination. In previous research, a common reason why parents indicate that the child is incompletely vaccinated is because they were not told they still needed to bring the child back for additional vaccinations. Until this dissertation, very little had been published on the effects of any type of parental reminder for vaccination in a low or middle income country setting. Evidence has also shown that negative parental attitudes towards vaccination could result in either vaccination delay or non-receipt. However, until this dissertation, no research had been conducted into development of a valid and reliable diagnostic tool for measuring parental attitudes towards vaccination in a low or middle income country setting.

Each of our three studies examined different, yet complementary, reasons why children fail to complete all recommended vaccinations. For our first study, we developed a valid and reliable scale for assessing parental attitudes towards vaccination in Ghana. In our second study, we implemented a cluster-randomized controlled trial (cRCT) designed to assess the

causal effect of two vaccination reminder interventions in Indonesia. These vaccination reminders were based on home-based records (HBR), also known as vaccination cards, which are used to store a child's record of vaccinations received, but are not necessarily kept by the parent at home. In our final study, we assessed the costs and cost-effectiveness of the vaccination reminder interventions evaluated in our cRCT in Indonesia.

Review of study findings

In our first study, we developed the first valid and reliable scale for measuring child caregiver attitudes towards childhood vaccinations in a low or middle-income country setting, Ghana. We adapted several questions from existing scales validated for use in the US and also developed several new questions based on our past experiences conducting caregiver vaccination knowledge, attitudes and beliefs surveys in low and middle-income countries. Our final valid and reliable scale contained 3 psychometric constructs to describe caregiver attitudes towards vaccination, with two items loading onto each construct. The caregiver interviewed in Ghana had relatively low levels of hesitancy and a very high proportion had children who had received all recommended vaccinations, although a majority of them showed some vaccination delays. The constructs with the most consistently significant associations across the various measures of a child's vaccination status were labeled as *vaccination benefits*, *vaccine safety & efficacy*, and *past vaccination practices*. Two other constructs were also identified among the caregivers but did not show a significant and consistent association with the child's vaccination status; these were *vaccine-preventable disease awareness* and *health sector trust*. The final 3-factor scale was parsimonious in nature and could be a strong consideration for inclusion in routine caregiver surveys conducted in Ghana and similar settings to provide ongoing data on

hesitancy trends. Similar to rationale for setting up a vaccine-preventable disease surveillance system, a vaccine hesitancy surveillance system could act as an early alert of changing trends in caregiver attitudes towards vaccination so that immunization program implementers can quickly react to thwart any "outbreaks" in negative attitudes which could result in fewer children being completely vaccinated in a timely manner and the accompanying build-up of an unprotected population susceptible to a disease outbreak.

In our second study, we evaluated two parental reminder interventions in Indonesia designed to ensure that children who start the recommended vaccination schedule also complete the schedule. In the first intervention, healthcare providers were trained to ensure that every child that came for vaccination received an HBR and that the family was allowed to keep the HBR at home. If any HBR was forgotten or lost, a replacement HBR was provided to the family. The second intervention package built on this latter intervention, plus it included the use of a future vaccination visit reminder sticker which was placed on the front of the HBR by the healthcare provider who also wrote the date of the next vaccination visit on the sticker. The results from this study indicated that the purposeful provision of an HBR to any child who did not have one did not necessarily have any positive effect on vaccination coverage or timeliness. However, in our interviews with intervention group healthcare providers, a slight majority of them indicated resistance to fully implementing this intervention.

Generally, the intervention group providers indicated that they perceived extra work burden to refill a new HBR when a parent either forgot or lost a child's HBR; these experiences were also why providers often wanted to have the HBR stored at the health facility rather than at home. This latter desire would place severe limitations on the ability of any HBR-based reminder to have any type of effect on vaccination outcomes. The provider feedback indicated a greater need in the future to ensure that healthcare providers are fully bought into such an

intervention. At the very least, incorporating their feedback during an intervention design phase may have produced a more acceptable intervention approach to the providers, which could have resulted in a more positive effect on the measured vaccination outcome indicators.

The results from the use of the parental reminder sticker alongside the HBR provision strategy were mixed. The HBR+sticker intervention results indicated that the sticker helped to mildly improve vaccination timeliness, but failed to improve vaccination coverage over the long term (end of 7 months). The result suggests that the sticker does help program performance, but cannot be the sole strategy used to remind parents of future vaccination visits. We did observe that the effect of the sticker intervention on timeliness was stronger in our per-protocol analyses, where we only included intervention facilities that had promptly started the intervention such that the parents and children in those facilities were actually provided the sticker and home-based record intervention. However, even among this per-protocol analysis, no effect was seen on vaccination coverage by the end of 7 months. Such results show the limits of this simple reminder intervention.

In our final study, we examined the costs and cost-effectiveness of the two HBR-based reminder interventions in Indonesia. For both interventions, the economic cost per targeted child was relatively low, at about US$1. However, since the home-based record-only intervention did not have any significant causal effect on the vaccination coverage outcomes, this investment in this intervention yield no significant gains. In contrast, since the sticker and home-based record intervention did at least have an effect on vaccination timeliness, a range of incremental cost effectiveness ratios could be calculated. At the upper end of the range, the ICER was high ($14) in comparison to the budget that Indonesia allocates per child for vaccination services ($30 in 2016). However, at the lower end of the range, the ICER values made the sticker intervention considerably more realistic to consider. These lower end ICER

values were generated from sensitivity analyses which incorporated only the ongoing (rather than ongoing + startup) costs and the per-protocol incremental effects which were more favorable than the intention to treat effects. The costs of this sticker and home-based record intervention could be further reduced if only the sticker component cost of the intervention were included, particularly since the home-based record-only intervention group results indicated no significant incremental effect on vaccination outcomes. Lastly, costs of the sticker and home-based record intervention could be further reduced if the sticker were incorporated into a comprehensive vaccine communications package designed to improve the messages a healthcare provider gives to a caregiver. Lack of knowledge about future vaccination visits is only one determinant of why children fail to complete the vaccination schedule; other documented determinants are a caregiver's negative experiences with minor side effects following vaccination (notably, fever which can force the caregiver to stay home from work to care for the child), caregiver's knowledge and concern about side effects following vaccination, and caregiver's potentially negative experience with the way healthcare providers behave towards them during a healthcare visit. A comprehensive package could be designed to address these multiple determinants in an ideally more cost-effective manner. Particularly since any fixed costs (for instance, startup workshops for key stakeholders and the initial wave of health worker trainings) required to implement any single intervention designed to address the previously mentioned determinants could be spread out across the multiple interventions that would make up a comprehensive package.

Future directions: scales to assess caregiver attitudes towards vaccination

In high-income countries where vaccine-preventable diseases are now relatively uncommon due to the success of vaccination, parents have become increasingly concerned about perceived drawbacks about vaccination rather than benefits of vaccination, leading to vaccine hesitant parents. As immunization programs in low and middle-income country settings also continue to increase vaccination coverage and greatly reduce the risk of a child being infected with a vaccine-preventable disease, the possibility that parental attitude trends could mirror those seen in the high-income country settings seems likely.

Rapidly scaling up the evaluation and use of diagnostic tools such as our validated scale in multiple settings is needed. Evaluation (i.e. replication of our study) is critical because different parental attitude constructs may be associated with the child's vaccination status in different settings. A one-size-fits-all scale seems very unlikely since immunization program performance differs (which could affect trust), cultures differ (which could affect social norms), languages differ (which could affect question formats), and vaccination decision-making processes differ (which could affect many psychometric constructs). Use of these diagnostic tools is also critical for multiple reasons. First, the use of these tools provides quantitative evidence to indicate that hesitancy either is or is not a current issue to consider in these countries; in many countries, little or nothing is known about hesitancy trends. Secondly, it can also reinforce the need to invest in demand-generation activities that focus on behavior change. Lastly, it provides an opportunity to stay ahead of any negative attitudes towards vaccination which could downstream result in lower vaccination coverage. With the recent update of the World Health Organization vaccination coverage survey guidelines, an opportunity exists to incorporate a parental attitudes scale into these national immunization coverage surveys. In multiple high-income countries, national immunization surveys have already moved beyond

providing simple estimates of country vaccination coverage to also provide insight into caregiver and healthcare provider attitudes, knowledge and beliefs about vaccination. Our scale, or a similar version, is a good starting point for questions to consider when low and middle-income countries are planning coverage surveys, particularly since the incremental cost to include a small number of questions in an already planned survey of caregivers should be extremely low.

Future directions: Vaccination reminders for caregivers

The global public health arena is currently fixated on the use of technology-based solutions for several different challenges identified as key bottlenecks to improving the performance of maternal and child health interventions. In particular, vaccination appointment reminders targeted at caregivers of child have often taken the form of phone-based strategies, such as the use of short message service (SMS) to prompt parents to bring the child for vaccination. However, these technology-based solutions have often failed at the step of scale-up, largely due to the substantial startup and ongoing costs required to maintain such systems in low and middle-income country settings. These technology-based solutions are likely to still be many years away from realistic implementation at a nation-wide scale in many countries. Considering simpler and cheaper options such as the reminder sticker is a much more immediately scalable option, with the consideration that effects reported thus far on vaccination outcomes are relatively mild. Two future options are suggested. In the first, further understanding the public health impact of these reminder stickers in a low/moderate vaccination coverage setting is needed. Secondly, a strong consideration should be given to evaluating the effect of a comprehensive healthcare provider – caregiver communications package where the sticker is only one component.

Since the reasons why children start but fail to complete all recommended vaccinations are so diverse, addressing only one determinant with a single strategy is likely to only ever yield a very small effect. We suggest that a comprehensive package include strategies to address a series of barriers to complete vaccination, including: how the caregiver is treated by the healthcare provider; the information the caregiver receives about potential side effects following vaccination; how the caregiver should react if the child has fever following vaccination; the benefits that receipt of all scheduled vaccinations provides; and the date and location of the future vaccination visit.

At the global level, there is already recognition that more needs to be done to generate demand for vaccinations among caregivers; examples include the Gavi demand generation strategy and the Tailor Immunization Program developed by the WHO office in the European region. The intent of our suggested package would be to maintain demand for vaccination through the entire vaccination schedule among the population of caregivers who have already made it through doors of the health facility. A key part of this suggested option is to ensure that research is supported to examine the costs and effects of various demand generation packages targeted at this particular group of caregivers which would help inform the composition of such packages.

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APPENDIX 1: AIM 1 QUESTIONNAIRE

Parent / Infant Caregiver Questionnaire

Baseline Household Survey

000. General Information

ID	QUESTION	RESPONSE	GO TO
000	Region Name	☐ 1. Greater Accra ☐ 2. Northern ☐ 3. Volta	
001	District Name	Select from drop down list provided	
002	Enumeration Area (EA) Name	Select from drop down list provided	
003	PSU ID	____ ____	
004	Household ID	____ ____ ____	
005	Child ID	____	
006	Household GPS	North:_____ West: _____	
007	Date of interview	____ ____ / ____ ____ / 2016 a. DD b. MM	
008	Name of interviewer		

009	Interviewer ID number	____ ____	
010	Supervisor ID number	____ ____	
011	Attempted visit to this household	☐1. 1st ☐2. 2nd ☐3. 3rd	

100. Verify Eligibility

101	How many children 0-11 months of age live in this household?	____ ____ children 99 if don't know	
102	How many children aged 12-23 months live in the household as their primary residence? Household: Eating from the same pot Primary residence: Lived in the household for at least 6 months out of the year	____ ____ children 99 if don't know	If >1 children aged 12-23 months old live in the household, randomly select one of them using the random selector app. If 99, schedule a time to revisit when the child's primary caregiver is available.

103	How many children ages 24-35 months live in the household as their primary residence?	____ ____ children 99 if don't know	If >1 children 24-35 months, randomly select one of them using the random name picker. If 99, schedule a time to revisit when the child's primary caregiver is available. If Q103 and Q104= 0, household is not eligible. Thank the respondent for their time and continue to the next household.
IF THERE IS ONE CHILD IN BOTH 102 AND 103 PLEAE START A SECOND QUESTIONNAIRE USING THE SAME HOUSEHOLD NUMBER FOR THE SECOND CHILD.			
Thank you for your time. We are here today representing Ghana Health Service and its partners. We would like to ask you about your experience with immunizations that your child aged 12-23/24-35 months has received. The information provided will help the Ghana Health Service in improving the country's immunization programme. The information we collect will be anonymous, which means that you and your child/children will not be personally identified with the information. The interview has 6 sections and should take 30-45 minutes to conduct. Participation in the survey is voluntary, but I hope you will agree to answer the questions since your views are important.			
104	Do you consent to participate in the interview?	☐1. Yes ☐2. No	If no, thank the person for his/her time and continue to the next household.

105	What is your relationship with the selected child?	☐1. Mother ----------> ☐2. Father ----------> ☐3. Grandmother ----------> ☐4. Grandfather ----------> ☐5. Sibling ☐6. Other relative ☐7. Other non-relative	Q107 Q107 Q107 Q107
106	Is the respondent 16 years of age or older?	☐1. Yes ☐2. No	If no, thank the respondent for their time and schedule a revisit when an adult will be available and continue to the next household.
107	Are you the primary caregiver?	☐1. Yes----------> ☐2. No	Q109
108	Are you able to answer questions about this child's health on behalf of the caregiver?	☐1. Yes ☐2. No ---------->	If no, thank the respondent for their time and schedule a revisit when primary caregiver will be available and continue to the next household.

109	Date of birth of selected child	Day (DD) ____ ____ Month (MM) ____ ____ *99=don't know* Year **[____]** 2014 **[____]** 2015 **[____] 2016** **[____]** DK	If month or year is unknown, child is ineligible. • If there are other children in this age group, choose another eligible child and return to Q101 • If there is at least one child in the other age group, seek consent for that child. • If there are no other children in either age group, thank the respondent and continue to the next household.

110	Check that the child is eligible. If child 12-23m: June 2015-May 2016 If child 24-35m: June 2014-May 2015	☐ 1. Yes ☐ 2. No	If no, the child is ineligible. • If there are other children in this age group, choose another eligible child and return to Q101 • If there is at least one child in the other age group, seek consent for that child. • If there are no other children in either age group, thank the respondent and continue to the next household.

111	Did this child live in Ghana at any time between the ages of 12 and 23 months?	☐1. Yes ☐2. No	If the child did not live in Ghana between 12 and 23 months of age, the child is ineligible. • If there are other children in this age group, choose another eligible child and return to Q101 • If there is at least one child in the other age group, seek consent for that child. • If there are no other children in either age group, thank the respondent and continue to the next household.
112	Which age group is the child in this questionnaire?	☐1. 12-23 months ☐2. 24-35 months	

Now, ask the respondent for the following information:

- ***Child health record book or any other document with immunization history for this child. Please remember to avoid letting the mother read or look at the child health record book until after the interview.***

200. Family and child demographic characteristics

I would now like to ask you a few questions about your home.

NB: Ask child's name and substitute "this child" with the name of the child in this section.

ID	QUESTION	RESPONSE	GO TO
201	How many people live in this child's household as primary residents?	____ ____	
202	How many children does this child's mother have in total? [living children]	____ ____ children	
203	What order is this child from the oldest? [Birth order]	____ ____ rank	
204	What is this child's sex?	☐1. Female ☐2. Male	
205	How long has this child's family lived in this neighborhood?	____ ____ years **or if less than 1 year**: ____ ____ months *999 if don't know*	

206	What is this child's mother's marital status?	☐1. Single ☐2. Married ☐3. Co-habitation ☐4. Divorced/Separated ☐5. Widowed	
207	What is this child's mother's age?	____ ____ Years *99 is don't know*	
208	What is this child's mother's highest level of school attended?	☐1. Never attended school ☐2. Primary ☐3. Jr. Secondary/ MSLC ☐4. Sr. Secondary ☐5. Post-secondary ☐99. Don't Know	
209	What is this child's mother's religion?	☐1. Christian ☐2. Muslim ☐3. Traditionalist ☐4. None ☐5. Other: specify_____	

210	What is this child's mother's occupation?	☐1. Storekeeper ☐2. Trader/Merchant ☐3. Civil Servant (e.g. healthcare worker, educator) ☐4. Farmer / Laborer / Fisherwoman /Fish cleaner ☐5. Artisan (e.g. plumber, carpenter, mechanic) ☐6. Miner ☐7. Driver ☐8. Student ☐9. Housewife/Homemaker ☐10. Unemployed ☐11. Seamstress ☐12. Cook ☐13. Cleaner/housegirl ☐14. Other: specify_____	
211	What is this child's father's age?	____ ____ Years *99 is don't know*	
212	What is this child's father's highest level of school attended?	☐1. Never attended school ☐2. Primary ☐3. Jr. Secondary/ MSLC ☐4. Sr. Secondary ☐5. Post-secondary ☐99. Don't Know	

213	What is this child's father's religion?	☐1. Christian ☐2. Muslim ☐3. Traditionalist ☐4. None ☐5. Other: specify_____ ☐99. Don't Know	
214	What is this child's father's occupation?	☐1. Storekeeper ☐2. Trader/Merchant ☐3. Civil Servant (e.g. healthcare worker, educator) ☐4. Farmer / Laborer / Fisherman ☐5. Artisan (e.g. plumber, carpenter, mechanic) ☐6. Miner ☐7. Driver ☐8. Student ☐10. Unemployed ☐11. Other: specify_____ ☐99. Don't Know	
217	Does this child attend a formal school, crèche, or daycare?	☐1. Yes ☐2. No---------- >	Q301
221	Are routine immunization services offered at this child's school, crèche, or daycare?	☐1. Yes ☐2. No ☐99. Don't know	
223	Would you allow this child to be given immunizations at their school, crèche, or daycare?	☐1. Yes ☐2. No ☐99. Don't know	

224	Do you have concerns about this child being given immunizations at their school, crèche, or daycare?	☐1. Yes ☐2. No ----------> ☐99. Don't know ---------->	 Q301 Q301
225	If so, what are your concerns?	[Open response]	

300. Immunization awareness at 2YL

ID	QUESTION	RESPONSE	GO TO
301	At what ages are children supposed to be sent for immunization before their second birthday (2 years)? Do not read response options. Select all that are mentioned as "YES" otherwise select "NO".	☐a. Birth ☐b. 6 weeks ☐c. 10 weeks ☐d. 14 weeks ☐e. 9 months ☐f. 1 year ☐g. 18 months ☐h. Other: specify_____ ☐i. Don't know	302 if mentions 18m; otherwise Q303

302	How did you hear about the 18 month visit for immunizations? Do not read response options. Select all that are mentioned as "YES" otherwise select "NO".	☐a. Family or Friends ☐b. Religious leader or organizations ☐c. Traditional healer ☐d. Healthcare provider ☐e. Opinion or political leader ☐f. Radio ☐g. Television ☐h. Posters or pamphlets ☐i. Information van ☐j. Community information center ☐k Don't know ☐l. Other: specify_____	
303	Have you heard of the immunization against measles? *Prompt: given at the upper arm for rash and fever*	☐1. Yes ☐2. No---------- >	Q305
315_ NEW	How many injections of measles vaccine does your child need to take to fully protect your child against measles disease?	☐1. One injection ☐2. Two injections ☐3. Mentions a number greater than two injections ☐99. Don't know	
304	At what age or ages are it measles-rubella vaccine routinely given to children?	☐1. Mentions 9 months ☐2. Mentions 18 months ☐3. Mentions both 9 and 18 months ☐4. Mentions neither ☐99. Do not know	

305	Do you know someone in your family or community who had measles?	☐1. Yes ☐2. No ☐99. Do not know	
306	Have you heard of the immunization against meningitis? *Prompt: given to prevent CSM in the upper arm*	☐1. Yes ☐2. No---------- >	Q308
307	What age is the immunization against meningitis routinely given to children?	☐1. Mentions 18 months ☐2. Does not mention 18 months ☐99. Do not know	
308	Do you know someone in your family or community who had CSM (meningitis)?	☐1. Yes ☐2. No ☐99. Do not know	
309	Has this child received a vaccine (injection) in the right upper arm to prevent meningitis (CSM) during an immunization campaign?	☐1. Yes ☐2. No ☐99. Do not know	**Question asked only if Northern Region selected during Q000 above.**
310	Did you seek weighing services when this child was 18 months of age?	☐1. Yes ---------- > ☐2. No ☐3. Child less than 18 months of age ---------- > ☐99. Don't know ---------- >	Q312 316_NEW 316_NEW

311	What are the reasons why this child did not seek weighing services at 18 months of age? Do not read response options. Select all that are mentioned as "YES" otherwise select "NO".	☐a. Caregiver did not know child needed to be sent ☐b. Caregiver did not want the child to be given vaccine ☐c. Caregiver did not know where to go for services ☐d. Caregiver received poor treatment at facility ☐e. Caregiver was too busy or forgot ☐f. Facility is difficult to access (e.g. too far) ☐g. Facility hours of services are not convenient ☐h. Cost of transportation to facility is too much ☐i. There would be a long wait ☐j. Other: specify_____	316_NEW
312	What is the main reason why this child sought weighing services at 18 months of age? **<u>Do not read responses</u>** ***Ask for the main reason and mark ONLY ONE.***	☐1. Measles vaccine ☐2. Growth monitoring ☐3. Bednet distribution ☐4. Vitamin A ☐5. Deworming medication ☐6. Presented with younger child for services ☐7. Not sure ☐8. Healthcare worker told caregiver to return ☐9. Other: specify_____	

313	Was the child given an immunization at that visit (Q310)?	☐1. Yes ---------- > ☐2. No ☐99. Don't know ---------- >	Q315 Q315
314	Why didn't they immunize this child at that visit? **<u>Do not read responses</u>** ***Ask for the main reason and mark only one.***	☐1. Caregiver did not think vaccine was necessary ☐2. Caregiver is fearful of vaccines/side effects ☐3. Caregiver did not have the health card with them ☐4. Father or head of household did not allow ☐5. Child was ill, mother refused vaccine ☐6. Child was ill, nurse refused service ☐7. Nurse said the child was not at the right age ☐8. Nurse said they did not have vaccine ☐9. It was not an immunization day ☐10. The waiting time was too long ☐11. Don't know ☐12. Other: specify_____	

316_NEW	What child health services should your child receive during their second year of life? Do not read response options. Select all that are mentioned as "YES" otherwise select "NO".	☐1. Measles-Rubella vaccine ☐2. Meningitis A vaccine ☐3. Any previously missed vaccine doses ☐4. Long-lasting insecticide net ☐5. Growth monitoring ☐6. Other: Specify_____ ☐7. Don't know	

400. Immunization History

ID	QUESTION	RESPONSE	GO TO
401	Has this child ever received any routine immunizations?	☐1. Yes ☐2. No---------->	Q419
402	Where did this child receive their most recent immunization?	☐1. Hospital ☐2. Health Center/Polyclinic/Clinic ☐3. Private health facility ☐4. CHPS ☐5. School ☐6. Outreach (another location) ☐99. Don't know	

403	What is the **most** important factor in choosing this health facility (Q402) for your child's care? **<u>Do not read responses</u>** ***Ask for the main reason and mark ONLY ONE.***	☐1. Quality of services ☐2. Treatment by staff ☐3. Availability of vaccine ☐4. Convenience of transportation ☐5. Convenient hours of service ☐6. Distance ☐7. Recommendation of a relative or friend ☐8. Nice/neat facility environment ☐9. Other: specify_____	
405	Would you prefer daytime or evening immunization sessions during the week?	☐1. Daytime ☐2. Evening ☐3. No preference	
407	Would you prefer weekday or weekend immunization sessions?	☐1. Weekday ☐2. Weekend ☐3. No preference	
408	Has this child always gone for routine immunization at the same site (Q402)?	☐1. Yes ---------- > ☐2. No ☐99. Don't know ---------- >	Q410 Q410
409	What is the main reason why you did not go to the same site? **<u>Do not read responses</u>** ***Ask for the main reason and mark ONLY ONE***	☐1. Family moved ☐2. Site (health facility or outreach) closed or moved ☐3. Availability of vaccine ☐4. Instructed by health care worker ☐5. Convenience of location ☐6. Other personal preference ☐7. Other _____	

410	In your opinion, is it more important to vaccinate infants who are under 12 months, children who are 12-23 months, or is it the same?	☐1. More important to vaccinate infants less than 12 months ☐2. More important to vaccinate children 12-23 months ☐3. Same importance ----------> ☐99. Don't know ---------->	Q412 Q412
411	What is the main reason why it is more important to immunize this age group of children (Q410)?	☐1. Older children have already gotten some vaccines ☐2. Younger children are more vulnerable to diseases ☐3. Older children are more exposed to danger and must be protected ☐4. There is more information promoting infant vaccination ☐5. There is more information promoting vaccination of children 12-23 months ☐6. Other: specify_____	
412	In your opinion, is it easier, the same, or harder to bring a child for immunization services who is 9 months compared to a child who is 18 months of age?	☐1. Easier to bring a child aged 9 months ☐2. Easier to bring a child aged 18 months ----------> ☐3. The same---------->☐99. Don't know ---------->	Q414 Q414 Q414

413	In what ways would bringing an older child for immunization be difficult? ***Do not read responses.*** Select all that are mentioned as "YES" otherwise select "NO".	☐a. 18 month old children can be difficult to handle ☐b. 18 month old children are physically stronger ☐c. 18 month old children are too heavy to carry ☐d. 18 month old children recognize and are frightened by needles ☐e. 18 month old children can say words when they are hurt or upset ☐f. It's difficult to bring more than one child for immunization at one time ☐g. It's harder to remember the appointment date for older children ☐h. Other: specify_____	
414	Has this child been to any health facility for curative care from 18 months of age? **Prompt: malaria, diarrhea, cough etc**	☐1. Yes ☐2. No ☐99. Don't know	
601	As far as you know, has your child received ALL of the recommended immunizations up to 14 weeks of age?	☐1. Yes ☐2. No ☐3. Don't know	
602	As far as you know, did your child received ALL of the recommended immunizations at 9 months of age?	☐1. Yes ☐2. No ☐3. Don't know	
603	As far as you know, did your child received ALL of the recommended immunizations at 18 months of age?	☐1. Yes ☐2. No ☐3. Don't know ☐4. Child is less than 18 months of age	

415	Have you ever had an immunization card [weighing card] that records the immunizations this child has received?	☐1. Yes ☐2. No ---------->	Q418
416	How many immunization [weighing] cards have you ever had for this child?	____ cards *99 is don't know*	If Q416= 0 return to Q415
417	How many immunization [weighing] cards can I see for this child?	____ cards seen	If >0 go to Q501
418	Why do you not have an immunization [weighing] card or other documentation of immunization history for this child? **<u>Do not read responses</u>** ***Ask for the main reason and mark ONLY ONE.***	☐1. This child never received an immunization card ☐2. The health facility keeps the immunization card ☐3. The immunization card is lost or destroyed ☐4. The immunization card is kept at a different location ☐5. Other : specify_____ ☐99. Don't know	If any go to Q606a

419	What is the main reason why the child did not receive ANY routine immunizations? **Do not read responses** ***Ask for the main reason and mark ONLY ONE.***	☐1. Caregiver does not think vaccines are necessary ☐2. Caregiver is fearful of vaccines/side effects ☐3. Caregiver's cultural / religious beliefs do not permit immunization ☐4. Father or head of household does not allow ☐5. Facility treated caregiver poorly ☐6. Facility is difficult to access (e.g. too far away) ☐7. Facility does not have convenient times of services ☐8. Other: specify_____	If any go to Q701

500. Routine Immunization Card Data

Request to see the health card / immunization card of the infant.
For each vaccine, check « Yes » if there is a checkmark or a date for the vaccine and « no » if there is nothing written. Copy the dates. Write « 99 », if there is a poorly written or missing day/month and « 9999 » for missing year.

501	Child's date of birth (DOB) recorded on card ☐☐ / ☐☐ / ☐☐☐☐ a. DD b. MM c. YYYY	
502	At which health facility did this child receive their most recent routine immunization? Record health facility written on card. If no health facility name is written ask the respondent to recall the name.	Name:
503	Type of card(s) ***Mark all available.***	☐a. Child Health Record Book ☐b. Yellow Card ☐c. Piece of paper/other documentation

ID	Vaccine	a. Vaccine received	b. Day	c. Month	d. Year
504	BCG	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
505	OPV0	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐

507	OPV1	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
508	DTP/ Hib/ Hep B (1)	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
509	PCV 13 (1)	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
510	Rotavirus 1	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
511	OPV2	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
512	DTP/ Hib/ Hep B (2)	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
513	PCV 13 (2)	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
514	Rotavirus 2	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
515	OPV3	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
516	DTP/ Hib/ Hep B (3)	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
517	PCV 13 (3)	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
519	Vitamin A (1)	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
520	Measles (1) or Measles-Rubella [MR1]	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐

521	Yellow Fever	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
522	Vitamin A (2)	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
523	Vitamin A (3)	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
524	Measles (2) or Measles-Rubella [MR2]	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
525	Meningitis-A	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
526	Treated Net	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
527	Additional vaccine (specify):	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
528	Additional vaccine (specify):	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
529	Additional vaccine (specify):	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐
530	Date indicated to return for Measles-Rubella 2	☐1. Yes ☐2. No	☐☐	☐☐	☐☐☐☐

600. Vaccine recall (if no card available)

ID	QUESTION	RESPONSE	GO TO

604	At what age did your child receive his/her most recent immunization?	_____months Enter 99 if don't know	
605a	At which health facility did this child receive their most recent routine immunization?	☐ 1. Name: _____ ☐ 2. Don't know----------→	606a
605b	What is the full name of the child given at the health facility named?	Name: _____ _	
605c	What is the full name of mother given at the health facility named?	Name:_____ _____	
NEW 606a	Has the child ever received an injection in the right upper arm or shoulder that usually causes a scar? – that is, BCG vaccination (against tuberculosis)	☐1. Yes ----------→ ☐2. No ----------→ ☐3. Don't know----------→	Q606b Q607a Q607a
NEW 606b	If the child is present, check for evidence of a scar and record	☐1: Scar Present ☐2: No Scar Present ☐3: Child not available to check	
NEW 607a	Has the child ever received any "vaccination drops in the mouth" – that is, polio?	☐1. Yes ----------→ ☐2. No ----------→ ☐3. Don't know ----------→	Q607b Q608a Q608a

NEW 607b	How many times was the polio vaccine received at a routine immunization session?	Number of times: _____	
NEW 607c	If yes, did the child ever received the first oral polio vaccine in the first two weeks after birth?	☐1. Yes ☐2. No ☐3. Don't know	
NEW 608a	Has the child ever received an injection on the **left thigh**? – that is a five-in-one vaccination (pentavalent) to prevent him/her from getting tetanus, whooping cough, diphtheria, influenza & hepatitis.	☐1. Yes ----------→ ☐2. No ----------→ ☐3. Don't know ----------→	Q608b Q609a Q609a
NEW 608b	How many times did the child receive the pentavalent vaccine on the left thigh?	Number of times: _____	
NEW 609a	Has the child ever received a pneumococcal vaccination, that is, an injection in the **right thigh** to prevent pneumonia?	☐1. Yes ----------→ ☐2. No ----------→ ☐3. Don't know ----------→	Q609b Q610a Q610a
NEW 609b	How many times did the child receive the pneumococcal vaccine?	Number of times: _____	

NEW 610a	Has the child ever received an injection on the **left upper arm**? that is measles-rubella injection at the age of 9 months or older - to prevent him/her from getting measles and rubella	☐1. Yes ----------→ ☐2. No ----------→ ☐3. Don't know ----------→	Q610b Q611a Q611a
NEW 610b	How many times was measles-rubella vaccine given at a routine immunization session?	Number of times: _____	
NEW 611a	Has the child ever received an injection on the **right upper arm** ? that is a Yellow Fever injection at the age of 9 months or older to prevent yellow fever disease.	☐1. Yes ----------→ ☐2. No ----------→ ☐3. Don't know ----------→	Q611b Q612a Q612a
NEW 611b	How many times did the child receive yellow fever at a routine immunization session?	Number of times: _____	
NEW 612a	Has the child ever received Rotavirus vaccine ? That is liquid which its entire contents are emptied into the cheek of the child to protect against diarrheal disease.	☐1. Yes ----------→ ☐2. No ----------→ ☐3. Don't know ----------→	Q612b Q613a Q613a
NEW 612b	How many times was rota virus vaccine given at a routine immunization session?	Number of times: _____	

NEW 613a	Has the child ever received an injection on the **right upper arm**? that is meningitis injection at the age of 18 months or older - to prevent him/her from getting meningitis	☐1. Yes ----------→ ☐2. No ----------→ ☐3. Don't know ----------→	Q613b Q614a Q614a
NEW 613b	How many times was meningitis vaccine given at a routine immunization session?	Number of times: _____	
NEW 614a	Has the child ever received Vitamin A drops ?	☐1. Yes ----------→ ☐2. No ----------→ ☐3. Don't know ----------→	Q614b Q701 Q701
614b	How many times did child receive Vitamin A drops?	Number of times: _____	

700. Immunization Knowledge, Attitudes and Beliefs (KAB)

ID	QUESTION	RESPONSE	GO TO
701	What is the maximum number of vaccine injections you will **allow** this child to receive during a single healthcare visit? ***Read the options. Choose only one answer***.	☐1. 0 vaccine injections ☐2. 1 vaccine injection ☐3. 2 vaccine injections ☐4. 3 vaccine injections ☐5. 4 or more vaccine injections ☐6. I am comfortable with any number	

702	What is the maximum number of vaccine injections you feel **comfortable** with this child receiving during a single healthcare visit? ***Read the options. Choose only one answer***.	☐1. 0 vaccine injections ☐2. 1 vaccine injection ☐3. 2 vaccine injections ☐4. 3 vaccine injections ☐5. 4 or more vaccine injections ☐6. I am comfortable with any number	
703	What are the reasons why you gave the previous response with respect to the maximum number of vaccine injections you are comfortable with this child receiving during a single visit? Do not read response options. Select all that are mentioned as "YES" otherwise select "NO".	☐1. I want to avoid too much pain in a single visit ☐2. I want to limit the risk of fever ☐3. I want to limit the risk of harmful side effects ☐4. I feel that it is better for my child's health to get it done at once ☐5. I don't want to have to come back for vaccines on a different day ☐6. My child's doctor or nurse knows best about the vaccines my child needs ☐7. Other: specify_____	
704	If the national immunization policy states that 2 injectable vaccines should be given in the same arm/leg would you allow it?	☐1. Yes ☐2. No ☐99. Don't know	

705	In your household, who makes the decision to immunize the children?	☐1. Father only ☐2. Mother only ☐3. Both father and mother ☐4. Other family member(s) ☐5. Other: specify_____	
706	What are the different ways that you get information about immunization? Do not read response options. Select all that are mentioned as "YES" otherwise select "NO".	☐a. Family or Friends ☐b. Religious leader or organizations ☐c. Traditional healer ☐d. Healthcare provider ☐e. Opinion or political leader ☐f. Radio ☐g. Television ☐h. Posters or pamphlets ☐i. Information van ☐j. Community information center ☐k. Gong-gong ☐l. Don't know ☐m. Other: specify_____	

707	Which of the ways mentioned do you trust the most for information about immunization? ***Ask for the main source and mark ONLY ONE.***	☐1. Family and friends ☐2. Radio/media ☐3. Healthcare worker ☐4. Traditional healer ☐5. Television ☐6. Posters at local vendors ☐7. Opinion/political leader ☐8. Religious leaders and organizations ☐9. Internet ☐10. Information van ☐11. Community information center ☐12. Gong-gong ☐13. None ☐14. Other: specify_____	Q706 must be selected in Q707. If not, go back to 706 .
709	Does this child's primary caregiver have regular access to a phone that can receive text messages? **Select the phone that is the *primary* phone that the caregiver would use for text messages.**	☐1. Yes, own phone ☐2. Yes, another phone in the household ☐3. Yes, another phone outside the household ☐4. No access to a phone for SMS ----------> ☐99. Don't know ---------->	Q711 Q711
710	In the last 6 months, has the phone number for this phone (Q709) changed?	☐1. Yes ☐2. No ☐99. Don't know	

711	Who in this child's household is able to read text messages? Do not read response options. Select all that are mentioned as "YES" otherwise select "NO".	☐1. Primary caregiver ☐2. Other person in the household ☐3. Neighbour ☐4. No one ☐99. Don't know	
Q713_NEW	Have you heard messages about getting your child vaccinated?	☐1. Yes ☐2. No ----------→ ☐3. Do not know----------→	 Q715_NEW Q715_NEW

Q714_NEW	If yes, where have you heard these messages? Do not read response options. Select all that are mentioned as "YES" otherwise select "NO".	☐ Mother-in-law ☐ Husband ☐ Other family member(s) ☐ Radio ☐ Healthcare provider ☐ Community volunteers ☐ Television ☐ Posters ☐ Friends ☐ Religious leaders and organizations ☐ Community leaders and organizations ☐ Internet ☐ SMS ☐ Teachers ☐ Social Media (e.g. Whatsapp, Facebook) ☐ Community announcer (gong-gong) ☐ Other	
Q715_NEW	*For the following statement respond by telling me if you 1) agree, 2) are not sure, or 3) disagree with the statement:* I believe vaccines are safe	☐ 1. Agree ☐ 2. Not sure ☐ 3. Disagree	

Q716_NEW	*For the following statement respond by telling me if you 1) agree, 2) are not sure, or 3) disagree with the statement:* I believe vaccines protect my child from vaccine preventable disease.	☐1. Agree ☐2. Not sure ☐3. Disagree	

800. General concerns

801	Do you have any worries about immunizations that you would like to discuss today?	☐1. Yes ☐2. No ----------> Q803 ☐99. Don't know ----------> Q803	
802	What are your worries about immunizations?	[open text]	
803	Is there anything about immunization services that you would want to see a change?	☐1. Yes ☐2. No ----------> ☐99. Don't know ---------->	If from Northern Region start module 2 supplemental modules; else End
804	What would you like to see changed?	[open text]	

END OF INTERVIEW. Thank the person for their time.

Module 2. Supplemental Modules to be conducted in Northern Region ONLY

900. Vaccination Knowledge, Attitudes, Beliefs (KAB)

Interviewer: Read the following to the caregiver: *I am going to read to you a series of statements. For each statement, respond by telling me if you 1) agree, 2) are not sure, or 3) disagree with the statement I just read to you. Please tell me if you do not understand these instructions at any point during this interview.*

Interviewer: Read each statement and mark the answer given by the caregiver.

ID	Statement	Agree (1)	Not Sure (2)	Disagree (3)
901	Children get more vaccinations than are good for them			
902	Healthy children do not need immunizations			
903	Vaccination does more good than harm			
904	It is better for a child to develop immunity by getting sick than to get a vaccination			
905	A parent should be allowed to selectively choose the vaccines which she believe her child needs			
906	It is better for a child to receive two injectible vaccinations in 1 visit rather than 1 injectible vaccination in 2 visits			
907	Many of the illness which vaccinations prevent are severe			
908	When a parent refuses to vaccinate a child, it harms the entire community through risk of disease			
909	People in this community have expressed concerns that a child might have a serious side effect from a vaccination			

910	Following the nationally recommended vaccination schedule is a good idea for a child			

1000. KAB: Personal experience with diseases

Interviewer: Read the following to the caregiver: *I am going to read to you a series of questions about your personal experience with diseases that are preventable by vaccination. For each statement, respond by telling me 1) Yes, 2) No, or 3) Not Sure.*

ID	Statement	Yes	No	Not Sure
1001	Have you personally seen someone with either polio, pneumonia, measles or whooping cough?			
1002	Do you know of someone in your family or community who had either polio, pneumonia, measles or whooping cough?			
1003	Have you ever delayed having your child get a vaccination for reasons other than illness or allergy?			
1004	Have you ever decided not to have your child get a vaccination for reasons other than illness or allergy?			
1005	If you had another infant today, would you want your infant to get all recommended vaccinations?			
1006	Do you know the location where you can have your child vaccinated?			
1007	Do you know the days and times when vaccination services are offered in your community?			
1008	Are you able to discuss any concerns you have about vaccinations with your child's healthcare provider?			
1009	Do you trust the information that you receive from your local healthcare worker about vaccinations?			