Maternal determinants of timely vaccination coverage among infants in rural Bangladesh

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ABSTRACT

Background: Timely vaccination, i.e., the receipt of all scheduled vaccinations in an age-appropriate fashion, is critical for the prevention of deadly diseases in infants and achievement of the UN Millennium Development Goal to reduce infant mortality. Infants, especially in rural or underprivileged settings often receive delayed vaccinations leaving them susceptible to vaccine-preventable illnesses early in the first year of life. In this study, we examined rates of timely vaccination among 24,435 infants born in Gaibandha and Rangpur rural districts of Bangladesh from 2001 to 2007.
Methods: Vaccinations due by 14 weeks of age and administered through routine government immunization services were assessed using interviews with enrolled mothers between 11 and 18 weeks postpartum. We created a Timely Vaccination (TV) score to classify infants as vaccinated fully and on schedule (TV = 1) or not (TV = 0), and used multivariable logistic regression to identify maternal characteristics associated with infant's timely vaccination status.
Results: Our results suggest that only 19% of infants in this cohort received scheduled vaccinations on time by 11–18 weeks postpartum. Mothers' engagement in paid employment [OR = 1.13, 95% CI: 1.03–1.23], receipt of tetanus toxoid vaccination [OR = 1.24, 95% CI: 1.11–1.38], history of antenatal care [OR = 1.22, 95% CI: 1.12–1.32], or higher socioeconomic status [OR = 1.07, 95% CI: 1.03–1.11] were positively associated with timely vaccination of their infants. Mother's perception of small infant size at birth was negatively associated with timely vaccination [OR = 0.89, 95% CI: 0.82–0.97].
Conclusion: Timely vaccination coverage of infants in rural Gaibandha and Rangpur districts is extremely low. This analysis identifies important shortcomings associated with the 1-year vaccination benchmark of routine immunization performance and suggests the need for specific interventions based on potential maternal determinants as well as known system and programmatic barriers of timely vaccination among infants in rural Bangladesh.

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1. Introduction

The role of vaccines in reducing childhood mortality is well documented [1–3]. Since the establishment of the Expanded Program on Immunization (EPI) in Bangladesh in 1979, the country has seen a rise in the coverage of routine immunization services, and in parallel, a steady decline in infant morbidity and mortality attributable to a reduction in vaccine-preventable diseases [3–6]. The EPI schedule in Bangladesh includes vaccinations against

tuberculosis, diphtheria, tetanus, pertussis, poliomyelitis, and measles in children less than a year old (2009 schedule, Supplementary Table 1) [4,7–9]. In 2009, the national coverage for these vaccines was estimated to be over 90% [7,8,10]. However, the mortality rates among Bangladeshi infants in 2011 remained high at 37 deaths per 1000 live born infants [10].

Routine immunization services in most countries, including Bangladesh, rely on the percentage of infants receiving each recommended vaccines by 12 months of age, but measured when the infant is 12–23 months of age, as an indicator of vaccination coverage success [5,9,11,12]. However, the potential drawback with using this crude coverage estimate is that it does not adequately capture departures from recommended vaccination schedules

during the first year of life [9,11–16]. Vaccine doses administered to infants too soon, or at incorrect intervals are included when determining crude coverage, even though these doses do not adequately protect the infant from vaccine-preventable diseases [9,11–16]. Not surprisingly, even in countries with high crude vaccination coverage, delays in administering timely vaccinations have been associated with an increased risk of morbidity and mortality among children [9,11,13–16]. Infants living in rural areas often face a combination of low vaccination coverage and delayed vaccination [1–3,9,11,17,18]. These critical vaccination gaps are further magnified when framed against a landscape of high disease burden, prevalent micronutrient deficiencies and vulnerabilities of low birth weight and preterm birth, present in a number of developing countries [19–21].

There are limited data describing specific factors that contribute to a complete, timely vaccination status among infants living in rural areas in Bangladesh [3–5,17]. While many studies have attempted to generalize the reasons for under-vaccination across the globe, determinants of vaccination can vary widely by societal contexts, necessitating country- and context-specific analyses of these determinants [2,9,14,22]. In this study, we used data from the Johns Hopkins Vitamin A (JiVitA-1) randomized community trial to determine the timeliness of vaccinations due in the first 14 weeks of life among infants residing in the Gaibandha and Rangpur rural districts of Bangladesh, as well as describe maternal characteristics associated with timely vaccination coverage in this region.

2. Methods

2.1. Study population

The JiVitA-1 randomized community trial was conducted to study the effects of micronutrient supplementation on maternal mortality in the Gaibandha and Rangpur rural districts of Bangladesh [23]. This trial is described in depth elsewhere, but in brief, a total of 60,000 women of reproductive age were enrolled and prospectively followed, with 47,091 births occurring between 2001 and 2007 [20,23]. All data used in this study on maternal determinants of timely vaccination coverage were collected through household interviews of mothers at 3 months postpartum, referred to henceforth as the first postpartum interview [23]. Infants were assessed for their eligibility to be included into this analysis based on criteria established in the vaccine literature, including only live singleton births as well as consent and completion of the postpartum interviews (Fig. 1). Since we analyzed vaccinations due by 14 weeks of age (Supplementary Table 1), only those first postpartum interviews completed between 11 and 18 weeks of age of infant were included in the analysis (see Supplementary methods). Infants with no available vaccination information (by mother's recall or vaccination card) from the postpartum interviews were excluded [24]. Infants whose mothers died or who were adopted were excluded from this analysis, limiting the inclusion to pairs of living infants and birth mothers [13].

2.2. Outcome

Supplementary Table 1 depicts the Bangladesh EPI schedule of vaccinations for infants by 1 year of age. According to this schedule, infants should receive one dose of the Bacillus Calmette-Guerin vaccine (BCG) at birth, followed by 3 doses each of the diphtheria-pertussis-tetanus (DPT) vaccine and oral polio vaccine (OPV) by 14 weeks post-birth [4,7]. Since the dates on which the infants were vaccinated were not recorded in the postpartum interviews, we used the date of the postpartum interview as a proxy for the date of most recent vaccination. The infant's Timely Vaccination (TV)

score was calculated as the primary outcome as described below. Infants included in the study were classified into two sub-cohorts depending on whether the first postpartum interview was completed between 11 and 14 weeks (sub-cohort 1) or between 15 and 18 weeks (sub-cohort 2) after birth. Infants in sub-cohort 1 were eligible to receive 5 vaccine doses, namely 1 dose of BCG and 2 doses each of DPT and OPV and infants in sub-cohort 2 were eligible to receive 7 vaccine doses, namely 1 dose of BCG and 3 doses each of DPT and OPV. It should be noted that this method of classification allowed for different buffer times for the infant to receive any particular vaccine. For instance, an infant in sub-cohort 1 had a time frame of 11–14 weeks to receive the BCG vaccine, but only a time frame of 1–4 weeks to receive the second dose of OPV or DPT vaccine. Due to the high ownership of vaccination cards for children 12–23 months of age in Bangladesh (up to 67%), the TV score across both sub-cohorts was analyzed using reports from the government issued vaccination cards alone (Table 1) [5]. Infants receiving all due vaccine doses (either 5 or 7 vaccine doses depending on when the postpartum interview was conducted) between 11 and 18 weeks of age were assigned a TV score of 1 (Table 1). Infants who were not vaccinated at all or were partially vaccinated by the date of the first postpartum interview were assigned a TV score of 0. Mother's recall was not used for calculating this score due to questions surrounding the validity of this method and associated recall bias for estimating vaccine coverage [25,26] (see Supplementary methods).

2.3. Statistical analysis

Multivariable logistic regression was used to identify associations between maternal characteristics and infant's TV score, after adjusting for household and infant-specific characteristics. Characteristics previously shown to be associated with timely vaccination of infants or urban/rural differences in coverage of vaccination were identified from the literature and classified as maternal, household or infant-specific [2,4,9,27]. These were analyzed both independently and jointly for their association with the outcome (TV score) as described below.

Maternal variables analyzed included the age of the mother (in years) when the pregnancy was detected, number of previous live births (parity), and number of previous pregnancies (gravidity). The wantedness of pregnancy was assessed based on whether the mother reported wanting to become pregnant then, wanting to wait until later or not wanting any more children. In addition, the number of years of formal education attained by the mother was also included. The mother's employment status was assessed based on whether she was engaged in any form of paid employment. Visits to a doctor or health center specifically for antenatal check-up, and receipt of the tetanus toxoid (TT) vaccine were included as covariates in the analysis in addition to the mother's perception of infant's size at birth as large, medium or small.

Household socioeconomic status was expressed using a living standards index as well as using a measure of the distance from the nearest market or town to the respondent's household. In brief, the living standards index was created using principal component analysis of the following categories of variables collected during the enrollment of women into the JiVitA trial: land ownership, productive assets, dwelling characteristics, and durable assets [28].

Infant-specific characteristics analyzed included sex and morbidity. Report of morbidity was based on whether the infant experienced any of the following conditions in the first three months of life: cough, cold, difficulty breathing, high fever, diarrhea, or dysentery.

Multivariable logistic regression models were constructed using manual selection of characteristics based on their association with the outcome in univariable models, Wald tests and χ^2 probabilities of groups of variables in multivariable models, and previously