

Identifying households with low immunisation completion in Bangladesh*

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ABSTRACT

The objective of this study was to investigate if the mothers' demographics and household characteristics—including type of use of cooking fuel, energy and toilet facilities—have any implication for complete immunisation rates among their children. A cross-sectional data analysis of a nationally representative sample of 4925 women with at least one child was performed. Chi-squared tests and multivariate logistic regression analyses were used. Immunisation coverage was positively associated with the mother's education and with household characteristics such as toilet facility, electricity and involvement in a microfinance group. These findings indicate the need for further advocacy for increased knowledge on the importance of vaccination and affordable public immunisation programs focusing on higher risk households such as those with pit facilities, lack of electricity and no participation in a microfinance group. Such households warrant further attention and can be targeted for immunisation coverage.

Keywords: Bangladesh; Children; Household Characteristics; Vaccination Completion

1. INTRODUCTION

Child immunisation is one of the most successful strategies for reducing child illness and mortality. It is one of the most efficient ways of protecting the health of women and children around the world against contemporary diseases that can be both burdensome and deadly [1]. Immunisation of children under one year of age against the six major vaccine preventable diseases: tu-

berculosis, diphtheria, pertussis, tetanus, poliomyelitis, and measles, is one of the most cost-effective strategies to reduce both infant and child morbidity and mortality. A recent estimate suggests that immunisation programs prevent 3.2 million deaths annually [2]. Although child immunisation is a cost-effective public health strategy [3, 4], incomplete vaccinations still exist and the factors related with incomplete immunisations are poorly understood. In Bangladesh, the high density of the population, along with poverty contributes significantly to health issues [5]. The Expanded Program for Immunisation (EPI) of the World Health Organization (WHO) was created in 1974 as a worldwide alliance to expand immunisation services and coverage [4]. In 1979 Bangladesh launched EPI to combat 6 major childhood diseases—polio, measles, pertussis, tetanus, diphtheria and tuberculosis, yet the program did not take-off until 1985 when Bangladesh made the commitment to reach child immunisation by 1990 [4,6]. The Bangladeshi national budget includes a line item to purchase routine immunisation programme vaccines; in 2009 almost half (40%) of all spending on routine immunisation was financed with government funds [7]. The program managed to increase vaccination rates from 2% coverage in 1985 to 61% coverage in 1991 and the coverage continued to improve thereafter [7,8]. In Bangladesh measles vaccination rates tend to be lower, possibly because the incidence of measles has declined over the last three decades and complacency has grown regarding the measles vaccination [9]. Although achievement of the immunisation program in Bangladesh has been impressive and the WHO's health profile showed high rates of immunisation in 1998 (BCG coverage was at 96.8%, measles at 96%, DPT3 at 95%, and oral polio at 92%), the coverage of fully immunised children (all doses given at the correct intervals) was only 71% [10,11]. A similar study in Nigeria found that 61.9% children were under complete immunisation coverage, while the coverage level was

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higher in rural community (81%) against DPT/OPV [3]. Another study conducted by Jha *et al.* in Nepal found that immunisation rates were 65.7% [12]. A child is said to be fully immunised if he or she has received all of the following vaccines: a dose of Bacille Calmette Guerin (BCG), three doses of oral polio (OPV), three doses of diphtheria, pertussis and tetanus (DPT), three doses of Hepatitis B (HB) and one dose of measles [3]. For certain vaccines, the first dose does not provide complete immunity, hence more than one dose is necessary in order to build more complete immunity. Both correct timing and spacing of vaccine doses are essential to adequate vaccine administration. By decreasing the intervals between dosages, the vaccine's antibody response may be interrupted [13,14].

In spite of the success of this immunisation program, some significant challenges still remain. Studies found that coverage is lowest for DPT3, Polio3 and measles in rural areas [15-17]. The acceptance of these vaccinations has increased but levels of full immunisation coverage are less than satisfactory and can be improved. Moreover, there are still large variations among different levels of education and socio-economic factors (electricity, toilet facility, microfinance and cooking fuel), leaving room for new policies targeting more equitable coverage. A study conducted by Chowdhury and colleagues found that immunisation coverage was higher for children whose mothers were more educated [17]. Other studies also reported a strong relationship between child mortality and maternal education [18,19]. Odusanya *et al.* identified that completeness of vaccination significantly correlated with knowledge of mothers on immunisation [3]. A study by Sanou *et al.* showed that in rural areas, children from Muslim families had lower immunisation coverage rates compared to others and that religion was not significantly related to lower immunisation coverage in urban areas [20]. Similarly, a study in India by Nath *et al.* showed that Muslim religion was a significant independent predictor of partial immunisation status of the child and that Muslim religion was associated with the unimmunised status of the child [21,22].

In Bangladesh, poor households depend heavily on wood, dung and other biomass fuels for cooking [23]. Studies found that solid cooking fuels remain the principal household fuel for around 3 billion people [24,25]. Since the use of solid cooking fuels is closely linked to poverty, it is also linked with generally poor access to health care [24]. In order to overcome the reasons for incomplete immunisation we must identify the household characteristics most strongly associated with delayed or non-immunisation (low acceptance of immunisations) of their children. This paper examined whether the effects of these variables were different for children in households with type of cooking fuel use, use of electricity,

type of toilet use, association with microfinance groups and mothers' social, economic, demographic, and regional characteristics.

2. METHODS

This study was a secondary analysis from the fifth and latest Bangladesh Demographic and Health Survey (BDHS, 2007), a nationally representative household survey using a structured questionnaire [5]. There were 10,996 women, aged 15 - 49 years old, surveyed from 10,400 households.

The survey involved multistage cluster sampling and was based on the 2001 population census enumeration areas (EAs) with population and household information. EAs were used as primary sampling units (PSUs) for the whole survey. Each PSU had 100 households with locational maps and geographical boundaries. In total 361 PSUs (227 in rural areas and 134 in urban areas) were randomly selected from the six divisions—Barisal, Chittagong, Dhaka, Khulna, Rajshahi and Sylhet. During January to March 2007, a household listing operation was carried out in all PSUs. In the next part, 30 households were selected from each PSU, using an equal probability systematic sampling technique in relation to the 2001 population census. Finally 10,819 households were initially selected from the sample clusters for the survey.

All ever-married women of reproductive age (15 - 49 years) who slept in the chosen households the night before the survey were eligible to participate in the survey. In the end, 10,400 households were selected for the study. From these selected households, 11,178 eligible women aged 15 - 49 years were identified and 10,996 were interviewed. There was a response rate of 98%. In the current study women (N = 6150) with at least one child were included. For the purpose of this study, a limited number of available DHS variables expected to contribute to identifying households with low immunisation coverage were chosen.

Immunisations: Mothers were asked in a retrospective manner whether her children were immunised (BCG, Measles, DPT1, DPT2, DPT3, Polio1, Polio2, Polio3) and they were asked to show their vaccination card to the interviewer. The response validated by vaccination card was included in our study.

Cooking fuel: Respondents were asked whether they used solid cooking fuel (biomass fuels such as wood, charcoal, dung or straw) or non-solid cooking fuels (kerosene, LPG/natural gas, or electricity).

Age of the respondents in 7 age groups: 15 - 19, 20 - 24, 25 - 29, 30 - 34, 35 - 39, 40 - 44 and 45 - 49. *Place of residency:* rural or urban. *Education:* No education, primary education, secondary education and higher educa-

tion. *Religion*: Muslim and others. *Economic status*: wealth index constructed from data on all household assets. Rustein *et al.* developed this as an indicator to measure the level inequalities in household income, use of health services, and health outcomes [26]. Wealth index has five quintiles: poorest, poorer, middle, richer and richest. *Divisions*: Bangladesh has six administrative divisions: Barisal, Chittagong, Dhaka, Rajshahi, Sylhet, and Khulna. *Microfinance*: yes or no. *Type of Toilet Facility*: flush, pit or no facility. *Electricity*: yes or no.

Place of delivery: Respondents were asked whether they had their delivery at home (either their own or someone else's), or at health care facilities (private health facility, public health facility or somewhere with medical delivery facilities).

Prevalence estimates were calculated to reflect acceptance of BCG, measles, DPT and polio vaccinations. The vaccinations were the dependent variables. The proportions and chi-square test were used to examine the cross-relationships between dependent (vaccinations) and independent variables (demographics). Multivariate logistic regressions were employed to study the potential association between target variables such as vaccinations with independent demographic variables.

Also a separate variable was constructed where children had no vaccination at all and a multivariate logistic regression analysis was used with that variable. Proportions of non-immunised children in all primary sampling units (PSUs) were presented in bar-diagram in all the six administrative divisions by rural and urban areas. Initially all PSUs were extracted from GPS base of the BDHS. Then non-immunisation variable was matched to each PSU. Finally, proportions of non-immunised children in each division were estimated in rural and urban areas.

Confidence intervals (CI) were measured at 95% level. Data were analysed using SPSS version 18.0.

The survey received ethical approval from the Institutional Review Board of Opinion Research Corporation (ORC), Macro International Incorporated. Informed consent was obtained from the participants prior to the interview, and the right to withdraw was emphasised throughout the survey.

3. RESULTS

Table 1 shows among the women surveyed ($n = 6150$) the majority (circa 91%) used solid cooking fuel. Almost half of the respondents (47%) had electricity at home. The majority of them (48%) used pit toilets, 24% used flush toilets, while 28% of the respondents had no toilet facilities. Around 80% of households with electricity used solid fuels to cook. **Table 2** shows that 93% of children received BCG and 71% of children received the

measles vaccine. DPT1 had been received by 92%, DPT2 by 87% and DPT3 by 81% of children. The Polio1 vaccine had been received by 94%, Polio2 by 89% and Polio3 by 83% of children.

Approximately 80% of Dhaka residents used solid cooking fuel, while around 90% of residents in other divisions used solid fuel to cook. Findings showed that a wide gap in vaccination coverage still exists between urban and rural areas. People who lived in urban areas used significantly less amount of solid cooking fuel than those who lived in rural areas, 75% and 99% respectively. There is an inverse trend with education and solid cooking fuel use. As education levels rise, the use of solid cooking fuel decreases. Participants who were part of a microfinance group were more likely to use solid cooking fuels. Likewise with education we found an inverse relationship between economic status and use of solid cooking fuel. As wealth increases, use of solid cooking fuel significantly decreases.

Barisal and Sylhet had the lowest electricity rates. Seventy six percent of people who live in urban areas had electricity, compared with 32% in rural areas. Use of electricity increased as education increased and less than half of those participating in a microfinance group had electricity.

People residing in Barisal were the least likely to have a flush toilet. Significant associations were found between flush toilet facilities and demographics. Forty seven percent of the respondents living in urban areas had a flush toilet, compared with 13% living in rural areas. There was a positive relationship between education and flush toilet facilities; as education increased the likelihood of having a flush toilet increased. As wealth increased, so did the probability of having a flush toilet.

Significant associations were found among and between the divisions in Bangladesh and vaccination coverage. Rates of measles vaccinations among children in Bangladesh are still low. Overall, only 71% of children received the measles vaccine. As doses increased, the percentage of children receiving the DPT and polio vaccines decreased. Sylhet and Chittagong had lower vaccination coverage than Barisal, Dhaka, Khulna and Rajshahi. Urban Dhaka (27.7%), rural Chittagong (23.6%) and rural Shyllet (23%) demonstrated highest percentage of non-vaccinated children according to distribution of non-immunised children in PSUs (**Figure 1**). On the other hand, rural Khulna (7.2%) and urban Barisal (9.4%) had the lowest proportion of non-immunised children. The mother's education was a very important predictor of the child's immunisation coverage. For almost all the vaccines, 90% of children from mothers with secondary or higher education showed vaccination coverage.

There was a strong association between type of toilet facility and vaccination acceptance. Children in the

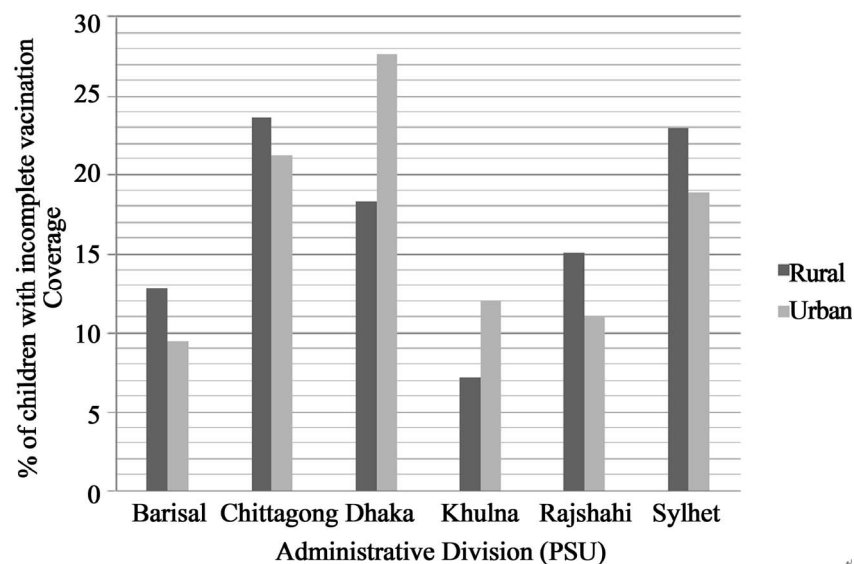


Figure 1. Incomplete vaccination coverage for children by administrative division (urban & rural PSUs*).

households without facilities (no flush toilet or pit) had lower rates of vaccination than those with facilities (**Table 2**). For DPT, 75% of children in the households without a toilet facility were vaccinated, while 84% of those in a household with a flush or pit toilet were vaccinated. Similar results were observed with BCG, measles and Polio3. Households with electricity had better immunisation coverage of their children. For the measles, DPT 2 and DPT 3 vaccines we found 8% - 12% more coverage in the households with electricity. Significant associations between microfinance and vaccination coverage were also found. Those who participated in a microfinance group were more likely to be vaccinated against all the vaccines included in this study. Strong positive associations were found between wealth and acceptance of vaccines. As wealth increased, vaccination coverage increased in all cases, except measles. Measles coverage was 87% for the poorest group, 67% for the second poorest group and 75% for the richest group.

In addition to the strong association with the aforementioned variables, a strong association was found between choice of cooking fuel and vaccination coverage. Households using non-solid cooking fuel had a higher proportion of vaccinated children. Around 76% of children in households using non-solid cooking fuel were vaccinated for measles in comparison to only 70% of those that used solid fuels. For households using solid cooking fuel, 81% of children were fully vaccinated for DPT and 82% were fully vaccinated for polio. Place of delivery emerged as an important factor for predicting immunisation of the children. Mothers who delivered at home had less immunisation coverage of their children than women who delivered at health care facilities.

Results of the multivariate analysis for individual vaccine dosages are presented in **Table 3**. Among the independent variables, residency, education, type of toilet, electricity, microfinance and cooking fuel showed statistically significant associations with acceptance of immunisation. Rural residents were more likely to be fully vaccinated with DPT3 and Polio3.

A significant positive association was found between education and vaccine acceptance. Women with no education or a primary education had lower odds of having vaccinated their children against BCG. Children of women with the highest education had twice the odds of being vaccinated for measles than children of mothers with no education {OR = 0.5; $p < 0.001$ }. Women in the two lowest education categories had lower odds of fully vaccinating their children against DPT {OR = 0.33; $p < 0.001$ } and {OR = 0.48; $p < 0.001$ } and polio {OR = 0.34; $p < 0.001$ } and {OR = 0.45; $p < 0.001$ }, respectively.

Households with a pit as a main toilet facility had twice the odds of having their children vaccinated than those with no facility {OR = 1.75; $p < 0.001$ } for the BCG vaccine, {OR = 1.61; $p < 0.001$ } for DPT3 and {OR = 1.68; $p < 0.001$ } for Polio3. Electricity was also found to have a positive association with vaccination rates. Children living in households without electricity had lower odds of being vaccinated against BCG {OR = 0.64; $p < 0.001$ }, measles {OR = 0.72; $p < 0.001$ }, DPT3 {OR = 0.66; $p < 0.001$ } and Polio3 {OR = 0.64; $p < 0.001$ }.

Members of microfinance groups had higher odds of vaccinating their children. Those who were not members had lower rates of BCG {OR = 0.62; $p < 0.001$ }, measles

Table 1. Demographics of the households according to use of type of cooking fuel, energy consumption and use of toilet facilities.

	N	Access to electricity			Type of toilet			Cooking fuel		
		Yes	Flush	Pit	No facility	Non-Solid	Solid			
Division		p < 0.001	p < 0.001							
Barisal	787	188 (27%)	92 (12%)	461 (58%)	238 (30%)	16 (2%)	775 (98%)			
Chittagong	1271	569 (50%)	346 (27%)	542 (43%)	387 (30%)	162 (12.7%)	1113 (87.3%)			
Dhaka	1282	694 (60%)	399 (31%)	563 (44%)	323 (25%)	268 (20.9%)	1017 (79.1%)			
Khulna	714	354 (55%)	162 (23%)	425 (60%)	127 (18%)	21 (2.9%)	693 (97.1%)			
Rajshahi	967	371 (43%)	189 (20%)	507 (52%)	271 (28%)	26 (2.7%)	941 (97.3%)			
Sylhet	1114	427 (41%)	310 (28%)	458 (41%)	350 (31%)	59 (5.3%)	1059 (94.7%)			
Residency		p < 0.001	p < 0.001							
Urban	2107	1445 (76%)	994 (47%)	736 (35%)	377 (18%)	525 (24.9%)	1582 (75.1%)			
Rural	4043	1158 (32%)	504 (13%)	2220 (55%)	1319 (33%)	27 (0.7%)	4016 (99.3%)			
Education		p < 0.001	p < 0.001							
No Education	1676	467 (29%)	222 (13%)	831 (50%)	623 (37%)	57 (3.4%)	1619 (96.6%)			
Primary	1927	667 (38%)	326 (17%)	1081 (56%)	520 (27%)	123 (6.4%)	1804 (93.6%)			
Secondary	2094	1121 (62%)	654 (31%)	957 (48%)	483 (23%)	216 (10.3%)	1878 (89.7%)			
Higher	450	345 (89%)	293 (65%)	87 (19%)	70 (16%)	155 (34.4%)	295 (65.6%)			
Religion		p = 0.004	p = 0.042							
Muslim	5609	2399 (47.5%)	1380 (25%)	2668 (48%)	1561 (28%)	518 (9.2%)	5091 (90.8%)			
Others	541	204 (41%)	118 (22%)	288 (53%)	135 (25%)	34 (6.3%)	507 (93.7%)			
Microfinance association		p < 0.001	p < 0.001							
No	3475	1745 (50%)	1122 (29%)	1711 (44%)	1087 (28%)	442 (11.3%)	3478 (88.7%)			
Yes	2075	857 (41%)	375 (17%)	1244 (56%)	609 (27%)	110 (4.9%)	2118 (95.1%)			
Economic status		p < 0.001	p < 0.001							
Poorest	1153	11 (1%)	16 (1%)	608 (50%)	598 (49%)	0	1222 (100%)			
Poorer	1176	173 (15%)	42 (3%)	827 (65%)	413 (32%)	0	1282 (100%)			
Middle	1020	441 (43%)	110 (10%)	746 (65%)	297 (26%)	2 (0.2%)	1151 (99.8%)			
Richer	1009	816 (81%)	322 (28%)	610 (53%)	214 (19%)	32 (2.8%)	1114 (97.2%)			
Richest	1194	1162 (97%)	1008 (75%)	165 (12%)	174 (13%)	518 (38.5%)	829 (61.5%)			

p-values of Chi-squared test.

Table 2. Demographics of mothers whose children had received vaccines.

	N	BCG n (% of N)	Measles n (% of N)	DPT 1 n (% of N)	DPT 2 n (% of N)	DPT 3 n (% of N)	Polio 1 n (% of N)	Polio 2 n (% of N)	Polio 3 n (% of N)
Division									
Barisal	787	p < 0.001 715 (96%)	p < 0.001 555 (75%)	p < 0.001 699 (93%)	p < 0.001 667 (89%)	p < 0.001 624 (83%)	p < 0.001 711 (95%)	p < 0.001 674 (91%)	p < 0.001 627 (84%)
Chittagong	1271	1081 (90%)	810 (68%)	1069 (89%)	1006 (84%)	942 (79%)	1097 (92%)	1021 (86%)	947 (80%)
Dhaka	1282	1156 (94%)	8-8 (70%)	1143 (93%)	1089 (89%)	1021 (83%)	1170 (95%)	1102 (91%)	1037 (86%)
Khulna	714	663 (97%)	532 (78%)	656 (96%)	637 (94%)	607 (89%)	664 (98%)	637 (94%)	609 (90%)
Rajshahi	967	874 (95%)	677 (74%)	863 (94%)	835 (91%)	785 (86%)	872 (95%)	836 (92%)	792 (87%)
Sylhet	1114	872 (86%)	639 (63%)	868 (85%)	801 (79%)	725 (71%)	895 (88%)	804 (81%)	722 (83%)
Total		5361 (93%)	4061 (71%)	5298 (92%)	5035 (87%)	4704 (81%)	5409 (94%)	5074 (89%)	4734 (83%)
Residency									
Urban	2107	p = 0.028 1877 (94%)	p = 0.031 1442 (72%)	p = 0.017 1859 (93%)	p = 0.021 1772 (88%)	p = 0.017 1663 (83%)	p = 0.053 1891 (94%)	p = 0.038 1780 (90%)	p = 0.045 1666 (84%)
Rural	4043	3484 (92%)	2619 (70%)	3439 (91%)	3263 (86%)	3041 (80%)	3518 (93%)	3294 (88%)	3068 (82%)
Education									
No Education	1676	p < 0.001 1352 (87%)	p < 0.001 991 (64%)	p < 0.001 1331 (86%)	p < 0.001 1250 (81%)	p < 0.001 1138 (73%)	p < 0.001 1398 (90%)	p < 0.001 1266 (84%)	p < 0.001 1154 (76%)
Primary	1927	1684 (93%)	1262 (70%)	1665 (92%)	1560 (86%)	1453 (80%)	1693 (94%)	1577 (88%)	1463 (82%)
Secondary	2094	1896 (96%)	1467 (74%)	1878 (95%)	1807 (91%)	1710 (86%)	1890 (95%)	1813 (92%)	1714 (87%)
Higher	450	426 (96%)	339 (77%)	428 (96%)	415 (94%)	400 (91%)	425 (96%)	415 (94%)	400 (91%)
Type of Toilet Facility									
Flush	1498	p < 0.001 1344 (94%)	p < 0.001 1047 (74%)	p < 0.001 1340 (94%)	p < 0.001 1275 (89%)	p < 0.001 1201 (84%)	p < 0.001 1350 (95%)	p < 0.001 1280 (90%)	p < 0.001 1202 (85%)
Pit	2956	2617 (94%)	2006 (72%)	2579 (93%)	2476 (89%)	2328 (84%)	2638 (95%)	2499 (91%)	2348 (85%)
No Facility	1696	1400 (89%)	1008 (64%)	1379 (88%)	1284 (82%)	1175 (75%)	1421 (90%)	1295 (83%)	1184 (76%)
Electricity									
No	2949	p < 0.001 2501 (91%)	p < 0.001 1831 (67%)	p < 0.001 2461 (90%)	p < 0.001 2319 (84%)	p < 0.001 2134 (78%)	p < 0.001 2537 (92%)	p < 0.001 2340 (86%)	p < 0.001 2152 (79%)
Yes	2603	2348 (95%)	1847 (75%)	2332 (94%)	2241 (91%)	2129 (86%)	2357 (95%)	2256 (92%)	2141 (87%)
Religion									
Muslim	5609	p = 0.086 4878 (92%)	p = 0.811 3705 (71%)	p = 0.237 4823 (91%)	p = 0.199 4581 (87%)	p = 0.509 4283 (81%)	p = 0.882 4932 (94%)	p = 0.836 4620 (89%)	p = 0.783 4314 (83%)
Others	541	483 (95%)	356 (70%)	475 (93%)	454 (89%)	421 (82%)	477 (93%)	454 (89%)	420 (82%)
Microfinance									
No	3920	p = 0.002 3386 (92%)	p < 0.001 2524 (69%)	p < 0.001 3342 (91%)	p < 0.001 3155 (86%)	p < 0.001 2947 (80%)	p < 0.001 3414 (93%)	p < 0.001 3181 (87%)	p < 0.001 2967 (81%)
Yes	2228	1973 (94%)	1535 (74%)	1954 (93%)	1878 (90%)	1755 (84%)	1993 (95%)	1891 (91%)	1765 (85%)
Economic status									
Poorest	1222	p < 0.001 1042 (91%)	p < 0.001 766 (87%)	p < 0.001 1024 (90%)	p < 0.001 968 (85%)	p < 0.001 891 (78%)	p = 0.021 1054 (92%)	p < 0.001 973 (86%)	p < 0.001 898 (80%)
Poorer	1282	1087 (91%)	792 (67%)	1069 (90%)	1006 (84%)	928 (78%)	1109 (93%)	1016 (86%)	937 (80%)
Middle	1153	993 (92%)	753 (70%)	983 (91%)	932 (87%)	869 (81%)	1004 (93%)	944 (89%)	874 (82%)
Richer	1146	1014 (94%)	791 (74%)	1003 (93%)	961 (89%)	902 (84%)	1014 (94%)	970 (90%)	912 (85%)
Richest	1347	1225 (95%)	959 (75%)	1219 (95%)	1168 (91%)	1114 (86%)	1228 (95%)	1171 (91%)	1113 (87%)
Cooking Fuel									
Non-solid	533	p < 0.001 517 (97%)	p = 0.007 400 (76%)	p < 0.001 517 (97%)	p < 0.001 501 (94%)	p < 0.001 477 (90%)	p < 0.001 522 (98%)	p < 0.001 504 (95%)	p < 0.001 478 (90%)
Solid	5252	844 (92%)	3661 (70%)	4781 (91%)	4534 (86%)	4227 (81%)	4887 (93%)	4570 (88%)	4256 (82%)
Place of Delivery									
Home	4783	p < 0.001 4403 (92%)	p < 0.001 3310 (70%)	p < 0.001 4347 (91%)	p < 0.001 4116 (86%)	p < 0.001 3821 (78%)	p = 0.009 4454 (93%)	p < 0.001 4154 (88%)	p < 0.001 3856 (82%)
Healthcare Facility	1002	956 (95%)	749 (75%)	949 (95%)	917 (92%)	881 (88%)	953 (95%)	918 (92%)	876 (88%)

p-values of Chi-squared test.

Table 3. Multivariate logistic regression of vaccine doses in relation to maternal and household characteristics.

	N	BCG OR (95% CI)	Measles OR (95% CI)	DPT 1 OR (95% CI)	DPT 2 OR (95% CI)	DPT 3 OR (95% CI)	Polio 1 OR (95% CI)	Polio 2 OR (95% CI)	Polio 3 OR (95% CI)
Residency									
Urban	1781	0.95 (0.72 - 1.24)	0.91 (0.78 - 1.06)	0.89 (0.69 - 1.14)	0.88 (0.71 - 1.08)	0.82* (0.69 - 0.98)	0.96 (0.72 - 1.27)	0.89 (0.71 - 1.11)	0.81* (0.67 - 0.98)
Rural	3352	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Education									
No Education	1428	0.21*** (0.10 - 0.43)	0.57*** (0.42 - 0.78)	0.28*** (0.15 - 0.53)	0.24*** (0.14 - 0.42)	0.33*** (0.22 - 0.51)	0.32*** (0.16 - 0.65)	0.28*** (0.16 - 0.48)	0.34*** (0.22 - 0.53)
Primary	1638	0.42** (0.21 - 0.86)	0.80 (0.59 - 1.08)	0.52 (0.28 - 0.99)	0.35 (0.21 - 0.60)	0.48*** (0.32 - 0.73)	0.50 (0.28 - 1.00)	0.37*** (0.21 - 0.64)	0.45*** (0.29 - 0.69)
Secondary	1691	0.75 (0.37 - 1.52)	1.04 (0.78 - 1.40)	0.91 (0.48 - 1.7)	0.65 (0.38 - 1.10)	0.76 (0.51 - 1.15)	0.80 (0.41 - 1.58)	0.63 (0.3 - 1.09)	0.69 (0.45 - 1.06)
Higher	376	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Type of Toilet									
Facility	1407	1.14 (0.76 - 1.71)	1.26 (0.99 - 1.61)	1.29 (0.87 - 1.89)	1.13 (0.82 - 1.56)	1.03 (0.78 - 1.36)	1.11 (0.73 - 1.70)	1.07 (0.76 - 1.50)	0.97 (0.73 - 1.29)
Flush	2736	1.75*** (1.35 - 2.28)	1.43*** (1.22 - 1.68)	1.60*** (1.25 - 2.04)	1.70*** (1.38 - 2.09)	1.61*** (1.34 - 1.94)	1.79*** (1.35 - 2.36)	1.84*** (1.48 - 2.29)	1.68*** (1.39 - 2.02)
Pit	990	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
No Facility									
Electricity									
No	2693	0.64*** (0.46 - 0.89)	0.72*** (0.59 - 0.86)	0.63*** (0.46 - 0.86)	0.65*** (0.50 - 0.85)	0.66*** (0.53 - 0.82)	0.68*** (0.48 - 0.97)	0.65*** (0.50 - 0.86)	0.64*** (0.51 - 0.81)
Yes	2440	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Religion									
Muslim	4664	0.69 (0.45 - 1.07)	1.04 (0.84 - 1.29)	0.79 (0.54 - 1.16)	0.88 (0.65 - 1.20)	0.97 (0.75 - 1.26)	1.03 (0.69 - 1.53)	1.04 (0.77 - 1.42)	1.10 (0.85 - 1.42)
Others	469	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Microfinance									
No	3210	0.62*** (0.49 - 0.78)	0.74*** (0.65 - 0.85)	0.61*** (0.50 - 0.78)	0.61*** (0.50 - 0.73)	0.69*** (0.59 - 0.80)	0.59*** (0.46 - 0.76)	0.60*** (0.50 - 0.73)	0.70*** (0.60 - 0.82)
Yes	1923	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Wealth									
Poorest	1057	1.59 (0.87 - 2.90)	1.26 (0.90 - 1.77)	1.51 (0.85 - 2.66)	1.4 (0.88 - 2.23)	1.08 (0.72 - 1.62)	1.40 (0.75 - 2.61)	1.31 (0.80 - 2.14)	1.07 (0.70 - 1.61)
Poorer	1070	1.16 (0.65 - 2.05)	1.06 (0.77 - 1.45)	1.19 (0.69 - 2.04)	1.08 (0.70 - 1.67)	0.89 (0.61 - 1.31)	1.28 (0.70 - 2.33)	1.06 (0.67 - 1.69)	0.91 (0.62 - 1.35)
Middle	935	1.04 (0.61 - 1.78)	1.07 (0.80 - 1.43)	1.07 (0.65 - 1.78)	1.07 (0.71 - 1.61)	0.92 (0.65 - 1.31)	1.02 (0.59 - 1.77)	1.09 (0.71 - 1.67)	0.92 (0.64 - 1.32)
Richer	937	0.91 (0.57 - 1.44)	1.00 (0.78 - 1.28)	0.94 (0.61 - 1.47)	0.96 (0.68 - 1.37)	0.84 (0.62 - 1.14)	0.86 (0.54 - 1.37)	0.99 (0.69 - 1.43)	0.89 (0.5 - 1.22)
Richest	1134	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cooking Fuel									
Non-solid	525	2.10** (1.15 - 3.83)	1.10 (0.84 - 1.44)	2.34*** (1.29 - 4.23)	2.03*** (1.31 - 3.16)	1.58* (1.13 - 2.25)	3.10*** (1.50 - 6.16)	2.40*** (1.50 - 3.86)	1.70*** (1.18 - 2.44)
Solid	4608	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Place of Delivery									
Home	4269	0.95 (0.63 - 1.43)	0.95 (0.78 - 1.16)	0.94 (0.64 - 1.37)	0.94 (0.70 - 1.27)	0.80 (0.62 - 1.04)	1.00 (0.67 - 1.51)	1.00 (0.74 - 1.37)	0.90 (0.70 - 1.17)
Healthcare Facility	864	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

OR—odds ratio, CI—confidence interval, the contrast category is denoted with OR = 1.00, ***p < 0.001, **p < 0.01, *p < 0.05.

Table 4. Multivariate logistic regression of non-vaccinated children according to maternal and household characteristics.

	N	Non-vaccinated children OR (95% CI)
Residency		
Urban	1781	1.09 (0.93 - 1.28)
Rural	3352	1.00
Education		
No education	1428	1.60 (1.18 - 2.18)**
Primary	1638	1.28 (0.95 - 1.72)
Secondary	1691	1.05 (0.80 - 1.39)
Higher	376	1.00
Type of toilet facility		
Flush	1407	0.82 (0.54 - 1.04)
Pit	2736	0.70 (0.60 - 0.83)***
No facility	990	1.00
Electricity		
No	2693	1.39 (1.15-1.68)***
Yes	2440	1.00
Religion		
Muslim	4664	0.96 (0.77 - 1.19)
Others	469	1.00
Microfinance		
No	3210	1.38 (1.21 - 1.57)***
Yes	1923	1.00
Wealth		
Poorest	1057	0.86 (0.62 - 1.21)
Poorer	1070	1.06 (0.77 - 1.45)
Middle	935	1.01 (0.76 - 1.35)
Richer	937	1.10 (0.86 - 1.40)
Richest	1134	1.00
Cooking fuel		
Non-solid	525	0.90 (0.69-1.17)
Solid	4608	1.00
Place of delivery		
Home	4269	1.08 (0.89-1.32)
Healthcare facility	864	1.00

OR-Odds Ratio, The contrast category is denoted with OR = 1.00, *** $p \leq 0.001$, ** $p \leq 0.01$, * $p \leq 0.05$.

{OR = 0.74; $p < 0.001$ }, DPT3 {OR= 0.69; $p < 0.001$ } and Polio3 {OR = 0.70; $p < 0.001$ } vaccines. Children in households using non-solid cooking fuel had higher odds of being vaccinated than children in households that used solid cooking fuel. Those which used non-solid cooking fuel had lower odds of being vaccinated against BCG {OR = 0.5; $p < 0.01$ }, 50% more likely for DPT3 {OR = 1.58; $p < 0.05$ } and almost twice the odds to vaccinate

for Polio3 {OR = 1.7; $p < 0.001$ } (Table 3).

Results of the multivariate regression of non-vaccinated children according to maternal and household characteristics are presented in Table 4. Children whose mothers had no education had lower odds of having received complete immunisation coverage than those whose mother had a higher education {OR = 1.60; $p < 0.01$ }.

Households containing a pit facility had lower odds of having completely vaccinated children {OR = 0.70; $p < 0.001$ } and children living in households without access to electricity had lower odds of having received complete vaccination coverage {OR= 1.39; $p < 0.001$ }. Children whose mothers were not part of a microfinance group had lower odds of receiving complete vaccinations {OR = 1.38; $p < 0.001$ }.

4. DISCUSSION

In this study we have examined predisposing factors associated with higher rates of immunisation. The immunisation coverage was higher for children whose mothers were more educated and had higher incomes [23]. Our study shows that households using electricity, households with access to flush toilets and households with mothers participating in microfinance programs were more likely to have their children completely vaccinated. The current findings reflect that, irrespective of need, children of higher economic or educational groups are more likely to be vaccinated. Also, our study highlights the fact that full immunisation coverage is still lacking in Bangladesh. To the best of the authors' knowledge this is the first time such household characteristics for child immunisation coverage have been identified.

Similar to the study by Rahman *et al.*, we found that children with mothers of higher education or higher wealth status were more likely to be immunised [15]. In contrast to Rahman *et al.* our study did not find substantial differences in vaccination rates among children in urban and rural areas. Consistent with other studies [7,27-31], we found that the mother's education is important for the acceptance of complete vaccination.

This study was based on national statistics rather than focusing on one or just a few areas of the country. By using a nationally representative sample this study achieved a more accurate representation of the situation. There are a few limitations that need to be acknowledged regarding the present study. This study is a cross-sectional analysis and it is not possible to assign causality. The current study has an advantage of eliminating the limitation of recall bias through validating with vaccination cards. The method of obtaining immunisation status through recall interview is not effective. Ensuring the

availability of vaccination cards with mothers for inspection are recommended for obtaining accurate estimation of vaccine coverage [32]. We have used the same for collecting immunisation data.

Despite the increase in healthcare services and the various immunisation initiatives in Bangladesh, complete immunisation coverage for children under one year of age continues to be inadequate. Since households without electricity and/or toilet facilities, and households with mothers who were not part of a microfinance group were less likely to immunise their children, policy makers should target future interventions to households indicating aforementioned poverty related risk factors. In absence of adequate health staff, it is difficult to visit every house to check the immunisation card. Some visible physical characteristics of the households, such as use of non-electric lighting and use of solid fuels can be used to identify the non-immunised children. At the neighbourhood level it is easy to identify those visible physical household characteristics. These variables can help better identify households with low full immunisation coverage. Mass media promotion programs can be used to educate mothers about the importance of full immunisation, and vaccines should be made not only available, but also affordable throughout the country. Future research could help profile PSUs in which these characteristics predominantly occur and subsequently emphasize the importance of tailoring media and education programs to these areas and their needs.

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