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Correlates of completing routine vaccination among children in Mysore, India

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Summary
Background: More than half of the over 18 million incompletely vaccinated children worldwide in 2011 lived in India (32%), Nigeria (14%) and Indonesia (7%). Overall immunization coverage in India was 61% in 2009. Few studies have explored the role of parental attitudes in children's vaccination.
Objectives: To explore the correlates of completion of routine vaccination among children in Mysore City, India.
Methods: A two-stage probability sample of 800 girls aged 11—15 years was selected from 12 schools in Mysore to take home questionnaires to be completed by their parents. The questionnaire elicited information on socio-demographic characteristics, attitudes and practices relevant to vaccination. Bivariate and multivariable logistic regression analyses were performed to identify factors independently associated with completion of routine vaccination.
Results: Of the 797 (99.6%) parents who completed questionnaires, 29.9% reported completing all routine vaccinations for their children. Parents who had obtained optional vaccinations for their children (adjusted odds ratio [AOR]: 4.56; 95% confidence interval [CI]: 3.09—6.74), who believed in vaccines' effectiveness (2.50; 1.19—5.28) and who asked doctors or nurses about vaccination (2.07; 1.10—3.90) were significantly more likely to report complete vaccination, after controlling for all

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other factors. Belief that the disease was more protective than vaccination was independently associated with lower likelihood of vaccination series completion (0.71; 0.52—0.96). No other attitudinal or socio-demographic factors were associated with vaccine completion.
Conclusion: Interest and belief in vaccine effectiveness are important facilitators motivating parents to obtain full vaccination for their children in India.

Introduction

The goal of the Expanded Program on Immunization (EPI) established by the World Health Organization (WHO) in 1974 was to provide vaccination to all children globally against six initially targeted, vaccine-preventable diseases: severe infant tuberculosis, poliomyelitis, diphtheria, tetanus, pertussis and measles [1]. According to the WHO, immunization prevents 2—3 million deaths annually worldwide [2]. However, in 2008, nearly 1.7 million children under the age of five years died due to a vaccine-preventable disease [3]. At the end of 2010, 19.3 million children worldwide had not been fully vaccinated against the six basic vaccine-preventable diseases [1]. India, Nigeria and Indonesia together accounted for 53% of these under-vaccinated children [4]. Under-vaccination in low and middle-income countries has been associated with distance from vaccination centers, cost, family characteristics such as low education level of caregivers, low socioeconomic status and parental attitudes such as fear of adverse effects and lack of belief in effectiveness [5].

In 1978, to reduce child mortality, India implemented the EPI four years after it was adopted by the WHO. The Universal Immunization Program (UIP) was introduced in India in 1985, with the objective of achieving complete immunization coverage of all infants and pregnant women by the 1990s [6]. The 2012 coverage estimates for Indian children are 87%, 72%, 85% and 70% for BCG, the third dose of DPT, one dose of measles and the third dose of polio vaccine, respectively [7]. Although considerable progress has been made, the Coverage Evaluation Survey (2009) showed that only 61% of Indian children were fully immunized [8]. Reports from the National Family Health Survey-3 (NFHS-3), conducted in 2005—2006, indicated only approximately 43.5% immunization coverage in India, which ranged from 81% in states such as Tamil Nadu to 21% in Nagaland [9]. While some states had low coverage for some segments of the population, others had low coverage for all population segments [10]. Furthermore, NFHS-3 results showed a significant decline in coverage for each subsequent dose of DPT/OPV and between the third dose of DPT/OPV and the measles vaccine [9].

There is an urgent need to examine factors associated with incomplete or non-immunization of Indian children. Such efforts are, however, not commonly pursued. With additional ''optional'' vaccines becoming more widely available, there is considerable interest in exploring the acceptability of the human papillomavirus (HPV) [11,12], rotavirus [13,14] and influenza vaccines [15,16]. While the potential contribution of these vaccines is extremely important, there is no reason to assume that universal coverage for routine vaccination has been achieved in India [9,10,17,18]. Studies in Uttar Pradesh found lack of faith in vaccination at the family level, lack of knowledge of vaccine efficacy, fear of side effects, lack of family support [19], and lack of motivation and information [20] as common reasons behind non-immunization of children. A systematic review revealing vaccine inequity in India focused on various family and socio-demographic characteristics, but none of these studies had examined the role of parental attitudes in vaccination completion [21]. The poor immunization coverage rates from national surveys make examination of parental attitudes toward vaccination relevant and necessary. This paper examines the correlates of complete routine vaccination among children in the South Indian city of Mysore in Karnataka.

Methods

Study site

Karnataka, the eighth largest state of India by area and the ninth largest by population, is located in the southwestern part of the country [22]. This study was conducted in Mysore, which is the second largest city in Karnataka. The city of Mysore

has an area of 128 km^2 and a population of 920,550 according to 2011 census [23].

Study participants

Participants were parents with at least one adolescent daughter (aged 11—15 years) attending a school in an urban region of Mysore. A random sample of 800 female students was selected from a range of schools located in the city of Mysore, including public, private, religious and secular using two-stage probability proportionate-to-size sampling. This was an attempt to ensure that the target population had a wide range of parental backgrounds. After contacting the schools and soliciting their participation, a program announcement (including information and an invitation to complete a short questionnaire if selected) was sent home with all girls attending the seventh to 10th grades. Interested parents were asked to return the information sheet with their age, sex and the grade attended by the student along with a suitable time when the parent could be reached. All selected students' parents were then contacted over the phone or requested to call in to speak to a trained interviewer to assess their eligibility to participate in the study. Eligible participants had to have an adolescent daughter (aged 11—15 years), be able to read or speak English or *Kannada* and have the ability to provide informed consent.

Study procedures

This cross-sectional study included all parents who expressed interest and were eligible to participate. A package containing a pen, a self-administered questionnaire with a copy of the informed consent form along with information about the HPV vaccine and cervical cancer in English or *Kannada* were sent home with their daughters. The questionnaire covered socio-demographic characteristics; knowledge; attitudes; and beliefs about vaccination in general, vaccination completion, and about HPV infection. Several questions explored perceived barriers and benefits of vaccination in general. All participants were asked to return the forms within a week and were subsequently compensated for their time. Trained interviewers checked all of the returned forms for completeness and called the participant up to two additional times on the phone to complete any question left incomplete. Parents were given a choice to not answer any questions that made them uncomfortable.

Data analysis

Data were analyzed using SAS Version 9.3 (SAS Institute Inc., Cary, NC, USA). Descriptive analyses were conducted to examine socio-demographics (e.g., age, religion, employment status, education) and behavioral and psychosocial predictors (e.g., knowledge, beliefs, attitudes, social norms and practices relevant to vaccination). The outcome variable ''*complete immunization of all children*'' was dichotomized and developed from respondents who answered 'yes' to all of the questions about all of their children having received the UIP vaccine which were then classified as parents of 'completely immunized' children; all others' children were defined as 'unimmunized or incompletely immunized'. The associations of complete vaccination status with the independent variables were tested using bivariate logistic regression. All independent variables were considered statistically significant at a p-value < 0.2 in bivariate analyses and were included in multivariable logistic regression analysis. The daughters of the respondents were enrolled in 12 different schools in Mysore City. To adjust for potential clustering and correlations in behaviors among parents with children in the same schools, the 'proc genmod' procedure was used in SAS for logistic regression analyses [24]. Furthermore, parents were asked to indicate whether all of their children received the vaccinations. Hence, even if one (or more) child was vaccinated completely, but not all of them, the parents had to report 'no' to whether all of the children received all of the vaccines. This could potentially lead to an underestimation of the full vaccination rate. Therefore, the same analyses were performed separately for the sub-sample of parents who had only one child at the time of the survey and another subsample of respondents who were only women. The results for both subgroup analyses were compared with the entire sample. A 2-sided p-value of 0.05 was considered statistically significant and 95% confidence intervals (CIs) were calculated for each of the odds ratios (ORs).

Results

Sample characteristics

Of the 800 questionnaires distributed, 797 were completed (response rate = 99.6%). Of the completed surveys, 19 (2.3%) were excluded from the analyses because they were returned without a signed consent form. Only 233 (29.9%) parents reported complete vaccinations of all of their children. Nearly 70% of the respondents were women (Table 1). One-third of the respondents were 36—40 years of age, and <16% were 46 or

Table 1 Bivariate logistic regression analysis of the association of demographic characteristics of parents with children having received all UIP vaccines ($N = 778$).

Characteristics	*N* (%[a])	All UIP vaccines		OR[d] (95% CI)
		Received (%[b])	Not received (%[c])	
Parents with one child				
Yes	89 (11.4)	25 (10.7)	64 (11.7)	0.8 (0.52—1.23)
No	689 (85.6)	208 (89.3)	481 (88.3)	1.00
Gender of the respondent parent				
Male	241 (31.0)	77 (33.0)	164 (30.1)	1.14 (0.55—2.34)
Female	537 (69.0)	156 (67.0)	381 (69.9)	1.00
Respondent age				
≤35 years	242 (31.1)	56 (24.0)	186 (34.1)	1.00
36—40 years	257 (33.0)	80 (34.3)	177 (32.5)	1.33 (0.98—1.81)
41—45 years	157 (20.2)	50 (21.5)	107 (19.6)	1.32 (0.78—2.23)
≥46 years	122 (15.7)	47 (20.2)	75 (13.8)	**1.74 (1.16—2.61)**
Education level (in years)				
None	116 (14.9)	27 (11.6)	89 (16.3)	1.00
1st—10th	394 (50.6)	92 (39.5)	302 (55.4)	0.99 (0.52—1.90)
11—15 years	189 (24.3)	79 (33.9)	110 (20.2)	**2.20 (1.13—4.28)**
Master's degree or above	39 (5.0)	19 (8.2)	20 (3.7)	**2.77 (1.02—7.49)**
Vocational training	40 (5.1)	16 (6.9)	24 (4.4)	2.03 (0.68—6.08)
Occupation				
Employed full-time	214 (27.5)	81 (34.8)	133 (24.4)	1.00
Employed part-time	83 (10.7)	14 (6.0)	69 (12.7)	**0.42 (0.21—0.85)**
Self-employed	112 (14.4)	34 (14.6)	78 (14.3)	0.77 (0.49—1.21)
Full-time homemaker	339 (43.6)	98 (42.1)	241 (44.2)	**0.74 (0.57—0.97)**
	30 (3.7)	6 (2.6)	24 (4.4)	0.45 (0.16—1.24)
Retired/unemployed/disabled/too ill to work				
Marital status				
Married	737 (94.7)	222 (95.3)	515 (94.5)	1.04 (0.52—2.07)
Divorced/separated/widowed	41 (5.3)	11 (4.7)	30 (5.5)	1.00
Religion				
Hindu	607 (78.0)	199 (85.4)	408 (74.9)	1.00
Muslim/Christian/other	171 (22.0)	34 (14.6)	137 (25.1)	**0.5 (0.36—0.70)**

[a] Percentage for each category out of the total.
[b] Percentage of parents among parents within each category with children that received all UIP vaccines.
[c] Percentage of parents among parents within each category with children that did not received all UIP vaccines.
[d] Unadjusted odds ratio.
Percentages may not always add up to 100 because of approximation to one decimal place.

above (Table 1). Nearly 95% reported being married, and 78% reported their religion as Hindu. Of the 89 (11.4%) parents who had a single child at the time of the interview, 25 (28.1%) reported complete vaccination of their children (Table 1). Approximately 77 (32.0%) of the 241 male respondents and 156 (29.1%) of the female respondents reported complete vaccination of their children.

Parental attitudes toward vaccination

Over half (52%) of the respondents reported that their child had received at least one optional vaccine not included in the UIP schedule (Table 2). Almost 80% believed in the effectiveness of vaccines in general. Nearly one-third of respondents were concerned about side effects, and 17% were afraid of vaccinating their children. While most (95%) felt that vaccines were a way of ensuring children's health, 67.5% thought that parents should make the decisions as to whether the child should receive a vaccine, instead of a doctor or other health worker. Nearly 40% reported that they would feel responsible for a bad outcome for the child post-vaccination and 72% would feel similarly if something bad happened because of non-vaccination. Nearly 60% of parents had arranged for their child to receive at least one optional vaccine and 83% believed that vaccines are effective (Table 2).

Table 2 Bivariate logistic regression analyses results for parental attitudes with children who have received all UIP vaccines among a random sample of parents in Mysore City, India ($N = 778$).

Characteristics		*N* (%[a])	All UIP vaccines		OR[d] (95% CI)
			Received (%[b])	Not received (%[c])	
Believe that vaccinations are effective	Yes	618 (79.4)	215 (92.3)	403 (73.9)	**3.74 (2.00—6.97)**
	No	160 (20.6)	18 (7.7)	142 (26.1)	1.00
Concerned about side effects	Yes	246 (31.6)	79 (33.9)	167 (30.6)	1.13 (0.86—1.48)
	No	532 (68.4)	154 (66.1)	378 (69.4)	1.00
Afraid of vaccinating children	Yes	131 (16.8)	25 (10.7)	106 (19.4)	**0.54 (0.36—0.81)**
	No	647 (83.2)	208 (89.3)	439 (80.6)	1.00
Better to get the disease	Yes	375 (48.2)	87 (37.3)	288 (52.8)	**0.58 (0.46—0.74)**
	No	403 (51.8)	146 (62.7)	257 (47.2)	1.00
Vaccine one way to protect child's health	Yes	738 (94.9)	225 (96.6)	513 (94.1)	1.64 (0.72—3.74)
	No	40 (5.1)	8 (3.4)	32 (5.9)	1.00
Govt. does good job in providing vaccines	Yes	718 (92.3)	217 (93.1)	501 (91.9)	1.38 (0.80—2.37)
	No	60 (7.7)	16 (6.9)	44 (8.1)	1.00
Would feel responsible for a bad outcome after vaccination	Yes	306 (39.3)	94 (40.3)	212 (38.9)	1.12 (0.99—1.27)
	No	472 (60.7)	139 (59.7)	333 (61.1)	1.00
Would feel responsible for a bad outcome due to non-vaccination	Yes	559 (71.9)	178 (76.4)	381 (69.9)	1.35 (0.93—1.96)
	No	219 (18.1)	55 (23.6)	164 (30.1)	1.00
Knows where to take child for vaccination	Yes	453 (58.2)	156 (67.0)	297 (54.5)	**1.64 (1.28—2.10)**
	No	325 (41.8)	77 (33.0)	248 (45.5)	1.00
Expensive transport would influence vaccination decisions	Yes	234 (30.1)	61 (26.2)	173 (31.7)	0.86 (0.58—1.27)
	No	544 (69.9)	172 (73.8)	372 (68.3)	1.00
Cost an important factor to decide vaccination	Yes	341 (43.8)	99 (42.5)	242 (44.4)	1.00 (0.78—1.27)
	No	437 (56.2)	134 (57.5)	303 (55.6)	1.00
Taking time off work makes vaccination difficult	Yes	161 (20.7)	34 (14.6)	127 (23.3)	**0.60 (0.43—0.82)**
	No	617 (79.3)	199 (85.4)	418 (76.7)	1.00
Told about vaccinations by doctor or nurse	Yes	643 (82.7)	200 (85.8)	443 (81.3)	1.38 (0.94—2.04)
	No	135 (17.4)	33 (14.2)	102 (18.7)	1.00
Ask their doctor or nurse about vaccinations	Yes	665 (85.5)	215 (92.3)	450 (82.6)	**2.34 (1.43—3.83)**
	No	113 (14.5)	18 (7.7)	95 (17.4)	1.00
Get vaccines recommended by doctor or nurse	Yes	652 (83.8)	206 (88.4)	446 (81.8)	**1.53 (1.14—2.06)**
	No	126 (16.2)	27 (11.6)	99 (18.2)	1.00
Got children vaccinated with other (optional) vaccines	Yes	402 (51.7)	185 (79.4)	217 (39.8)	**5.59 (3.82—8.16)**
	No	376 (48.3)	48 (20.6)	328 (60.2)	1.00
Take sick child to Ayurveda, Unani, Homeopathy or Siddha doctor	Yes	438 (56.3)	126 (54.1)	312 (57.2)	0.87 (0.69—1.11)
	No	340 (43.7)	107 (45.9)	233 (42.8)	1.00
Take sick child to MD/MBBS doctor	Yes	656 (84.3)	212 (91.0)	444 (81.5)	**2.09 (1.19—3.67)**
	No	122 (15.7)	21 (9.0)	101 (18.5)	1.00
Have responsibility to protect child	Yes	737 (94.7)	224 (96.1)	513 (94.1)	1.57 (0.73—3.38)
	No	41 (5.3)	9 (3.9)	32 (5.9)	1.00
Parents should make health decisions	Yes	525 (67.5)	163 (70.0)	362 (66.4)	1.21 (0.97—1.50)
	No	253 (32.5)	70 (30.0)	183 (33.6)	1.00

[a] Percentage for each category out of the total.
[b] Percentage of parents within each category out of all parents whose children received all UIP vaccines.
[c] Percentage of parents within each category out of all parents whose children did not receive all UIP vaccines.
[d] Unadjusted odds ratio.
Percentages may not always add up to 100 because of approximation to one decimal place.

Predictors of complete vaccination

Tables 1 and 2 summarize the results of bivariate logistic regression analyses to look at the association of children having received all UIP vaccines with each of the independent variables. Compared with Hindus, parents of other religions had significantly lower odds of reporting that their children were completely vaccinated (Table 1). Parents who were fulltime homemakers or part-time workers also had lower odds of reporting complete immunization than other parents, while parents with 11—15 or more years of education were more likely to report complete immunization. Parents who had obtained at least one optional vaccine for their children, or who expressed the belief that vaccines are effective had higher odds of having fully immunized their children than others, while those who were afraid of vaccinating children had lower odds of reporting complete vaccination for their children (Table 2). Parents who felt that the disease was more protective than the vaccination and those who had difficulty finding time off work had significantly lower odds of fully vaccinating their children. For the subsample of parents with one child, none of the socio-demographic variables were significantly associated with complete vaccination of their children (results not shown). Opting to obtain at least one optional vaccine for their child was significantly associated with complete routine immunization of children among parents with a single child.

The results of multivariable logistic regression showed that having obtained optional vaccinations for their children, belief in vaccines' effectiveness, and having asked their doctor or nurse about vaccination continued to be significantly associated with reporting complete vaccinations, after adjusting for all of the other socio-demographic and attitudinal factors in the model (Table 3). Conversely, parent belief that disease was more protective than vaccination remained independently associated with lower odds of having fully vaccinated children, after controlling for other variables in the model.

Among parents with a single child, none of the socio-demographic variables were significantly associated with complete vaccination of their children (results not shown). Those who considered cost as an important factor in deciding vaccination had lower odds, and those who had opted for at least one optional vaccine had higher odds of having their children fully vaccinated by routine vaccines. Both of these associations were also statistically significant in multivariable analysis.

In the subgroup analysis with a sub-sample of respondents who were women, the results were similar to those of the entire sample. After adjusting for the covariates, mothers who believed that vaccines were effective in preventing disease, those who asked their doctor or nurse about vaccination and those who got their children vaccinated with optional vaccines had significantly increased odds for reporting complete routine immunization for their children. On the other hand, being afraid to get their children vaccinated and belief that it was better to get the disease than to get vaccinated significantly lowered the odds of complete vaccination of children.

Discussion

The complete vaccination rate (<30%) found in this study was less than the national average of 45.3% found in NFHS-3, as was the estimated coverage for any of the vaccines in 2012 [7,9]. The difference was even higher when the rate was compared with the NFHS-3 rate for urban areas, where 57.6% of infants were fully vaccinated [9]. While 4% of this sample reported that their children did not receive any vaccines, it was slightly less than the NFHS-3 estimates at 5% for non-vaccinated children [9]. The oral polio vaccination rate in this sample (94%) was even higher than the estimated nationwide coverage (70%) among 12- to 23-month-old children in 2012 [7]. After controlling for all covariates in our study, parents' belief in vaccines' effectiveness, asking a doctor or nurse about vaccination and choosing optional vaccines were facilitators, whereas fear about vaccines and considering illness more protective than vaccine were barriers to complete vaccination.

In this study, proportions of parents with completely vaccinated children were larger among older parents. This may be due to recall errors among older parents. The finding that more highly educated parents had higher proportion of fully vaccinated children is similar to that observed in NFHS-3 [9] and coverage evaluation surveys of 2009 [25], 2005 [26] and 2002 [27], where maternal education was directly related with vaccination status. A nationally representative sample from the India Human Development Survey in 2004—2005 also showed that maternal education was related to childhood immunization even after controlling for socio-demographic, village and neighborhood level characteristics [28]. Hindus were significantly more likely to vaccinate their children compared with the other religions, which in this study consisted mostly of Muslims. NFHS-3 [9] and surveys in some other states such as Goa [29] and West Bengal

Table 3 Multivariable logistic regression model to identify the determinants of completing routine vaccination for their children among a random sample of parents in Mysore City, India ($N = 778$).

Items	Children received all routine vaccines	
	Adjusted OR[a]	95% CI
Respondent age		
≤35 years	1.00	
36—40 years	1.34	0.96—1.88
41—45 years	1.00	0.61—1.65
≥46 years	1.31	0.71—2.40
Education level		
None	1.00	
1—10 years	0.72	0.39—1.32
11—15 years	1.20	0.63—2.28
Master's degree or above	1.14	0.50—2.61
Vocational training	1.03	0.36—2.95
Occupation		
Employed full-time	1.00	
Employed part-time	0.66	0.30—1.43
Self-employed	0.97	0.55—1.71
Full-time homemaker	0.99	0.68—1.45
Retired/unemployed/disabled/too ill to work	0.72	0.23—2.19
Religion		
Hindu	1.00	
Muslim/Christian/other	0.86	0.48—1.53
Other vaccine		
Yes	**4.56**	**3.10—6.71**
No	1.00	
Take child to an MBBS/MD doctor when child is sick		
Yes	1.21	0.61—2.43
No	1.00	
Told about vaccinations when visit a doctor/nurse		
Yes	0.84	0.51—1.38
No	1.00	
Asks about vaccination when visit a doctor/nurse		
Yes	**2.19**	**1.08—4.47**
No	1.00	
Always gets the vaccine recommended by doctors/nurses		
Yes	0.93	0.58—1.47
No	1.00	
Believe that vaccinations are effective in preventing disease		
Yes	**2.51**	**1.18—5.31**
No	1.00	
Afraid of getting children vaccinated		
Yes	0.86	0.57—1.30
No	1.00	
Believe that getting the disease and natural protection is better than getting vaccinated		
Yes	**0.70**	**0.52—0.95**
No	1.00	
Would feel responsible for a bad outcome after vaccination		
Yes	1.08	0.91—1.30
No	1.00	
Would feel responsible for a bad outcome due to non-vaccination		
Yes	1.04	0.65—1.69
No	1.00	
Knows where to get child vaccinated		
Yes	1.22	0.89—1.67
No	1.00	
Getting time of work or household duties makes it difficult to take child for vaccination		
Yes	0.69	0.42—1.15
No	1.00	
Believe that parents should make health decisions for their children		
Yes	1.12	0.84—1.50
No	1.00	

[a] Odds ratio adjusted for all other variables in the model.

[30] reported similar trends. This could be due to misconceptions, such as the belief that oral polio vaccination may cause illness in children and infertility and concerns that vaccination may be part of a plot to curb the growth of the Muslim population in India [31]. None of these socio-demographic predictors were significant in our study, after controlling for other factors.

Parents who believed that vaccines were effective and whose children had received optional vaccines had higher odds to report fully vaccinating their children, and those who were afraid of vaccinating children or felt that disease was superior to vaccination had lower odds to report fully vaccinating their children. Thus vaccination was associated with its perceived benefits and the perceived risks of disease. Parents' misinformation about the role of vaccination in disease prevention is reportedly related to under- or non-vaccination [5]. Although not statistically significant, parents who found it difficult to take time off work had lower odds of getting their children completely vaccinated, consistent with reports of direct and indirect costs being hindrances to vaccination [5]. A study in Pakistan found that the mother reporting being busy was associated with children's non-vaccination status [32]. A study in China reported caregiver's attitude toward vaccination as a significant predictor of timely routine vaccination of children [33]. Similar findings were found in our study; parents who were more likely to ask about vaccination during their visit to a doctor or nurse had higher odds to have their children completely vaccinated. Psychosocial determinants influenced parents' decision to vaccinate their children, as has been observed in other studies [34,35]. This can be explained based on the Health Belief Model of Health Behavior, which states that one is more ready to adopt a behavior if he/she perceives it to be beneficial [36]. According to this model, perceived susceptibility to vaccine-preventable diseases, perceived seriousness of the diseases, and perceived efficacy and safety of the vaccines, as well as social pressures and convenience, are some of the determinants for compliance with vaccination [36]. While evaluation of all of these factors is uncommon in low and middle income countries, our study suggests the importance of the Health Belief Model in understanding the roles of perceived efficacy of vaccines versus the disease (interpreted as more risky than protective), higher educational attainment and questioning of physicians and nurses (representing possible social pressures) in achieving complete vaccination.

Analysis of the sub-sample of parents with a single child demonstrated a complete immunization rate of 28.1%, which was comparable to the entire sample (29.9%). Thus, it appears that a falsely low complete vaccination rate because of varying vaccination status of different children in a family was not a serious concern for our study. However, obtaining optional vaccines and the role of cost were the only two statistically significant determinants of complete routine vaccination in this sub-sample. Perceived cost has always been an important barrier toward vaccination [5]. Overall, the results from this sub-sample of mothers yielded very similar results to those of the entire sample.

This study had several limitations. The studies on routine vaccination generally choose parents of children under five years old as respondents. In our study, all of the respondents had at least one adolescent daughter; therefore, it is possible that their youngest child was past the age of receiving the routine vaccines, leading to failure to recall vaccination data correctly from years before. Higher birth order has been associated with missed immunizations in India [37], something that was not controlled in our study. Our study utilized a school-based survey methodology; the participants might not be representative of the general population and the results may not be entirely comparable with other studies. While the issue of vaccination status being asked at the family level was partially taken care of comparing the results of the entire sample with the sub-sample of parents with a single child, there is a possibility that our results might not be entirely valid. Although the analyses were adjusted for clustering, different children of the same parent might have been enrolled in different schools. All parents had at least one daughter; females constituted more than 50% of all children of the respondents. Gender disparities continue to exist in vaccination completion in India [21]. It is possible that the rate of complete vaccination was lower than what would have been expected if there were equal representation of males and females in the sample.

Despite these limitations, our study had several strengths. In addition to socio-demographic variables that can predict childhood vaccination in an urban population in South India, we considered attitudinal factors in a large sample of parents among the most challenging populations for achievement of complete vaccination in the world. While the generalizability of these data may be limited, they focus on the final frontier of child vaccination worldwide: Indian sub-groups where girls are over-represented. These data offer important, hitherto unexplored clues as to how parents' feelings about

routine vaccination explain the poor vaccination coverage in India decades after UIP introduction.

Conclusions

As one of the few studies examining correlates of incomplete or non-vaccination, this study adds to the limited evidence linking parental education, occupation and religion with vaccination completion in India's children, providing insights about parental attitudes that act as facilitators and barriers to children's vaccination. Knowledge about these factors and strategies to address them can help to improve the poor routine immunization coverage in India.

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Competing interests

None declared.

Ethical approval

The study was approved by the Institutional Review Board of Public Health Research Institute of India (Protocol # 2009-04-19-04) and Florida International University (IRB-13-0022).

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References

[1] Global routine vaccination coverage, 2010. Wkly Epidemiol Rec 2011;86(November (46)):509—13.
[2] World Health Organization. Global health observatory. Global information system on alcohol and health (GISAH); 2012.
[3] WHO. Vaccine-preventable diseases [Internet]. Available from: http://www.who.int/immunization_monitoring/diseases/en/ [cited 07.08.13].
[4] CDC. Global routine vaccination coverage, 2011. MMWR 2012;61(43):883—5.
[5] Rainey JJ, Watkins M, Ryman TK, Sandhu P, Bo A, Banerjee K. Reasons related to non-vaccination and under-vaccination of children in low and middle income countries: findings from a systematic review of the published literature, 1999—2009. Vaccine 2011;29(October (46)): 8215—21.
[6] IAP immunization guide book-new.p65 — IAP guide book on immunization immunization schedule.pdf; 2012 [Internet]. Available from: http://www.iapcoi.com/hp/pdf/IAP GUIDE BOOK ON IMMUNIZATION IMMUNIZATION SCHEDULE.pdf [cited 07.08.13].
[7] WHO vaccine-preventable diseases: monitoring system. 2013 global summary; 2013 [Internet]. Available from: http://apps.who.int/immunization_monitoring/globalsummary/countries?countrycriteria[country] [] = IND.
[8] National_Fact_Sheet_CES_2009.pdf [Internet]. Available from: http://www.unicef.org/india/National_Fact_Sheet_CES_2009.pdf [cited 07.09.13].
[9] International Institute for Population Sciences. India national family health survey (NFHS-3), 2005—06. International Institute for Population Sciences; 2007.
[10] Pande RP, Yazbeck AS. What's in a country average? Wealth, gender, and regional inequalities in immunization in India. Soc Sci Med 2003;57(11):2075—88.
[11] Madhivanan P, Krupp K, Yashodha MN, Marlow L, Klausner JD, Reingold AL. Attitudes toward HPV vaccination among parents of adolescent girls in Mysore, India. Vaccine 2009;27(38):5203—8.
[12] Paul P, Tanner AE, Gravitt PE, Vijayaraghavan K, Shah KV, Zimet GD, CATCH Study Group, Health Care for Women International. Acceptability of HPV Vaccine Implementation Among Parents in India. Health Care for Women International; 2013, http://dx.doi.org/10.1080/07399332.2012.740115.
[13] Parashar U, Tate J, Arora R, Kang G. Prospects for routine childhood vaccination against rotavirus in India. Natl Med J India 2012;25(5):257—60.
[14] Kumar A, Goel MK, Jain RB, Khanna P, Vibha V. Rotavirus vaccine: a cost effective control measure for India. Hum Vaccin Immunother 2012;8(4):501—4.
[15] Bali NK, Ashraf M, Ahmad F, Khan UH, Widdowson MA, Lal RB, et al. Knowledge, attitude, and practices about the seasonal influenza vaccination among healthcare workers in Srinagar, India. Influenza Other Respir Viruses 2013;7(4):540—5.
[16] Suresh PS, Thejaswini V, Rajan T. Factors associated with 2009 pandemic influenza A (H1N1) vaccination acceptance among university students from India during the post-pandemic phase. BMC Infect Dis 2011;29(11):205.
[17] International Institute for Population Sciences and ORC-Macro. National family health survey (NFHS-2) 1998—99: India; 2000.
[18] International Institute for Population Sciences. National family health survey (MCH and family planning): India,

1992—93. International Institute for Population Sciences; 1995.
[19] Ahmad J, Khan M, Hazra A. Increasing complete immunization in rural Uttar Pradesh. J Fam Welfare 2010;56:65—72.
[20] Chaturvedi M, Nandan D, Gupta S. Rapid assessment of immunization practices in Agra district. Editorial Board 2007;51(April—June (2)).
[21] Mathew JL. Inequity in childhood immunization in India: a systematic review. Indian Pediatr 2012;49(3):203—23.
[22] About Karnataka; 2013 [Internet]. Available from: http://www.mapsofindia.com/karnataka/
[23] Mysore City Corporation; 2013 [Internet]. Available from: http://www.mysorecity.gov.in/
[24] The GENMOD procedure: Overview::SAS/STAT(R) 9.3 user's guide [Internet]. Available from: http://support.sas.com/documentation/cdl/en/statug/63962/HTML/default/statug_genmod_sect001.htm [cited 07.09.13].
[25] Coverage Evaluation Survey All India Report [Internet]. Available from: http://www.unicef.org/india/1_-_CES_2009_All_India_Report.pdf [cited 07.09.13].
[26] Coverage Evaluation Survey 2005.pdf [Internet]. Available from: http://www.unicef.org/india/Coverage_Evaluation_Survey_2005.pdf [cited 07.09.13].
[27] Coverage evaluation survey — 2002 — IPPI, routine immunization and maternal care — national report [Internet]. Available from: http://www.scribd.com/doc/38209187/Coverage-Evaluation-Survey-2002-IPPI-Routine-Immunization-and-Maternal-Care-National-Report [cited 07.09.13].
[28] Vikram K, Vanneman R, Desai S. Linkages between maternal education and childhood immunization in India. Soc Sci Med 2012;75(2):331—9.
[29] Dalal A, Silveira M. Immunization status of children in Goa. Indian Pediatr 2005;42(4):401—2.
[30] Som S, Pal M, Chakrabarty S, Bharati P. Socioeconomic impact on child immunisation in the districts of West Bengal, India. Singapore Med J 2010;51(5):406—12.
[31] Building_trust_immunization.pdf [Internet]. Available from: http://www.unicef.org/publications/files/building_trust_immunization.pdf [cited 07.09.13].
[32] Khowaja AR, Zaman U, Feroze A, Rizvi A, Zaidi AKM. Routine EPI coverage: subdistrict inequalities and reasons for immunization failure in a rural setting in Pakistan. Asia Pac J Public Health 2011, http://dx.doi.org/10.1177/1010539511430850.
[33] Hu Y, Chen E, Li Q, Chen Y, Qi X. Immunization coverage and its determinants among children born in 2008—2009 by questionnaire survey in Zhejiang, China. Asia Pac J Public Health 2011, http://dx.doi.org/10.1177/1010539511430995.
[34] Rosenstock IM, Derryberry M, Carriger BK. Why people fail to seek poliomyelitis vaccination. Public Health Rep 1959;74(2):98.
[35] Sturm LA, Mays RM, Zimet GD. Parental beliefs and decision making about child and adolescent immunization: from polio to sexually transmitted infections. J Dev Behav Pediatrics 2005;26(6):441—52.
[36] Janz NK, Becker MH. The health belief model: a decade later. Health Educ Behav 1984;11(1):1—47.
[37] Patel TA, Pandit NB. Why infants miss vaccination during routine immunization sessions? Study in a rural area of Anand district, Gujarat. Indian J Public Health 2011;55(4):321.