Distribution Agreement

In presenting this thesis or dissertation as a partial fulfillment of the requirements for an advanced degree from Emory University, I hereby grant to Emory University and its agents the non-exclusive license to archive, make accessible, and display my thesis or dissertation in whole or in part in all forms of media, now or hereafter known, including display on the world wide web. I understand that I may select some access restrictions as part of the online submission of this thesis or dissertation. I retain all ownership rights to the copyright of the thesis or dissertation. I also retain the right to use in future works (such as articles or books) all or part of this thesis or dissertation.

Signature:

_____ _____

Megan Alicia Cohen Date

Assessing Providers' Vaccination-Related Practices in India

By

Megan Alicia Cohen
Master of Public Health

Global Epidemiology

_____

Michael Goodman
Committee Chair

_____

James Hughes
Committee Member

Assessing Providers' Vaccination-Related Practices in India

By

Megan Alicia Cohen

Sc.B.

Brown University

2007

Thesis Committee Chair: Michael Goodman, MD, MPH

An abstract of

A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of
Master of Public Health
in Global Epidemiology

2014

Abstract

Assessing Providers' Vaccination-Related Practices in India

By Megan Alicia Cohen

Background: Significant progress has been made toward improving routine immunization coverage in India, but universal coverage has yet to be achieved. Substantial variation in vaccination coverage exists across the country and little is known about how providers' vaccination practices affect coverage rates.

Aims: To identify barriers to achieving optimal vaccination coverage and to investigate factors influencing missed opportunities to vaccinate in two Indian states with low routine vaccination coverage.

Methods: We conducted an observational, cross-sectional study of Auxiliary Nurse Midwife (ANM) and Public Health Centre (PHC) physician vaccination practices during clinic visits for children under 3 years of age in Bihar and Uttar Pradesh. Information on provider behaviors was collected through parent-report and direct-observation. Information on clinic visit purpose was collected from parent reports only.

Results: Both ANMs and PHC physicians were more likely to adhere to recommended immunization-related clinical practices during vaccination-specific visits compared to illness visits. Adjusting for state and healthcare worker type, providers were 8 times more likely to verify child vaccination status during vaccination visits compared to illness visits ($p<0.001$) and 3.4 times more likely to counsel parents on vaccination ($p=0.022$).

Conclusions: Rigorous training of all vaccination practitioners should focus on the necessity of verifying the vaccination status regardless of type of visit. It is also important to emphasize the difference between true and falsely perceived contraindications to vaccination. Improved counseling will help improve vaccination rates and reinforce the importance of completing the vaccination schedule to parents.

Assessing Providers' Vaccination-Related Practices in India

By

Megan Alicia Cohen

Sc.B.

Brown University

2007

Thesis Committee Chair: Michael Goodman, MD, MPH

A thesis submitted to the Faculty of the

Rollins School of Public Health of Emory University

in partial fulfillment of the requirements for the degree of
Master of Public Health
in Global Epidemiology

2014

Acknowledgements

I would like to thank James Hughes and Lisa Gargano for their continued guidance and excellent mentorship over the course of this project.

Thanks to my thesis advisor, Michael Goodman, for his assistance with preparing this manuscript.

I am grateful for Dianne Miller and Ashley Freeman at Emory University for their administrative support and members of the IAP Executive Board, the St. Stephen's Hospital survey team led by Vipin Gupta, the National Polio Surveillance Project, and the governments of UP and Bihar for making this study possible.

Finally, a special thanks to my friends and family for their continued love and support.

Table of Contents

List of Tables

Introduction

Despite aggressive measures by the Ministry of Health and Family Welfare and by the Government of India, the target of universal coverage by 2010 in that country has not yet been reached (1). According to the 2009 Coverage Evaluation Survey conducted by UNICEF, on average only 61% of Indian children were fully immunized. Substantial differences in state-specific coverage rates are present across India. Several populous states such as Uttar Pradesh (UP) and Bihar remain well below the national average with respect to vaccination coverage. Only 41% and 49% of children aged 12-23 months are reported to be fully immunized in UP and Bihar, respectively. UP and Bihar are also among the states with the highest rates of children who have received no immunizations (17.8% and 15.2%, respectively) and of children who drop off the immunization schedule after having received their first scheduled vaccination (30.9% and 29.3%, respectively) (2). Vaccination rates also differ according to socioeconomic and demographic measures, as coverage is better in wealthier, urban regions compared to poorer, rural areas (2).

While the higher vaccination rates in more affluent, urban areas may reflect increased utilization of private pediatricians in India, overall the majority (89.8%) of children aged 12-23 months reportedly receive vaccines in the public sector from auxiliary nurse midwives (ANMs) and public health center (PHC) physicians (2). For this reason, public sector vaccination providers including ANMs and PHC physicians are integral in achieving improvements in immunization coverage rates.

Many previous studies investigated factors contributing to poor vaccination coverage and assessed barriers to improving immunization rates in India and other developing countries. Most have focused on socioeconomic and demographic factors correlated with under-vaccination, including later birth order (i.e., being the third or fourth child in a family) (2-4), female sex (3, 5-

11), mother's lack of education/illiteracy (2-4, 6, 7, 10-15), Muslim religion (2, 3, 6, 15, 16), rural residence (2, 6, 8, 12), and home delivery (6, 13, 16-18). Other studies have identified mothers' forgetfulness (3), availability of the immunization card (13, 16, 18), and misconceptions (6, 18, 19) about immunizations as significant predictive factors.

Less is known about healthcare providers' vaccination-related practices that may affect coverage rates in India. Literature from the United States suggests that providers may contribute to under-immunization by missing opportunities to vaccinate eligible children, often due to lack of awareness of vaccine status or secondary to a false contraindication such as a minor respiratory illness (20-24). Studies in developed countries have also shown that information received from healthcare providers is highly influential in shaping parents' attitudes towards immunization (25-28). Healthcare visits represent an opportunity to counsel parents on the importance of vaccinations in promoting child health, dispel fears surrounding vaccinations, discuss potential side-effects and ways to treat them, reinforce the need to complete the immunization schedule, and inform parents when to return for the next scheduled dose. In India, maternal lack of knowledge about immunizations (3, 4, 6, 11, 18, 19, 29-34) or the immunization schedule (4, 6, 11, 19) and fear of vaccination side effects (4, 6, 10, 11, 32, 33) have been cited as main barriers to complete immunization. Parental satisfaction with information delivered by healthcare workers is another significant predictor of immunization completeness (35). To our knowledge, specific provider practices during clinic visits have not yet been studied in India. With these data needs in mind, the goal of our study was to assess ANM and PHC physicians' vaccination-related practices including offering vaccinations, verifying vaccination status and counseling parents. We specifically aimed to identify provider-related barriers to achieving optimal vaccination coverage in the two Indian states of Bihar and UP, where vaccination rates remain low.

Methods

Participants

This current analysis is based on a sub-sample of a larger study in Bihar and UP conducted from June 2009 to June 2010 to investigate the knowledge, attitudes, and practices of various immunization practitioners in different Indian states. The required numbers of clinics in the UP and Bihar study samples were calculated to be proportional to each state's population.

Data on the practices of ANMs and PHC physicians were combined into a larger dataset. Data from clinics with no children under 3 years of age present during the survey were excluded. The final dataset for this study included 152 PHC clinics.

Procedures

Staff members of St. Stephen's Community Hospital in New Delhi who had experience conducting community surveys served as interviewers for the current study. Each interviewer was trained to administer the survey instrument. At each clinic, interviewers were instructed to speak with at least three and up to five parents of children who had just been seen in clinic and inquire about their interaction with the providers. Interviewers were also asked to observe at least three and up to five different parent-child pairs in their encounters with the providers to directly assess vaccination-related practices. During the parent interviews, data were also collected regarding the purpose of the visit (whether for an illness or primarily for vaccination); for the observation data, no information was collected on the purpose of the visit. Exact numbers of parent-child pairs to be interviewed versus observed at each clinic were left to the discretion of the interviewer, leading to a difference in the total number of parents interviewed and the total number observed. Each parent-child pair was considered as an independent observation for each clinic, resulting in a total of 494 parent-recall interviews and 467 directly observed parent-child pairs.

The Emory University Institutional Review Board and the New Delhi Maulana Azad Medical College Institutional Ethics Committee both determined that this study did not meet the definition of "Human Subjects Research" and was classified as a "Quality Improvement" activity, not requiring review.

Instrument

The data collection instrument first required interviewers to indicate if it was a "vaccination day" in the clinic and to record how many children under the age of 3 were present at the time of the survey. "Vaccination days" (usually two per week) are specifically reserved for administration of routine immunizations.

For the assessment of provider vaccination-related practices, the instrument was divided into a parent-recall portion and a direct-observation portion. The survey assessed if the child was offered vaccines during the visit, if the child's vaccine status was verified, and if the parents were counseled on immunizations either verbally or via educational materials. For families seeing ANMs, an additional question assessed whether the child actually received vaccines. These core questions were the same for both the parent-recall section and the direct-observation section of the survey.

Data Variables

The binary (yes vs. no) dependent variables reflecting the provider vaccination-related practices included whether or not the surveyed provider 1) offered vaccines, 2) verified child's vaccination status, and 3) counseled parents on vaccinations. Child's receipt of vaccines was analyzed for ANMs only. Each dependent variable had both a parent-recall and a direct-observation version.

The main independent variables included healthcare worker type (ANM vs. PHC) and state (UP vs. Bihar). Covariates included in the analysis were number of children in the clinic and

visit purpose (illness vs. vaccination). Visit purpose was only included as a covariate for the analyses based on parent-recall, as it was not collected during the direct observation section of the survey. Number of children under 3 years of age in the waiting area of the clinic was categorized as 1-4 or ≥ 5. Clinic number was included in the analysis as a cluster variable given that there were multiple observations at the same clinic.

Data Analysis

Data were entered into SAS version 9.3 (Cary, NC) for analysis. For bivariate analyses, crude odds ratios (ORs) and the corresponding 95% confidence intervals (CIs) were computed and chi-square tests were performed to assess the unadjusted associations of the provider vaccination practices with state, healthcare worker type, and visit purpose. Multivariable analyses were performed using a generalized linear model to account for within-clinic clustering of observations, and adjusted ORs (95% CIs) were computed controlling for state, health care worker type, number of children in the clinic, the individual clinic, as well as (for parent-recall data only) purpose of the visit. Tests for all two-way interactions involving state, healthcare worker type, number of children in the clinic, and visit purpose were performed for each outcome variable as applicable.

Results

Unadjusted Analyses

Of the 152 clinics surveyed, 11 (7.2%) study sites (seven in Bihar and four in UP) were excluded as there were no children under 3 years of age present during the survey. Data for a total of 23 clinics in Bihar remained, representing 85 parent-child pair observations. Of these, 45 represented ANM visits, while 40 represented PHC physician visits. In UP, 118 clinics remained

for final analysis, representing 409 parent-child pair observations. Of these, 208 were for ANM visits, and 201 were for PHC physician visits.

UP providers were significantly more likely than Bihar providers to offer vaccines (94.6% vs. 77.7%, $p<0.001$), verify vaccination status (93.6% vs. 78.8%, $p<0.001$), and provide immunization counseling (90.7% vs. 50.6%, $p<0.001$) when reported by parents. These associations remained strong and statistically significant when directly observed (data not shown). Across all dependent variables and regardless of the data collection method, providers were also significantly more likely to perform immunization-related tasks in clinics with 1-4 children compared to clinics that had at least 5 children (data not shown).

Based on parent reports (Table 1), ANMs were more likely than PHC physicians to verify vaccine status (96.1% vs. 85.9%, $p<0.001$) or provide immunization counseling (88.9% vs. 78.4%, $p=0.002$). These differences were most pronounced in Bihar, where ANMs verified vaccine status in over 90% of encounters relative to only 62.5% of PHC physician visits ($p<0.001$, OR=0.12, data not shown).

When directly observed by researchers, ANMs were also more likely to offer vaccinations (95.3% of the time) compared to PHC physicians (89.6%, $p=0.019$). As shown in Table 1, ANMs were more often observed to verify vaccine status than were PHC physicians (98.3% vs. 86.2%, $p<0.001$). In contrast to patient reports, direct observation revealed no statistically significant differences in the frequency of immunization counseling between ANM and PHC physician visits.

Table 2 presents results of analyses comparing the parent-reported data by purpose of visit. Healthcare workers overall were significantly more likely to perform important immunization-related tasks during specific vaccination visits compared to visits for child illness. Verification of a child's immunization status was significantly more likely to take place during

vaccination visits than during visits prompted by illness (OR=15.6; 95% CI=7.83, 31.08; p<0.001). Only 53% of healthcare workers counseled parents on vaccination during illness visits, while 88% counseled during vaccination visits (OR=6.43; 95% CI=3.59, 11.53, p<0.001). These associations remained strong and statistically significant after stratification by healthcare worker type (Table 2).

During illness visits, no significant differences existed between ANMs and PHC physicians in terms of offering vaccines, verifying vaccine status, or counseling on vaccination (Table 3). For vaccination-specific visits, ANMs were significantly more likely to verify vaccine status (OR=0.15, p<0.001) and counsel parents on immunization (OR=0.50, p=0.019) when compared to PHC physicians (Table 3).

Multivariable Analyses

Table 4 presents results of multivariable analyses that included state, healthcare worker type, and visit purpose as three independent determinants of parent-reported practices and state and healthcare worker type as independent determinants of directly-observed provider practices. After controlling for other factors children in UP were more likely than children in Bihar to be offered vaccinations, have their vaccination status verified, and have their parents counseled on vaccinations. Visit purpose was also significantly and independently associated with parent-reported vaccination practices in all analyses. In the adjusted analyses comparing directly observed vaccination practices by HCW type, PHC physicians were less likely to verify vaccine status with an adjusted OR of 0.10 (95% CI=0.03, 0.35; p<0.001). By contrast, none of the remaining measures of vaccination practices were significantly associated with HCW type with adjusted ORs ranging between 0.41 and 0.99 (Table 4). The two-way interaction terms involving healthcare worker type, state, and visit purpose were not statistically significant.

Table 5 presents results from multivariable analysis also including the number of children in the clinic as a covariate. Number of children in clinic was significantly and independently associated with vaccination status verification (data not shown). When also controlling for number of children in clinic, PHC physicians were less likely than ANMs to verify vaccine status by parent report with an adjusted OR of 0.21 (95% CI=0.07, 0.65; p=0.007). Number of children in clinic was not a significant independent predictor of offering vaccines or providing counseling. State remained significantly and independently associated with all provider practices and the direction and magnitude of the associations remained similar. Visit purpose also remained significantly and independently associated with provider practices by parent report.

Significant interaction between healthcare worker type and number of children in clinic was observed for verification of vaccination status by parent report. Thus, Table 6 provides results of the adjusted associations between vaccination status verification and state, healthcare worker, and visit purpose, stratified by number of children in clinic. State and visit purpose, but not healthcare worker type, were significantly and independently associated with verifying vaccination status if there were 1-4 children in clinic. By contrast, healthcare worker type and visit purpose, but not state, were significantly and independently associated with verifying vaccination status when there were 5 or more children in clinic. With more children in clinic, PHC physicians were less likely than ANMs to verify vaccination status (adjusted OR=0.06; 95% CI=0.02, 0.20; p<0.001).

Discussion

Our results indicate that state and visit purpose had strong, significant, and independent associations with provider vaccination-related practices. In general, providers more regularly performed vaccination-related tasks in UP relative to Bihar. Both ANMs and PHC physicians neglected to offer vaccinations, verify vaccine status, or counsel parents more often during illness visits. Number of children in the clinic was significantly associated with vaccination status verification and also appeared to modify the effects of other factors. With only 1-4 children present in the clinic, providers were significantly more likely to verify vaccination status in UP than they did in Bihar. In clinics with 5 or more children, however, the state no longer appeared to matter, but PHC physicians were less likely than ANMs to verify vaccination status. Regardless of how many children were present in the clinic, verification was more likely to occur during vaccination compared to illness visits, although this difference was much more pronounced in clinics with fewer patients.

While it may not be surprising that providers offered vaccines more often during vaccination visits than during illness visits, this discrepancy is of concern. Our study is limited by the lack of information on the actual reasons for the illness visits, yet it is known that failure to verify vaccine status at every visit may lead to missed opportunities for immunization (20, 21, 23). Importantly, a previous study in Mumbai found that illness visits represent 80% of missed immunization opportunities versus only 0.7% of missed opportunities during a well-child visit (18). Parents in previous studies have also erroneously reported a belief that immunizations cannot be given when a child has a minor illness such as diarrhea without dehydration or an upper respiratory tract infection (6, 36). However, the previously cited Mumbai study found that 94% of missed vaccination opportunities occurred because the provider failed to review the child's immunization status, while only 2.2% were due to a perceived, yet false contraindication such as a minor illness (18).

Ensuring that vaccine status is routinely verified, even during illness visits, may be crucial for improving coverage rates. In the present study, PHC physicians verified vaccine status less often than ANMs, particularly when the analysis was based on direct observation. We previously showed that, when surveyed, PHC physicians reported verifying vaccine status only 22% of the time, which was attributed to the fact that PHC physicians are more likely to refer families to another vaccination provider (37). Previous studies in the United States have distinguished between "acknowledged missed opportunities," wherein a vaccine-eligible child is not immunized because of a real or perceived contraindication versus an "unacknowledged missed opportunity," due to the failure to verify immunization status. One such study found that only "unacknowledged" missed opportunities were significantly associated with under-immunization status, and that after an unacknowledged missed opportunity a child was significantly less likely to return for immunization within one month or to make up the immunization at the next visit when compared to an acknowledged missed opportunity (20).

This practice may also miss an important opportunity to reinforce the immunization schedule. Parents' lack of awareness of the timing of the next immunization dose has frequently been associated with incomplete immunization in India (4, 6, 11, 18). Every encounter should be viewed as a chance to tell parents when to return for the next vaccine dose, which has previously been shown to be an important strategy for ensuring completion of the immunization schedule (6, 17). Regularly emphasizing the importance of bringing the child's immunization card to each clinic visit may also reduce missed opportunities to vaccinate during illness visits.

In the current study fewer visits involved immunization counseling compared to other activities such as offering vaccines or verifying vaccination status. Counseling has been shown to be crucial, as parental lack of knowledge about immunizations has routinely been cited as an impediment to complete immunization coverage in India (19), and in other countries including the United States (25) and the UK (26). A study conducted in Rajasthan, found that mothers of

fully vaccinated infants were able to name more of the diseases covered by India's national Universal Immunization Programme and were more aware of the benefits of vaccination including prevention of illness than mothers of partially immunized or non-immunized children. Most of the women surveyed attributed the need for vaccination to "prevention of paralysis," suggesting they were primarily aware of immunization against poliomyelitis (19). Other studies have replicated these results, finding that barriers to complete immunization include inadequate maternal knowledge of vaccination schedules, fear of side effects, and the belief that only polio vaccination is required (3, 4, 6, 10, 11, 18, 19, 29-34).

The mothers surveyed in Rajasthan cited "an interpersonal approach" including direct interactions with ANMs and physicians' advice as the most important methods of improving vaccination coverage (19). Similarly, Nath et al. found that families of fully-immunized children reported significantly increased overall satisfaction with their healthcare providers and increased satisfaction with the information relayed by healthcare professionals when compared to the families with partially-immunized children within a district of UP (35). In the United States, the ability of healthcare providers to positively influence parents has also been associated with increased vaccination rates (38), highlighting the importance of improving counseling practices in a variety of health care settings.

Findings from intervention studies conducted in Pakistan indicate that counseling may serve as a feasible and effective way of increasing vaccination coverage. Owais et al. showed that a short, home-based education about the importance of vaccination and the importance of retaining immunization cards increased uptake of DPT3 and Hepatitis B vaccines by 39% (29). These sessions were delivered by community health workers to mainly low-literacy mothers using easily understandable pictorial cards. Usman et al. showed a significant increase in DPT3 series completion following a 2-3 minute center-based educational intervention on the importance of immunizations and potential adverse health effects associated with failure to complete the

vaccination schedule (39, 40). When combined with a redesigned immunization card prominently featuring the date of next required vaccination, the intervention resulted in a 31% increase in DPT3 completion in urban Pakistan (40) and a 67% increase in DPT3 completion in rural Pakistan (39).

Our study has several limitations. While recall bias in this study was unlikely because parents were interviewed immediately after their visit, it is possible that parent interviews were affected by differential reporting. For example, parents may have been less focused on verification of immunization status during illness visits than during vaccination visits. Although our study would have benefited from information on visit purpose from direct observations, it is reassuring that other results did not differ by ascertainment method.

Our study is also limited by the lack of information on whether the parent carried the child's immunization card, which has been shown to be an important predictor of immunization status (18). It is not clear if vaccine status was not verified because of the provider oversight or due to the parent's inability to produce the immunization card.

This study focused on healthcare workers' vaccination practices at the point of immunization delivery. There may be many other factors contributing to lack of achieving universal immunization coverage. These may include inaccessibility of immunization services to families because of distance, lack of resources or behavioral factors.

Conclusions

Healthcare workers are key sources of immunization-related information. It is essential that they counsel parents about the importance of immunization, help dispel misconceptions, and remind parents of the vaccination schedule. Parents must also be counseled on the need to bring immunization cards to any clinic visit. Training of vaccination practitioners should focus on the need to verify the vaccination status at each visit, and emphasize the difference between true and falsely perceived contraindications to vaccination. Verification of immunization status at every visit helps improve vaccination rates, sets an example for parents, and allows interrupting transmission of vaccine preventable diseases.

References

1. Ministry of Health and Family Welfare. *National Population Policy 2000*. Government of India: Delhi. http://india.unfpa.org/drive/NationalPopulation-Policy2000.pdf. Accessed May 10, 2013.

2. UNICEF. *Coverage Evaluation Survey 2009: All India Report*. New Delhi. http://www.unicef.org/india/1_-_CES_2009_All_India_Report.pdf. Accessed February 20, 2013.

3. Patel TA and Pandit NB. Why infants miss vaccination during routine immunization sessions? Study in a rural area of Anand district, Gujarat. *Indian J Public Health.* 2011;55:321-323.

4. Nath B, Singh JV, Awasthi S, et al. A study on determinants of immunization coverage among 12-23 months old children in urban slums of Lucknow district, India. *Indian J Med Sci.* 2007;61(11):598-606.

5. Corsi DJ, Bassani DG, Kumar R, et al. Gender inequity and age-appropriate immunization coverage in India from 1992 to 2006. *BMC Int Health Hum Rights.* 2009;9 Suppl 1:S3.

6. Kumar D, Aggarwal A, and Gomber S. Immunization status of children admitted to a tertiary-care hospital of north India: reasons for partial immunization or non-immunization. *J Health Popul Nutr.* 2010;28(3):300-4.

7. Kumar A and Mohanty S. Socio-economic differentials in childhood immunization in India, 1992–2006. *Journal of Population Research.* 2011;28(4):301-324.

8. Pande RP and 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.

9. Sharma R, Desai VK, and Kavishvar A. Assessment of immunization status in the slums of surat by 15 clusters multi indicators cluster survey technique. *Indian J Community Med.* 2009;34(2):152-5.

10. Chaudhary V, Kumar R, Agarwal VK, et al. Evaluation of Primary immunization coverage in an urban area of Bareilly city using Cluster Sampling Technique. *National Journal of Integrated Research in Medicine.* 2010;1(4):10-15.

11. Agrawal SC and Kumari A. Immunization status of children and the influence of social factors: A hospital based study in western Uttar Pradesh. *Pediatric Infectious Disease.* 2014.

12. Phukan RK, Barman MP, and Mahanta J. Factors associated with immunization coverage of children in Assam, India: over the first year of life. *J Trop Pediatr.* 2009;55(4):249-52.

13. Chhabra P, Nair P, Gupta A, et al. Immunization in urbanized villages of Delhi. *Indian J Pediatr.* 2007;74(2):131-4.

14. Chopra H, Singh AK, Singh JV, et al. Status of Routine Immunization in an Urban Area of Meerut. *Indian Journal of Community Health.* 2007;Jun. 2007:19-22.

15. Weiss WM, Choudhary M, and Solomon R. Performance and determinants of routine immunization coverage within the context of intensive polio eradication activities in Uttar Pradesh, India: Social Mobilization Network (SM Net) and Core Group Polio Project (CGPP). *BMC Int Health Hum Rights.* 2013;13:25.

16. Kulkarni SV and Chavan MK. A study to assess the immunization coverage in an urban slum of Mumbai by lot quality technique. *Int J Med Public Health.* 2013;3(1):21-25.

17. Takum T, Padung D, Joshua V, et al. Programmatic and beneficiary-related factors for low vaccination coverage in Papum Pare district, Arunachal Pradesh, India. *J Trop Pediatr.* 2011;57(4):251-7.

18. Muranjan M, Mehta C, and Pakhare A. An observational, health service based survey for missed opportunities for immunization. *Indian Pediatr.* 2011;48(8):633-6.

19. Manjunath U and Pareek RP. Maternal knowledge and perceptions about the routine immunization programme--a study in a semiurban area in Rajasthan. *Indian J Med Sci.* 2003;57(4):158-63.

20. Ball TM and Serwint JR. Missed opportunities for vaccination and the delivery of preventive care. *Arch Pediatr Adolesc Med.* 1996;150(8):858-61.

21. Rainey JJ, Watkins M, Ryman TK, et al. 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(46):8215-21.

22. Daley MF, Beaty BL, Barrow J, et al. Missed opportunities for influenza vaccination in children with chronic medical conditions. *Arch Pediatr Adolesc Med.* 2005;159(10):986-91.

23. Szilagyi PG and Rodewald LE. Missed opportunities for immunizations: a review of the evidence. *J Public Health Manag Pract.* 1996;2(1):18-25.

24. Szilagyi PG, Rodewald LE, Humiston SG, et al. Reducing missed opportunities for immunizations. Easier said than done. *Arch Pediatr Adolesc Med.* 1996;150(11):1193-200.

25. Gust DA, Kennedy A, Shui I, et al. Parent Attitudes Toward Immunizations and Healthcare Providers: The Role of Information. *Am J Prev Med.* 2005;29(2):105-12.

26. Smailbegovic MS, Laing GJ, and Bedford H. Why do parents decide against immunization? The effect of health beliefs and health professionals. *Child Care Health Dev.* 2003;29(4):303-11.

27. Benin AL, Wisler-Scher DJ, Colson E, et al. Qualitative analysis of mothers' decision-making about vaccines for infants: the importance of trust. *Pediatrics.* 2006;117(5):1532-41.

28. Falagas ME and Zarkadoulia E. Factors associated with suboptimal compliance to vaccinations in children in developed countries: a systematic review. *Curr Med Res Opin.* 2008;24(6):1719-41.

29. Owais A, Hanif B, Siddiqui AR, et al. Does improving maternal knowledge of vaccines impact infant immunization rates? A community-based randomized-controlled trial in Karachi, Pakistan. *BMC Public Health.* 2011;11:239.

30. Vohra R, Vohra A, Bhardwaj P, et al. Reasons for failure of immunization: A cross-sectional study among 12-23-month-old children of Lucknow, India. *Adv Biomed Res.* 2013;2:71.

31. Singh P and Yadav RJ. Immunisation status of children in BIMARU states. *Indian J Pediatr.* 2001;68(6):495-500.

32. Gupta PK, Pore P, and Patil U. Evaluation of immunization coverage in the rural area of pune, maharashtra, using the 30 cluster sampling technique. *J Family Med Prim Care.* 2013;2(1):50-4.

33. Mahyavanshi DK, Nagar SS, Patel MG, et al. Evaluation of immunization coverage among children aged 12-23 months in Surendranagar city. *Int J Basic Clin Pharmacol.* 2013;2(3):286-289.

34. Nath B, Singh JV, Awasthi S, et al. KAP Study on Immunization of Children in City of North India - A 30 Cluster Survey. *Online J Allied Health Scs.* 2008;7(1):2.

35. Nath B, Singh JV, Awasthi S, et al. Client satisfaction with immunization services in urban slums of Lucknow district. *Indian J Pediatr.* 2009;76(5):479-83.

36. Joseph N, Subba S, Nelliyanil M, et al. A study of the knowledge and attitude towards pulse polio immunization in semi urban areas of South India. *Australas Med J.* 2011;4(2):81-6.

37. Gargano LM, Thacker N, Choudhury P, et al. Attitudes of pediatricians and primary health center physicians in India concerning routine immunization, barriers to vaccination, and missed opportunities to vaccinate. *Pediatr Infect Dis J.* 2012;31(2):e37-42.

38. Smith PJ, Kennedy AM, Wooten K, et al. Association between health care providers' influence on parents who have concerns about vaccine safety and vaccination coverage. *Pediatrics.* 2006;118(5):e1287-92.

39. Usman HR, Rahbar MH, Kristensen S, et al. Randomized controlled trial to improve childhood immunization adherence in rural Pakistan: redesigned immunization card and maternal education. *Trop Med Int Health.* 2011;16(3):334-42.

40. Usman HR, Akhtar S, Habib F, et al. Redesigned immunization card and center-based education to reduce childhood immunization dropouts in urban Pakistan: a randomized controlled trial. *Vaccine.* 2009;27(3):467-72.

Tables

Table 1. Crude association between provider practices and healthcare worker type (ANM vs. PHC physician)

	ANM	PHC physician		
Parent Recall	**(n=253) n (%)**	**(n=241) n (%)**	**OR (95% CI)**	**p-value**
Offered Vaccine	237 (93.7%)	216 (89.6%)	0.58 (0.30, 1.12)	0.103
Vaccine Status Verified	243 (96.1%)	207 (85.9%)	0.25 (0.12, 0.52)	<0.001
Parents Counseled on Vaccination	225 (88.9%)	189 (78.4%)	0.45 (0.27, 0.74)	0.002
Direct Observation	**(n=236) n (%)**	**(n=231) n (%)**	**OR (95% CI)**	**p-value**
Observed Offered Vaccine	225 (95.3%)	207 (89.6%)	0.42 (0.20, 0.88)	0.019
Observed Status Verified	232 (98.3%)	199 (86.2%)	0.11 (0.04, 0.31)	<0.001
Observed Parents Counseled	208 (88.1%)	191 (82.7%)	0.64 (0.38, 1.08)	0.095

Table 2. Parent-reported differences in provider vaccination practices for illness compared to vaccination visits stratified by healthcare worker type

	Illness	Vaccination		
Overall (ANM+PHC)	**(n=60) n (%)**	**(n=434) n (%)**	**OR (95% CI)**	**p-value**
Offered Vaccine	39 (65.0%)	414 (95.4%)	11.15 (5.56, 22.33)	<0.001
Vaccine Status Verified	35 (58.3%)	415 (95.6%)	15.60 (7.83, 31.08)	<0.001
Parents Counseled on Vaccination	32 (53.3%)	382 (88.0%)	6.43 (3.59, 11.53)	<0.001
ANM	**(n=20) n (%)**	**(n=233) n (%)**	**OR (95% CI)**	**p-value**
Offered Vaccine	13 (65.0%)	224 (96.1%)	13.40 (4.31, 41.70)	<0.001
Vaccine Status Verified	13 (65.0%)	230 (98.7%)	41.28 (9.55, 178.36)	<0.001
Parents Counseled on Vaccination	12 (60.0%)	213 (91.4%)	7.10 (2.60, 19.40)	<0.001
Child Received Vaccines	11 (55.0%)	232 (99.6%)	189.82 (22.05, 1633.95)	<0.001
PHC physician	**(n=40) n (%)**	**(n=201) n (%)**	**OR (95% CI)**	**p-value**
Offered Vaccine	26 (65.0%)	190 (94.5%)	9.30 (3.82, 22.64)	<0.001
Vaccine Status Verified	22 (55.0%)	185 (92.0%)	9.46 (4.23, 21.17)	<0.001
Parents Counseled on Vaccination	20 (50.0%)	169 (84.1%)	5.28 (2.56, 10.91)	<0.001

Table 3. Parent-reported differences in healthcare worker vaccination practices, stratified by visit purpose

Illness				
Outcome	**ANM (n=20)**	**PHC physician (n=40)**	**OR (95% CI)**	**p-value**
Offered Vaccine	13 (65.0%)	26 (65.0%)	1.00 (0.32, 3.08)	1.00
Vaccine Status Verified	13 (65.0%)	22 (55.0%)	0.66 (0.22, 2.00)	0.459
Parents Counseled on Vaccination	12 (60.0%)	20 (50.0%)	0.67 (0.22, 1.98)	0.464
Vaccination				
Outcome	**ANM (n=233)**	**PHC physician (n=201)**	**OR (95% CI)**	**p-value**
Offered Vaccine	224 (96.1%)	190 (94.5%)	0.69 (0.28, 1.71)	0.425
Vaccine Status Verified	230 (98.7%)	185 (92.0%)	0.15 (0.04, 0.53)	<0.001
Parents Counseled on Vaccination	213 (91.4%)	169 (84.1%)	0.50 (0.27, 0.90)	0.019

Table 4. Association of vaccination practices and predictor variables, adjusting for state, healthcare worker type, visit purpose, and clinic

	State[a]		HCW Type[b]		Purpose[c]	
Parent Recall	**aOR (95% CI)**	**p-value**	**aOR (95% CI)**	**p-value**	**aOR (95% CI)**	**p-value**
Offered Vaccine	6.16 (2.53, 15.03)	<0.001	0.99 (0.38, 2.60)	0.99	7.92 (2.15, 29.21)	0.002
Vaccine Status Verified	5.06 (1.98, 12.98)	<0.001	0.42 (0.15, 1.20)	0.105	8.29 (2.74, 25.10)	<0.001
Parents Counseled on Vaccination	10.48 (4.79, 22.90)	<0.001	0.58 (0.25, 1.32)	0.195	3.38 (1.19, 9.56)	0.022
Child Received Vaccines	2.87 (0.44, 18.55)	0.268	---[d]	---	204.45 (19.89, 2101.2)	<0.001
Direct Observation[e]	**aOR (95% CI)**	**p-value**	**aOR (95% CI)**	**p-value**	**aOR (95% CI)**	**p-value**
Observed Offered Vaccine	7.86 (2.86, 21.60)	<0.001	0.41 (0.15, 1.12)	0.082	---	---
Observed Status Verified	5.60 (1.63, 19.23)	0.006	0.10 (0.03, 0.35)	<0.001	---	---
Observed Parents Counseled	14.44 (6.23, 33.22)	<0.001	0.60 (0.27, 1.35)	0.215	---	---

[a] Reference = Bihar

[b] Reference = ANM

[c] Reference = Illness visits

[d] Data collected for ANM only, so HCW Type not included in Generalized Linear Model

[e] Information on visit purpose was not collected with the direct observation data, so purpose is excluded from Generalized Linear Model for direct observation

Table 5. Association of vaccination practices and predictor variables, adjusting for state, healthcare worker type, purpose, number of children in clinic, and clinic

	State[a]		HCW Type[b]		Purpose[c]	
Parent Recall	**aOR (95% CI)**	**p-value**	**aOR (95% CI)**	**p-value**	**aOR (95% CI)**	**p-value**
Offered Vaccine	4.49 (1.77, 11.36)	0.002	0.76 (0.30, 1.93)	0.57	8.79 (2.72, 28.40)	<0.001
Vaccine Status Verified	2.86 (1.01, 8.11)	0.048	0.21 (0.07, 0.65)	0.007	13.59 (5.52, 33.44)	<0.001
Parents Counseled on Vaccination	9.28 (4.21 20.44)	<0.001	0.52 (0.22 1.23)	0.136	3.47 (1.26, 9.51)	0.016
Child Received Vaccines	3.66 (0.54 24.80)	0.184	---[d]	---	296.72 (30.37, 2899.1)	<0.001
Direct Observation[e]	**aOR (95% CI)**	**p-value**	**aOR (95% CI)**	**p-value**	**aOR (95% CI)**	**p-value**
Observed Offered Vaccine	6.56 (2.40, 17.37)	<0.001	0.35 (0.12, 1.01)	0.052	---	---
Observed Status Verified	4.20 (1.15, 15.33)	0.030	0.08 (0.02, 0.30)	<0.001	---	---
Observed Parents Counseled	12.40 (5.33, 28.86)	<0.001	0.54 (0.23, 1.28)	0.158	---	---

[a] Reference = Bihar

[b] Reference = ANM

[c] Reference = Illness visits

[d] Data collected for ANM only, so HCW Type not included in Generalized Linear Model

[e] Information on visit purpose was not collected with the direct observation data, so purpose is excluded from Generalized Linear Model for direct observation

Table 6. Predictors of verification of vaccination status as assessed by multiple regression, stratified by number of children in clinic

	State[a]		HCW Type[b]		Purpose[c]	
Number of children in clinic	**aOR (95% CI)**	**p-value**	**aOR (95% CI)**	**p-value**	**aOR (95% CI)**	**p-value**
1-4 Children	5.31 (1.60, 17.63)	0.006	0.89 (0.26, 3.03)	0.853	23.92 (7.97, 71.81)	<0.001
≥5 Children	1.35 (0.27, 6.75)	0.717	0.06 (0.02, 0.20)	<0.001	9.65 (1.28, 72.54)	0.028

[a] Reference = Bihar

[b] Reference = ANM

[c] Reference = Illness visits

Supplementary Tables

Table 7. Crude association between provider practices (ANM and PHC physician aggregated) and state

	Bihar	UP		
Parent Recall	**(n=85) n (%)**	**(n=409) n (%)**	**OR (95% CI)**	**p-value**
Offered Vaccine	66 (77.7%)	387 (94.6%)	5.06 (2.60, 9.87)	<0.001
Vaccine Status Verified	67 (78.8%)	383 (93.6%)	3.96 (2.06, 7.62)	<0.001
Parents Counseled on Vaccination	43 (50.6%)	371 (90.7%)	9.54 (5.55, 16.37)	<0.001
Child Received Vaccines (ANM only)	42/45 (93.3%)	201/208 (96.6%)	2.05 (0.51, 8.26)	0.300
Direct Observation	**(n=75) n (%)**	**(n=392) n (%)**	**OR (95% CI)**	**p-value**
Observed Parents Offered	57 (76.0%)	375 (95.7%)	6.97 (3.39, 14.30)	<0.001
Observed Vaccine Status Verified	60 (80.0%)	371 (95.6%)	4.42 (2.16, 9.04)	<0.001
Observed Parents Counseled	37 (49.3%)	362 (92.4%)	12.39 (6.90, 22.27)	<0.001
Observed Vaccines Received (ANM only)	40/40 (100%)	193/196 (98.5%)	Non-estimable	0.430
Missed Opportunities	3 (4.7%)	8 (2.0%)	0.42 (0.11, 1.64)	0.200

Table 8. Crude association between provider practices and number of children in clinic (1-4 vs. ≥5)

	1-4 Children	≥ 5 Children		
Parent Recall	**(n=359) n (%)**	**(n=130) n (%)**	**OR (95% CI)**	**p-value**
Offered Vaccine	338 (94.2%)	110 (84.6%)	0.34 (0.18, 0.66)	<0.001
Vaccine Status Verified	337 (93.9%)	108 (83.1%)	0.32 (0.17, 0.60)	<0.001
Received Vaccines (ANM only)	163/170 (95.9%)	80/83 (96.4%)	1.15 (0.29, 4.55)	0.847
Parents Counseled on Vaccination	312 (86.9%)	97 (74.6%)	0.44 (0.27, 0.73)	0.001
Direct Observation	**(n=346) n (%)**	**(n=116) n (%)**	**OR (95% CI)**	**p-value**
Observed Parents Offered	326 (94.2%)	101 (87.1%)	0.41 (0.20, 0.84)	0.012
Observed Status Verified	326 (94.2%)	100 (86.2%)	0.38 (0.19, 0.77)	0.005
Observed Parents Counseled	305 (88.2%)	89 (76.7%)	0.44 (0.26, 0.76)	0.003
Observed Received Vaccines (ANM only)	161/164 (98.2%)	72/72 (100%)	Non-estimable	0.248

Table 9. Crude association between vaccination practices and healthcare worker type in Bihar

	ANM	PHC physician		
Parent Recall	**(n=45) n (%)**	**(n=40) n (%)**	**OR (95% CI)**	**p-value**
Offered Vaccine	38 (84.44%)	28 (70.00%)	0.43 (0.15, 1.23)	0.11
Vaccine Status Verified	42 (93.33%)	25 (62.50%)	0.12 (0.03, 0.45)	<0.001
Parents Counseled on Vaccination	29 (64.44%)	14 (35.00%)	0.30 (0.12, 0.72)	0.007
Parents Have Cell phone	8 (18.18%)	9 (22.50%)	1.31 (0.45, 3.80)	0.620
Direct Observation	**(n=40) n (%)**	**(n=35) n (%)**	**OR (95% CI)**	**p-value**
Observed Parents Offered	34 (85.00%)	23 (65.71%)	0.34 (0.11, 1.03)	0.051
Observed Status Verified	40 (100%)	20 (57.14%)	Non-estimable	<0.001
Observed Parents Counseled	23 (57.50%)	14 (40.00%)	0.49 (0.20, 1.24)	0.130
Missed Opportunities	1 (2.70%)	2 (7.41%)	2.88 (0.25, 33.51)	0.380

Table 10. Crude association between vaccination practices and healthcare worker type in Uttar Pradesh

	ANM	PHC physician		
Parent Recall	**(n=208) n (%)**	**(n=201) n (%)**	**OR (95% CI)**	**p-value**
Offered Vaccine	199 (95.67%)	188 (93.53%)	0.65 (0.27, 1.57)	0.340
Vaccine Status Verified	201 (96.63%)	182 (90.55%)	0.33 (0.14, 0.81)	0.012
Parents Counseled on Vaccination	196 (94.23%)	175 (87.06%)	0.41 (0.20, 0.84)	0.013
Parents Have Cell phone	105 (50.48%)	81 (40.30%)	0.66 (0.45, 0.98)	0.039
Direct Observation	**(n=196) n (%)**	**(n=196) n (%)**	**OR (95% CI)**	**p-value**
Observed Parents Offered	191 (97.45%)	184 (93.88%)	0.40 (0.14, 1.16)	0.083
Observed Status Verified	192 (97.96%)	179 (91.33%)	0.22 (0.07, 0.66)	0.004
Observed Parents Counseled	185 (94.39%)	177 (90.31%)	0.55 (0.26, 1.20)	0.130
Missed Opportunities	2 (1.02%)	6 (3.06%)	3.06 (0.61, 15.37)	0.150