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RESEARCH

Epidemiology of measles infection in rural Uttar Pradesh, India

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ABSTRACT

Introduction: Measles infection continues to be a significant public health problem among children, with a high attack and incidence rate in India. The objective of this study was to estimate the measles attack rate among children in rural disadvantaged communities in India, and identify factors associated with measles infections. **Methodology:** Using a convenient sample of 2,615 children aged 5 years and under residing in four villages in Kanpur district in Uttar Pradesh, we conducted a cross-sectional study with valid and reliable questionnaire to determine the measles attack rates. Sociodemographic and economic characteristics including age, gender, health care access, measles prevention, vaccination, and vitamin A supplementation were included in the study. Descriptive statistics were reported using frequencies and proportions. A multivariable logistic regression model was conducted to delineate the factors associated with measles infections in these children. **Results:** Overall 12% of children reported measles attacks during the past 12 months, and 23% reported taking vitamin A supplementation. Grade 2 and 3 malnutrition was significantly associated with increased measles infections, while vaccination coverage and compliance with Universal Immunization Program was associated with decreased measles attacks. **Conclusion:** Malnutrition was identified as a major factor for measles infections in these children. Study findings necessitate the need for appropriate policy measures and health education initiatives about the importance of adequate nutrition in children. In addition, study results contribute to ongoing efforts in measles vaccination coverage and high compliance for Universal Immunization Program among children in India.

Key Words: Measles, malnutrition, vaccination, vitamin A supplementation.

Introduction

Measles, a highly contagious and seasonal acute viral illness, is one of the most important causes of childhood morbidity and mortality worldwide [1]. In 2008, a total number of 278,358 measles cases have been reported globally, with a significant decline of 67% from 852,937 cases in 2000 [2]. Similarly the number of deaths attributed to measles has significantly reduced by 78% from an estimated 733,000 deaths in 2000 to 164,000 in 2008 contributing to an overall 23% reduction in childhood mortality worldwide during these years [2,3]. The United Nations included an aim in the Millennium Development Goals 4 to reduce the mortality attributed to measles among children by two-thirds by 2015 compared to that of in 1990. To achieve this aim, measles vaccination with upto 90% coverage in children, routine measles surveillance coverage and management of complicated cases strategies have been adopted [4]. Most countries in the world have achieved the goals, except South Asian nations including India, where there has been only a 47% reduction in mortality [5]. Several social, demographic and cultural factors have been identified to play a significant role in high measles mortality in India, including lack of surveillance systems, second dose of measles vaccine in the National Immunization Schedule until 2010, lack of access, beliefs against immunization, lack of education, awareness about vaccination, and malnutrition [5-8].

Several measles outbreaks have been reported in India. Although most remain underreported, the latest incidents reported include double outbreak of measles in Bhavnagar district of Gujarat, modified measles outbreak in urban colony in Northern India, and outbreak in Dukpa tribe in West Bengal [9-11]. The case-fatality ratio for measles is <7% in most developing nations; however it is >30% in India [8]. In May 2007, the Government of India (GoI), the World Health Organization (WHO) and the United Nations Children Fund (UNICEF) convened a workshop on measles and identified that over 90% of deaths in India occur in 10 states, namely, Uttar Pradesh, Madhya Pradesh, Assam, West Bengal, Bihar, Rajasthan, Orissa, Andhra Pradesh, Jharkhand and Gujarat. In addition, the coverage of measles vaccination was less than 50% in these 10 states. In 1996, measles outbreaks were reported in seven districts of Uttar Pradesh with a case fatality ratio of 4.1% with < 1% of estimated cases captured by the surveillance system [12]. Given that Uttar Pradesh has high mortality rates and only few disease outbreaks reported, we conducted this project to study the epidemiology of measles in Kanpur district in rural Uttar Pradesh, India and identify social, demographic and economic characteristics associated with measles infection. In addition, the study was also aimed at providing evidence for public health professionals and policy makers the need for surveillance systems, policies for increased vaccination coverage and preventive approaches to combat measles

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infections in children aged 5 years and under.

Methodology

Study setting and population

The study was conducted in the four major villages in Kanpur district in rural Uttar Pradesh during the period July-November 2011. In assistance with the primary and community health care centers in the district, we were able to identify children with measles. Informed consent about participation in the study was obtained from the parents. A standardized questionnaire with previously validated questions was used to obtain information on socio-demographic characteristics of children in the study. A pilot test on 20 survey respondents (5 per each village) was conducted to test for reliability of questionnaire in this population, and the reliability index was 94%. The ethics board at the corresponding author's institution approved the study.

Measures

The study outcome included prevalence estimates of measles infection among survey respondents in four villages of Kanpur district in Uttar Pradesh, India. The exposure variables included demographic characteristics such as age, gender, number of people living in the house hold, and education and occupation status of parents and/or family members, socio-economic characteristics such as family socio-economic status, access to health care and transportation. Other components in the survey questionnaire included whether or not vaccinated with measles vaccination, compliance with the Universal Immunization Program (UIP) and presence or absence of complications of measles infection. Except for number of people living in a household, remaining variables in the study are categorical in nature and recoded accordingly for regression analysis.

Data analysis

The data were analyzed for descriptive and inferential statistics. Descriptive statistics were conducted for frequencies, percentage and proportions. Bivariate analyses to establish the relationship between the dependent variable, measles infection, and each independent variable were conducted for chi-square statistics for categorical variables and Kruskal Wallis test for continuous variables. Additionally, bivariate analyses were conducted to estimate the relationship between prevention of measles, which includes measles vaccination and vitamin A supplementation, and socio-economic and demographic characteristics of survey respondents. Finally, a multivariable logistic regression analysis using a socio-ecological theoretical framework was conducted to delineate the key socio-economic and demographic characteristics for measles infection among survey respondents.

The equation for the logistic regression model used in this research study is as follows:

$$logit\ (pi) = \ln\left(\frac{pi}{1-pi}\right) = \beta_o\ +\ \beta_1\, x_{1,i} + \cdots + \beta_k x_{k,i}$$

where,

pi represents the probability of measles infection among study participants,

β_0 represents intercept co-efficient,

$\beta_1, \beta_2 \ldots B_k$ represent co-efficients of the variables,

$X_1, X_2 \ldots X_k$ represent independent variables

Both adjusted odds ratio (AOR) and 95% confidence intervals (CIs) were reported. The significance level was set at 95% (p value ≤ 0.05). Data were managed and analyzed using SAS/STAT software, Version 9.1 (SAS Institute Inc., Cary, North Carolina, USA).

Results

Sample characteristics

The study included a total of 2,615 children. A majority of the study participants were between the ages 1 and 2 years (44.6%), males (61.6%), had low-to-average income status (85.5%) and visited primary health care center for regular health check-ups and visits (62.4%). Out of 12,615 study participants, 315 had measles infection during the past 12 months with a prevalent attack rate of 12.1%, and 6.5% of them developed complications such as fever with rash (see Table 1). Less than quarter of study participants were either vaccinated with measles vaccination or supplemented with vitamin A to prevent complications.

Table 1: Characteristics of survey respondents

Characteristics	Number (n)	Proportion
Age (in months)		
Less than 12	504	19.3
12 - 24	643	24.6
25 – 36	627	24.0
37- 48	480	18.3
48 - 60	361	13.8
Gender		
Male	1,610	61.6
Female	1,005	38.4
Parental education		
Only mother	248	9.5
Only father	725	27.7
Both	400	15.3
None	1,242	47.5
Socioeconomic status		
Upper	35	1.3
Upper middle	41	1.6
Middle	303	11.6
Lower middle	1,194	45.7
Lower	1,042	39.8
Health Care Access		
Community Health Center	983	37.6
Primary Health Center	1,632	62.4
Transportation	993	38.0
Any health camps	1,130	43.2
Grade of Malnutrition		
Normal	659	25.2
Grade 1	1,409	53.9
Grade 2	408	15.6
Grade 3	139	5.3
Measles infection		
Yes	315	12.1
No	2,300	87.9

Measles Prevention		
Measles vaccination	602	23.0
Vitamin A supplementation	605	23.1
Complications		
Fever with rash	170	6.5
Ear infections	25	0.9
Pneumonia	10	0.4
GI complications	3	0.1

Key determinants of measles infections or attacks

Table 2 illustrates the key socio-economic and demographic characteristics associated with measles infection among study participants. While status of malnutrition, especially grades 2 and 3 were significantly associated with increased infection, measles vaccination, compliance with UIP decreased the likelihood of measles infection among study participants. When compared to those with normal nutrient intake, it was found that those with grade 3 malnutrition had increased relative odds of measles infection by around nine times [AOR 8.73, 95% CI (4.68, 16.30)]. Similarly, those with grade 2 nutrition were around three times [AOR 2.77, 95% CI (1.75, 4.380] associated with increased measles infection. On the contrary, those being vaccinated with measles vaccination and compliance with UIP had significantly decreased relative odds of measles infection by 97% [AOR 0.03, 95% CI (0.01, 0.08)] for measles vaccination and AOR 0.03, 95% CI (0.02,0.05)], respectively. While socio-economic status was inversely associated with likelihood infection; meaning with decrease in income status, the likelihood for infection increases, the association is not statistically significant. Apparently, though not significant it was found that parental educational status and health care access for study participants was positively associated with measles infection.

Table 2: Key determinants of measles infection

Characteristics	Adjusted OR (95% CI)
Female (vs. male)	0.74 (0.52, 1.06)
Parental education	
Only mother	2.05** (1.30, 3.24)
Only father	1.01 (0.68, 1.48)
Both (vs. none)	1.54 (0.99, 2.37)
Socioeconomic status	
Upper middle	0.30 (0.03, 2.98)
Middle	0.23 (0.05, 1.11)
Lower middle	0.86 (0.21, 3.56)
Lower (vs. upper)	1.13 (0.27, 4.64)
Number of People in household	1.01 (0.86, 1.19)
Primary Health Center (vs. community health center)	0.98 (0.71, 1.34)
Transportation (vs. lack of transportation)	1.01 (0.74, 1.38)
Any health camps (vs. no health camps)	0.75 (0.55, 1.02)
Grade of Malnutrition	
Grade 1	0.83 (0.56, 1.23)
Grade 2	2.77** (1.75, 4.38)
Grade 3 (vs. normal)	8.73*** (4.68, 16.30)
Measles vaccination (vs. no vaccination)	0.03*** (0.01, 0.08)
Compliance with UIP (vs. lack of compliance)	0.03*** (0.02, 0.05)

** p <0.05 ** p <0.01 *** p <0.0001*
¬ OR means Odds Ratio, ‖ CI means Confidence Intervals
UIP means Universal Immunization Program

Measles vaccination and vitamin A supplementation

Table 3 illustrates the measles prevention, i.e., role of measles vaccination and vitamin A supplementation in the study population. It was found that survey respondents who were vaccinated with measles vaccine also received the vitamin A supplementation, as the frequencies and percentages were similar across different group characteristics. The study participants who were protected from measles infection were mostly males (75%), between 1-3 years (47%), have access to primary health care center (61%) and belong to lower middle (46%) and low (37%) socio-economic status.

Table 3: Measles vaccination and vitamin A supplementation

Characteristics	Measles Vaccination n= 602	Vitamin A Supplementation n= 605
Age (in months)		
Less than 12	101 (16.8)	102 (16.8)
12 - 24	146 (24.2)	148 (24.5)
25 – 36	136 (22.6)	136 (22.5)
37- 48	104 (17.3)	104 (17.2)
48 - 60	115 (19.1)	115 (19.0)
Gender		
Male	450 (74.7)	453 (74.9)
Female	152 (25.3)	152 (25.1)
Parental education		
Only mother	44 (7.3)	44 (7.3)
Only father	187 (31.1)	190 (31.4)
Both	95 (15.8)	95 (15.7)
None	276 (45.8)	276 (45.6)
Socioeconomic status		
Upper	7 (1.2)	7 (1.2)
Upper middle	10 (1.7)	10 (1.6)
Middle	85 (14.1)	85 (14.0)
Lower middle	275 (45.7)	277 (45.8)
Lower	225 (37.3)	226 (37.4)
Health Care Access		
Community Health Center	233 (38.7)	233 (38.5)
Primary Health Center	369 (61.3)	372 (61.5)
Transportation	233 (38.7)	233 (38.5)
Any health camps	258 (42.9)	259 (42.8)

Discussion

In a cross-sectional study of more than 2500 children aged 5 years and under, we found that the attack rate of measles was

12%, and malnutrition played a significant role in measles infection along with other socio-demographic and economic characteristics. In addition, we found that measles vaccination and compliance with UIP was associated with 97% reduction in measles attacks, signifying the importance of vaccination and the need for appropriate surveillance system to obtain and sustain 100% immunization coverage in rural disadvantaged communities in India.

Measles is a worldwide public health issue among children aged 5 years and under. This issue garners prominence in developing countries with low health care access and high mal- or under-nutrition including India. Although vaccination coverage and surveillance mechanisms to counter the measles outbreak exist, several rural communities with low socioeconomic status do not reach the coverage goals as set by the millennium development goals [13,14], and one such community include the Kanpur district in Uttar Pradesh where sanitation, malnutrition, health care access, over-crowding are highly prevalent. In this study, the overall measles incidence is 12%, which is almost similar to other studies [10,15]. We found that children with grade 2 and grade 3 malnutrition were at increased odds of measles attacks. Several studies have identified the role of malnutrition in measles incidence and outbreaks, with increased severity of measles-related complications. Previous studies have reported the severity of measles attacks and measles related complications including nutritional keratomalacia in malnourished children [16-19], signifying the importance of measles vaccination and vitamin A supplementation to prevent such complications [20-22]. In this study, we found that only a quarter of children received vitamin A supplementation, with a majority in low- and average- income group populations. In addition we found that 1-2 year olds constituted a higher proportion of supplements intake indicating the need for early vitamin A supplementation in children in rural disadvantaged communities [23]. Moreover, we found that children who received vaccination for measles or compliant with UIP had 97% reduced odds of measles infection, which implies the necessity for development of surveillance systems or networks to achieve 100% vaccination coverage with high compliance for UIP in children residing in these rural communities. Studies have reported that catch-immunization might have the potential to eliminate threat from measles attacks in school children [24].

The study is subject to limitations that merit discussion. The study is a cross-sectional in nature and limits establishment of causal relationships. In addition, the survey responses are self-reported and subject to recall bias. Future studies should be conducted to validate the self-reported responses with objective measures. Moreover, we used a convenient sample for the study, and a randomized cluster sampling technique might be an appropriate to minimize bias due to sampling. Furthermore, we obtained information on general vaccination coverage for measles, and no specific information was obtained on the number of doses, compliance, and seasonality. Despite these limitations the study findings highlight the need for immediate attention with respect to policies around vaccination coverage, addressing nutrition problems and vitamin A supplementation to meet the Millennium Development Goals.

Conclusion

In a cross-sectional study of 2615 children aged less than 5 years, we found that the measles attack rate is 12%, and malnutrition as the important factor associated with increased measles infections, and vaccination coverage and compliance with UIP as protective factor. Study results contribute to ongoing efforts in vaccination coverage in rural disadvantaged communities in India, where the measles morbidity and mortality is higher compared to other communities.

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Authors' Contributions

All authors contributed to research design, data collection, drafting article and analysis of data.

Competing Interest

The authors declare that they have no competing interests.

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