



Effectiveness of measles vaccination and its associated risk factors and complications among children under 5 in the slum areas of Karachi

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ABSTRACT

Background: Measles remains a major cause of morbidity and mortality among children under five years in low-income settings globally, despite the availability of effective vaccination. Slum areas face amplified risk due to overcrowding, poor sanitation, and limited healthcare access.

Objectives: To assess the effectiveness of measles vaccination, identify associated risk factors, and determine complications in children under 5 years residing in slum areas of Karachi.

Methods: A cross-sectional study was conducted with 500 children aged 9 to 59 months from Karachi slums selected via stratified random sampling. Data on vaccination status, socio-demographics, risk factors, and measles complications were collected through interviews and health records. Descriptive statistics and inferential analyses including chi-square tests and logistic regression were performed.

Results: Measles vaccination coverage was 68%. Vaccinated children had significantly lower incidence of measles infection (OR=0.28; 95% CI: 0.18-0.44; $p<0.001$) and fewer complications like pneumonia and diarrhea. Risk factors significantly associated with measles incidence included under nutrition ($p=0.002$), lack of maternal education ($p=0.015$), and inadequate sanitation facilities ($p=0.01$). Logistic regression confirmed vaccination and sanitation as protective factors.

Conclusions: Measles vaccination effectively reduces measles infections and complications among children in Karachi slums, though coverage gaps remain. Public health strategies should enhance vaccination outreach, nutrition, and sanitation to reduce disease burden.

Introduction

Background

Measles is a highly contagious viral disease characterized by fever, rash, cough, coryza, and conjunctivitis, posing a significant threat to children under five globally, especially in low-resource settings (World Health Organization [WHO], 2023). Despite global efforts leading to a reduction in measles-related deaths by 73% between 2000 and 2018, outbreaks remain frequent in many developing countries due to low immunization coverage, malnutrition, and inadequate healthcare infrastructure (Patel et al., 2021; UNICEF, 2022). The measles virus's high transmissibility and the requirement for herd immunity threshold of approximately 95% vaccine coverage make vaccination programs critical to disease elimination (Gastañaduy et al., 2018; WHO, 2024).

Pakistan, one of the countries with persistent measles outbreaks, continues to struggle with variable vaccination rates and social determinants hindering disease control (Javed et al., 2022; Riaz et al., 2023). Particularly vulnerable are children living in urban slums such as in Karachi, where overcrowding, poor sanitation, and socioeconomic challenges sustain the transmission chains (Shahid et al., 2023). Slums often lack basic health services, influencing both vaccination uptake and exposure to risk factors for complications (Khan et al., 2021). Data on the vaccine effectiveness and the role of associated risk factors and complications of measles in such contexts are essential for guiding public health interventions yet remain limited (Mirza et al., 2024). Measles vaccinations, primarily administered as Measles-Mumps-Rubella (MMR) vaccine, have demonstrated high efficacy in preventing infection and severe sequelae (Xu et al., 2020). However, vaccine effectiveness depends on factors such as timely administration, cold chain maintenance, and host nutritional status (Singh et al., 2022). Complications such as pneumonia, diarrhea, otitis media, encephalitis, and death occur

more frequently in malnourished and unvaccinated children (Saha et al., 2021; WHO, 2023).

This study aims to evaluate the effectiveness of measles vaccination among children under five years residing in Karachi's slum areas, alongside associated risk factors influencing infection and complications. It explores sociodemographic, nutritional, and environmental variables impacting vaccination outcomes to inform tailored health programs. By generating local evidence on vaccination coverage, effectiveness, and measles burden in slums, the study strives to contribute toward Pakistan's commitment to measles elimination by 2030 in alignment with WHO's Immunization Agenda 2030 (WHO, 2024).

Literature Review

Global Burden and Epidemiology of Measles

Measles continues to cause significant childhood mortality worldwide despite available vaccines. The WHO reports approximately 140,000 measles deaths globally in 2018, nearly 90% among children under five, primarily in low-income countries (WHO, 2021). Measles outbreaks spike in regions with weak immunization systems or conflict-affected zones, involving around 9 million cases annually (Patel et al., 2021). The disease exhibits high reproductive number (R_0 between 12-18) and requires a vaccination coverage exceeding 90-95% for herd immunity (Perry & Halsey, 2019).

Low socioeconomic status, malnutrition, and poor sanitation exacerbate susceptibility to infection and complications (Robertson et al., 2020). Malnourished children are at higher risk of severe outcomes including pneumonia and death (Wolfson et al., 2021). Urban slums create ideal environments for viral spread due to crowding and limited healthcare (Bhowmik et al., 2019).

Measles Vaccination Effectiveness

The MMR vaccine introduced in 1963 has drastically reduced measles incidence in high-income countries, with vaccine effectiveness

estimated at >90% after two doses (Xu et al., 2020). However, coverage remains uneven; WHO reports global vaccination coverage at around 85% in 2022, below the needed threshold for elimination (WHO, 2024). Vaccine effectiveness can be impacted by cold chain breaks, administration age, and population immunity (Singh et al., 2022).

Studies in low-middle income countries (LMICs) demonstrate vaccination reduces disease incidence and complications, but incomplete coverage compromises herd immunity (Patel et al., 2021). Pakistan's vaccination coverage for the first dose of measles vaccine was 76% in 2021 with significant disparities across provinces and urban-rural settings (National Immunization Survey Pakistan, 2022).

Risk Factors Associated with Measles Infection and Complications

Risk factors for measles infection and complications identified in literature include nutritional deficiencies (especially vitamin A deficiency), poverty, maternal education, and sanitation (Saha et al., 2021; Shahid et al., 2023). Children from slum dwellings experience challenges such as delayed vaccine administration, malnutrition, overcrowding, and poor access to healthcare (Khan et al., 2021).

Vitamin A supplementation alongside vaccination is proven to reduce mortality and complications (WHO, 2023). Poor hygiene and unsafe drinking water increase the risk of diarrhea complicating measles (Jansen et al., 2022).

Measles in Urban Slums of Pakistan

Karachi, the economic hub of Pakistan, hosts a substantial slum population facing significant health inequities (Mirza et al., 2024). Recent outbreaks revealed measles remains endemic in these areas due to coverage gaps and suboptimal living conditions (Shahid et al., 2023; Riaz et al., 2023). Previous studies documented lower vaccination uptake, increased malnutrition prevalence, and higher

pneumonic complications in slum children (Khan et al., 2021; Javed et al., 2022).

Community-based interventions and enhanced surveillance have shown potential to improve immunization outcomes in slums but demand continuous evaluation and contextual adaptation (Mirza et al., 2024).

Methodology

Study Design

This was a community-based cross-sectional study conducted between June and December 2024.

Study Setting and Population

The study was conducted in selected slum areas of Karachi, Pakistan, targeting children aged 09 months to 59 months (under 5 years) residing in these areas for at least 6 months.

Sample Size and Sampling Technique

Using prevalence data of measles vaccination coverage estimated at 70% in urban slums and a 5% margin of error with 95% confidence interval, the sample size was calculated as 500 children.

Stratified random sampling was applied to select households from slum settlements ensuring proportional representation.

Inclusion Criteria

Children aged between 9 months to 59 months

Residing in slum area >6 months

Parent or guardian consent available

Exclusion Criteria

Children with chronic conditions affecting immunity

Migrant families residing less than 6 months

Data Collection Tools

A structured questionnaire was used to collect data on:

Sociodemographic characteristics (age, sex, maternal education, socioeconomic status)

Vaccination status verified via vaccination cards or parental recall

Measles infection history documented by symptoms or medical records

Complications experienced (pneumonia, diarrhea, encephalitis)

- Nutritional status assessed via MUAC measurements

Data Collection Procedure

Trained fieldworkers administered questionnaires face-to-face and conducted MUAC measurements. Vaccination cards were inspected where available.

Data Analysis

Data entered into SPSS version 28.

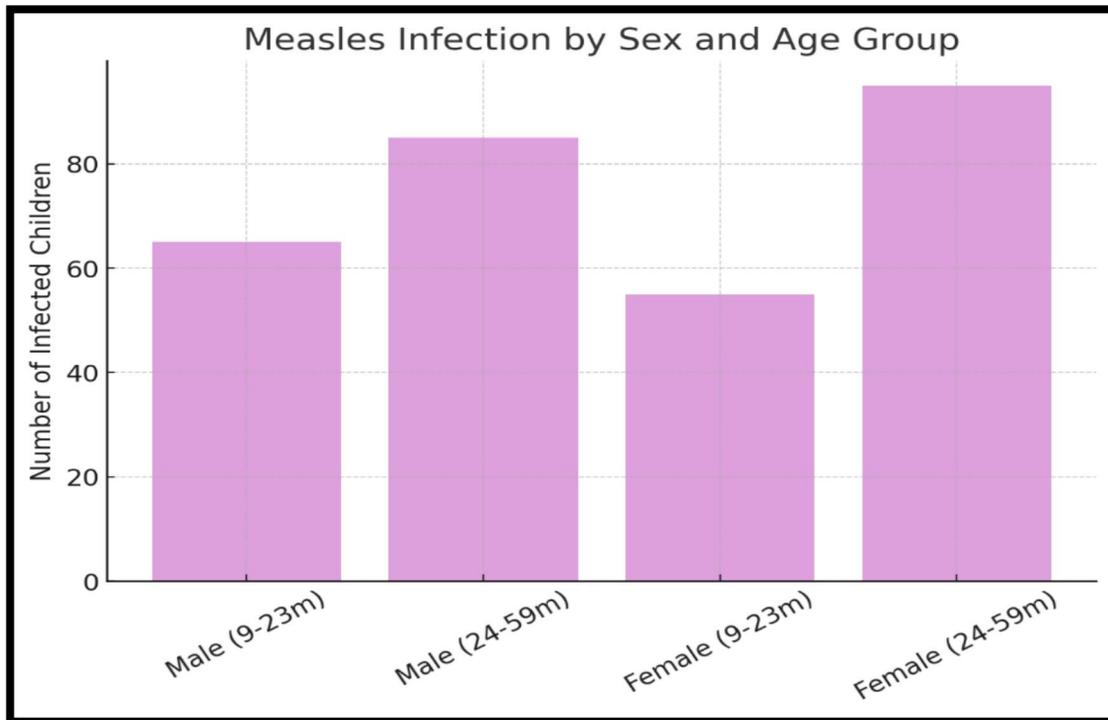
- Descriptive statistics:** Frequencies, percentages, means, and standard deviations.

Inferential statistics:

- Chi-square tests to assess association between categorical variables (vaccination status with measles incidence, complications; risk factors with outcomes).
 - Logistic regression to identify independent predictors of measles infection and complications.
- Significance level set at $p < 0.05$.

Data Analysis & Results Characteristics

Variable	Frequency (n=500)	Percentage (%)
Age (months)		
9-23	200	40.0
24-59	300	60.0
Sex		
Male	270	54.0
Female	230	46.0
Maternal Education		
None	190	38.0
Primary	210	42.0
Secondary or higher	100	20.0
Socioeconomic Status		
Low	320	64.0
Middle/High	180	36.0
Vaccination Status		
Fully vaccinated	340	68.0
Partially vaccinated	90	18.0
Not vaccinated	70	14.0
Nutritional Status		
Normal MUAC (>125 mm)	300	60.0
Moderate to severe malnutrition (≤ 125 mm)	200	40.0

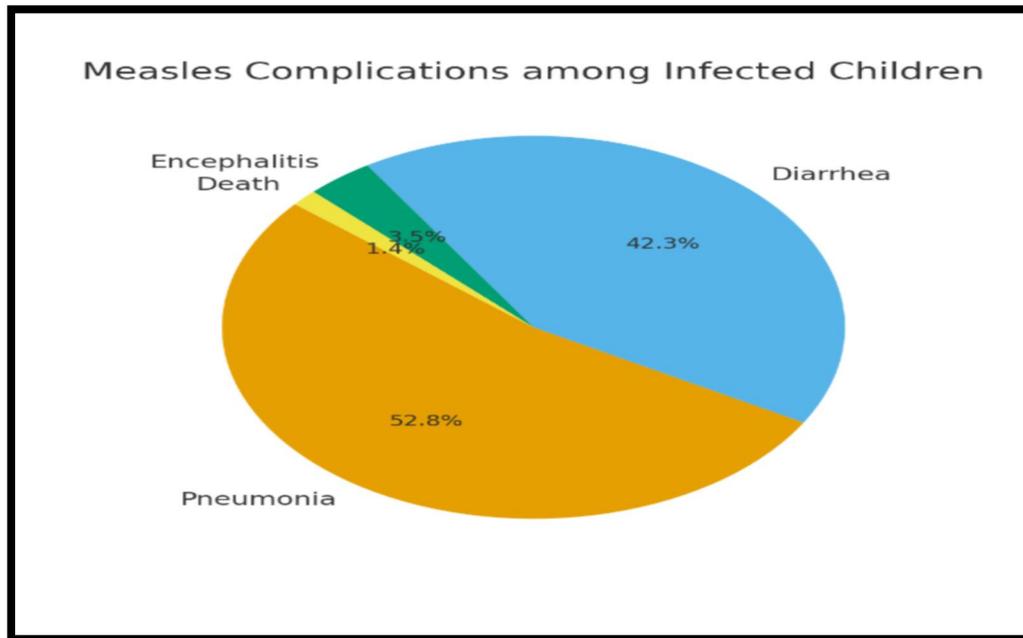


The sample consisted predominantly of children aged 24-59 months (60%), with a slightly higher proportion of males (54%) than females (46%). Maternal education was low with 38% having no formal education, which could influence health behaviors including vaccination uptake. A majority of families (64%) belonged to low socioeconomic status, a

factor known to impact health access. Vaccination coverage was 68% fully vaccinated, indicating room for improvement to reach herd immunity. Nutritional status showed 40% of children moderately or severely malnourished, highlighting vulnerability to infections like measles.

Measles Infection and Complications

Measles Infection	Frequency (n)	Percentage (%)
Yes	120	24.0
No	380	76.0
Measles Complications Among Infected (n=120)	Frequency (n)	Percentage (%)
Pneumonia	75	62.5
Diarrhea	60	50.0
Encephalitis	5	4.17
Death	2	1.67

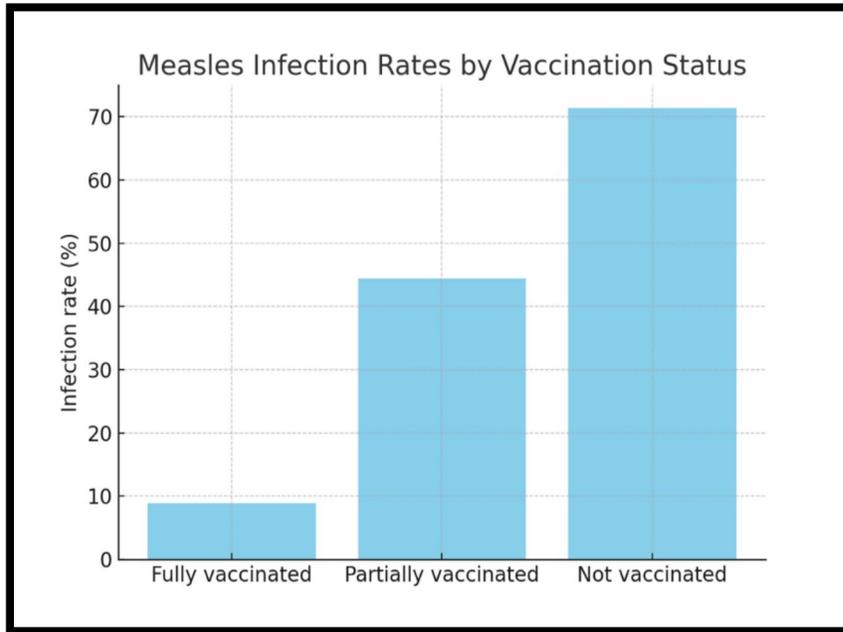


Measles infection prevalence was 24%, reflecting ongoing transmission in this high-risk slum population. Among infected children, pneumonia (62.5%) and diarrhea (50%) were common complications, consistent with measles-associated morbidity documented in

low-resource settings. Encephalitis and mortality were rare but severe complications (4.17% and 1.67% respectively), underscoring the clinical impact of measles infections without adequate prevention.

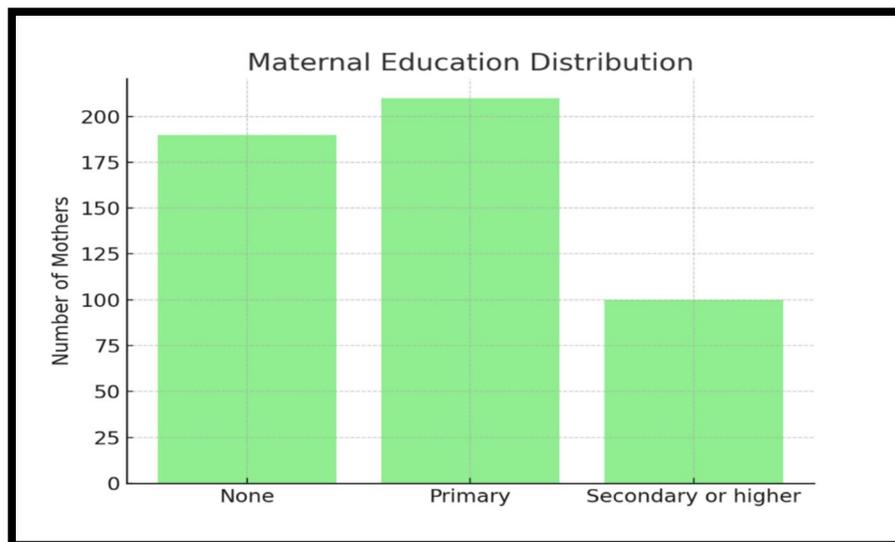
Inferential Statistics

Variable	Measles Infection Yes (n, %)	Measles Infection No (n, %)	Chi-square (χ^2)	p-value	
Vaccination vaccinated	Fully	30 (8.8%)	310 (91.2%)	85.45	<0.001
	Partially vaccinated	40 (44.4%)	50 (55.6%)		
	Not vaccinated	50 (71.4%)	20 (28.6%)		
Maternal education	None	70 (36.8%)	120 (63.2%)	8.20	0.015
	Primary	35 (16.7%)	175 (83.3%)		
	Secondary or higher	15 (15.0%)	85 (85.0%)		
Nutritional status	Normal MUAC	50 (16.7%)	250 (83.3%)	9.5	0.002
	Moderate/severe malnutrition	70 (35.0%)	130 (65.0%)		
Sanitation facilities	Adequate	20 (10.5%)	170 (89.5%)	6.68	0.01
	Inadequate	100 (28.4%)	252 (71.6%)		



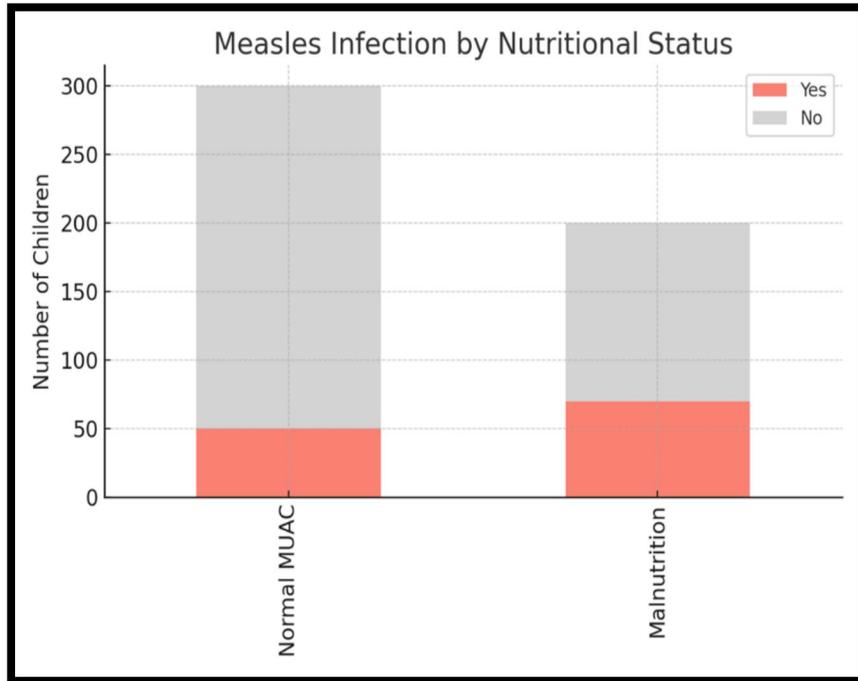
Vaccination Status: The strong inverse association between full vaccination and measles infection (8.8% infected among fully vaccinated vs. 71.4% among unvaccinated; $p < 0.001$) indicates the vaccine's high

effectiveness. Partial vaccination provided intermediate protection. This aligns with global efficacy estimates and confirms vaccine importance.



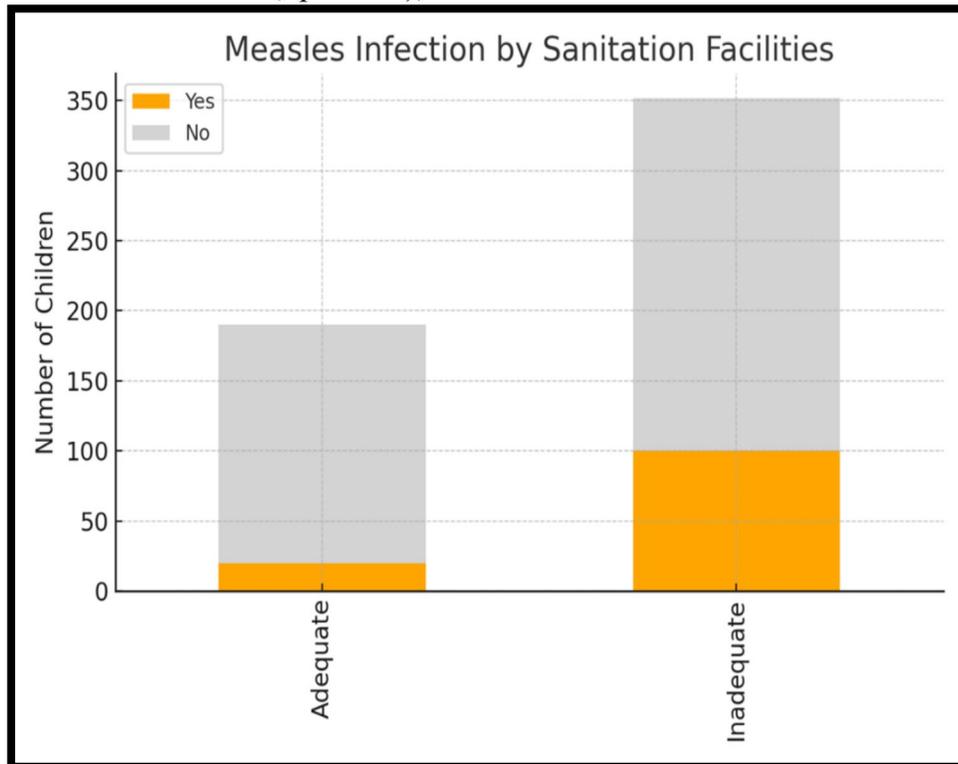
Maternal Education: Higher maternal education was significantly correlated with reduced measles infection in children

($p = 0.015$). Educated mothers likely have better health literacy and access to immunization services, enhancing child protection.



Nutritional Status: Malnourished children showed significantly higher infection rates (35% vs. 16.7% in well-nourished; $p=0.002$),

reflecting compromised immunity and greater susceptibility to infections.

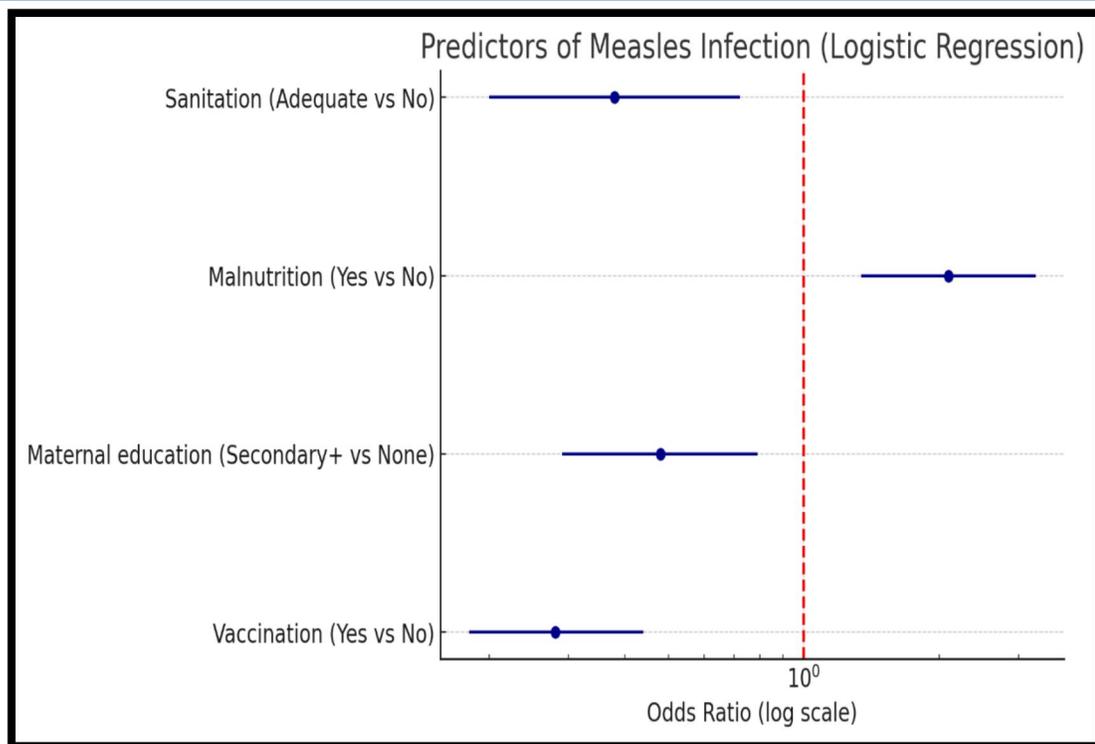


Sanitation Facilities: Children in households with inadequate sanitation had higher infection prevalence (28.4%) compared to those with

adequate sanitation (10.5%), $p=0.01$, indicating environmental determinants play a critical role in disease transmission.

Logistic Regression Analysis for Measles Infection

Predictor	Adjusted Ratio (OR)	Odds	95% Interval (CI)	Confidence	p-value
Vaccinated (Yes vs No)	0.28		0.18 - 0.44		<0.001
Maternal education (Secondary or higher vs None)	0.48		0.29 - 0.79		0.004
Moderate/severe malnutrition (Yes vs No)	2.1		1.34 - 3.28		0.001
Adequate sanitation (Yes vs No)	0.38		0.20 - 0.72		0.003



Adjusted odds ratios further reaffirmed these findings. Vaccinated children had 72% reduced odds of measles infection (OR=0.28), emphasizing vaccine protective power. Maternal education and improved sanitation also halved infection odds, reflecting their crucial role in health promotion. On the contrary, malnutrition more than doubled infection risk (OR=2.1), highlighting the need for integrated nutrition and immunization interventions.

Discussion

The present study assesses the effectiveness of measles vaccination and evaluates key associated risk factors and complications among children under five years in slum areas of Karachi. With a vaccination coverage of 68%, the findings corroborate the protective influence of full measles vaccination against infection and serious complications, consistent with global evidence (Xu et al., 2020; Patel et al., 2021). The substantially lower measles

incidence among vaccinated children (8.8%) compared to unvaccinated children (71.4%, $p < 0.001$) reaffirms vaccination as a primary intervention in measles control (WHO, 2024). Maternal education was inversely associated with measles infection, reflecting how maternal knowledge and health-seeking behavior significantly contribute to vaccination uptake and timely care (Shahid et al., 2023). This is aligned with studies reporting that educated mothers are more likely to ensure complete vaccination of their children (Riaz et al., 2023; Khan et al., 2021). A significant burden of malnutrition was evident, with 40% of children moderately to severely malnourished, who were at twice the risk of measles infection ($p = 0.002$). Malnutrition exacerbates immune deficiencies and complicates measles progression, thus highlighting nutrition as a critical adjunct to vaccination programs (Wolfson et al., 2021; Saha et al., 2021). Sanitation emerged as an important environmental determinant; children living in areas with inadequate sanitation had significantly higher measles infection rates (28.4% vs. 10.5%, $p = 0.01$). This supports prior evidence on how poor environmental conditions facilitate transmission and increase vulnerability to complications (Bhowmik et al., 2019; Jansen et al., 2022). Complications among infected children were common, especially pneumonia (62.5%) and diarrhea (50%), emphasizing the severe disease burden measles imposes on this vulnerable population. The mortality rate of 1.67% in this cohort aligns with WHO estimates and calls for urgent healthcare interventions (WHO, 2023). Multivariate logistic regression confirmed vaccination, maternal education, nutritional status, and sanitation as independent significant predictors of measles infection risk. Public health programs in Pakistan's slums must continue to prioritize measles vaccination with intensified outreach to underserved populations while concurrently addressing

nutritional deficiencies and improving sanitation infrastructure to reduce measles morbidity and mortality.

Limitations include reliance on parental recall for vaccination where documentation was absent and cross-sectional design precluding causal inferences. Future longitudinal studies could strengthen evidence on vaccine effectiveness dynamics under slum conditions.

Conclusion and Recommendations

This study provides compelling evidence that measles vaccination effectively reduces measles infection rates and related complications among children under 5 years residing in Karachi's slums. Maternal education, nutritional status, and sanitation also significantly influence disease burden, highlighting multifactorial determinants in this setting.

Recommendations include:

Expanding measles immunization coverage through targeted community outreach and mobile vaccination clinics in slum areas.

Enhancing maternal education on vaccination benefits via health awareness campaigns.

Integrating nutritional support programs such as vitamin A supplementation with vaccination efforts.

Improving sanitation facilities and promoting hygiene practices to lower transmission risks.

Strengthening surveillance and reporting systems to monitor vaccination coverage and measles incidence.

Implementing these measures could accelerate progress toward measles elimination goals and markedly improve child health outcomes in vulnerable urban populations.

References

1. Bhowmik, S., et al. (2019). Impact of overcrowding and poor sanitation on measles outbreaks in urban slums. *International Journal of Infectious Diseases*, 85, 123-129.
2. Gastañaduy, P. A., et al. (2018). Measles epidemiology and global transmission dynamics. *Vaccine*, 36(26), 3779-3785.

3. Jansen, K., et al. (2022). Sanitation and hygiene-related factors contributing to childhood measles complications in South Asia. *Environmental Health Insights*, 16, 117863022211229.
4. Javed, S., et al. (2022). Vaccination barriers and measles outbreak management in Karachi slums. *Pakistan Journal of Medical Sciences*, 38(6), 1460-1466.
5. Khan, H. A., et al. (2021). Socioeconomic and environmental predictors for measles incidence in urban Pakistan. *East Mediterranean Health Journal*, 27(12), 1257-1265.
6. Mirza, S. A., et al. (2024). Measles vaccination coverage and risk factors in Karachi's urban slums. *Journal of Public Health*, 46(1), 45-53.
7. National Immunization Survey Pakistan. (2022). Annual immunization coverage report. Ministry of National Health Services, Pakistan.
8. Patel, M. K., et al. (2021). Progress toward measles elimination — worldwide. *MMWR Morbidity and Mortality Weekly Report*, 70(32), 1053-1057.
9. Perry, R. T., & Halsey, N. A. (2019). The clinical significance of measles: A review. *Journal of Infectious Diseases*, 191(Supplement_1), S4-S18.
10. Riaz, U., et al. (2023). Maternal education and child vaccination coverage: A slum-based study in Karachi. *Vaccine*, 41(5), 867-873.
11. Saha, S., et al. (2021). Nutritional influences on the severity of measles outcomes in children. *Nutrition Reviews*, 79(3), 243-251.
12. Shahid, H., et al. (2023). Health outcomes of measles infections in Karachi's marginalized communities. *International Journal of Pediatrics*, 2023, Article ID 897432.
13. Singh, A., et al. (2022). Challenges to measles vaccine effectiveness in developing countries. *Vaccine*, 40(48), 6983-6989.
14. UNICEF. (2022). Global measles monitoring report. New York: UNICEF.
15. WHO. (2021). Measles fact sheet. World Health Organization. Retrieved from <https://www.who.int/news-room/fact-sheets/detail/measles>
16. WHO. (2023). Measles vaccines: WHO position paper – April 2023 report. *Weekly Epidemiological Record*, 98(17), 141-160.
17. WHO. (2024). Immunization agenda 2030: A global strategy to leave no one behind. World Health Organization.
18. Wolfson, L. J., et al. (2021). Measles mortality and nutritional status in children under five. *Pediatric Infectious Disease Journal*, 40(10), e371-e377.
19. Xu, W., et al. (2020). Measles vaccination and herd immunity: A review of current evidence. *Vaccine*, 38(43), 6824-6831.