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Original article

Epidemiological studies on measles in children in the District Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan

Muhammad Ashraf Khan *

Elementary and Secondary Education Department, Khyber Pakhtunkhwa, Pakistan

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ABSTRACT

Background: Measles is a highly contagious childhood airborne disease caused by a virus. Age- and sex-based monthly prevalence of measles in children aged ≤15 years was determined in the district of Dera Ismail Khan in 2021. **Methods:** This was a cross-sectional study. The unconsolidated and uncomputerized data was obtained from the admission register of the isolation ward in the Women and Children's Hospital Dera Ismail Khan. **Results:** Out of the total 1903 measles cases in children, males accounted for 58.8% and females (41.2%). Age group (>1y≤2y) showed 28.1% prevalence of measles, followed by 27.3% (>6m≤1y), 25.7% (>2y≤5y), 9.9% (>5≤10y), 7.6% (≤6 m), and 1.3% (>10y≤15y). April indicated the highest prevalence (20.1%) of measles, followed by March (19.0%), February (14.4%), May (11.5%), January (9.7%), June (5.5%), and December (5.2%). The remaining months showed each ≤3.9% prevalence of the disease. A relatively higher number of measles cases were recorded from February through May, and all age groups showed ≤12.0% relative prevalence in January and during June-December over months. The highest mortality due to the disease occurred in April (15), followed by March (11). **Conclusions:** The age-wise and month-wise/seasonal-wise variation in the prevalence of measles existed and showed a peak season of measles, winter through early summer. Males showed a higher prevalence of disease than females in all months/all age groups except a few cases. The present study helps to design a strategy for the control of measles in the study area.

Introduction

One of the most contagious viral infections in children is measles, or rubeola, which is one of the most infectious killer diseases, particularly in children globally, and accounts for 2.6 million annual deaths worldwide [1]. Measles is an acute viral respiratory illness. The disease is symptomized after 10–14 days of being infected with fever, dry cough, runny nose, sore throat, conjunctivitis, Koplik's spots, and skin rashes, and usually affects children of <5 years [2, 3]. The disease epidemic occurs mostly in the spring and winter and is endemic globally [4]. Worldwide, 870,000 cases of measles and 208,000 deaths due to the disease were reported in 2019 [3]. Measles mortality reduced by 78% between 2000 and 2008 globally due to high-level vaccination programs [2].

Pakistan is among the top five countries, in addition to Yemen, Tanzania, India, and Nigeria, with the largest number of children not vaccinated against measles in 2021 [1]. The country is ranked fourth and eighth highest in the prevalence of measles cases globally in 2022 [5], and in 2023 [6], respectively, indicated a decrease in the prevalence

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* *Corresponding author:* Muhammad Ashraf Khan
E-mail address: *muhammadashraf_k@yahoo.com*

of measles in Pakistan. Pakistan contributes 65% of the total measles prevalence among 22 nations in the Eastern Mediterranean region, and the disease is endemic in the country [1, 7]. An estimated 6,749 cases of measles with an incidence rate of 29 per million are reported in Pakistan [6, 8].

The World Health Organization (WHO) established the Expanded Program on Immunization (EPI) in 1974 for the free vaccination of children globally and to improve vaccination coverage of a recommended set of childhood vaccines [9, 10]. EPI in Pakistan provides two doses of measles vaccine to all children in Pakistan, the first dose at 9 months of age, followed by the 2nd dose during the second year of life. The WHO Eastern Mediterranean Region (EMR) passed a resolution in 1997 for the member countries to eliminate measles [11, 12] and adopted the Vaccine Action Plan 2016–2020 in 2015 to achieve measles elimination in the EMR [13].

This is the first study conducted to determine the prevalence of measles in Dera Ismail Khan (D.I. Khan) as well as the first study undertaken in Pakistan to know the gender-based, comprehensive, month-wise, and age-wise prevalence of measles in Pakistan. The study helps policymakers adopt comprehensive preventive measures for the disease and early vaccination of children, creating awareness about the disease in the local population to help reduce child mortality due to measles atleast in D.I. Khan.

Materials and methods

Study area

District D.I. Khan is situated on the west bank of the Indus River at its junction with the Gomal River in the province of Khyber Pakhtunkhwa (KP), Pakistan. The district covers an area of 9334 km^2 with 1.8 million population (Digital Census 2023 in Pakistan). The district is bounded on the east by the Bhakkar and Dera Ghazi Khan districts of Punjab. Fertile alluvial plains characterize eastern portions of the district along the Indus River, while lands farther from the river consist of clay soil cut by ravines from rainfall.

Patient diagnosis

Measles patients visited the District Head Quarter (DHQ) hospital D.I. Khan with symptoms of the disease diagnosed through a blood test (IgM test) for the detection of the measles virus. ELISA Diagnostic Kit (ELK Biotechnology: USA) is used for quantitative measurement of IgM.

Data collection and organization

During the cross-sectional study, the in-patient data was collected from the admission register of the isolation ward in the district women and children hospital (D.I. Khan). The data in the hospital record was neither in consolidated form nor computerized. In addition, the age of some children was not recorded. Therefore, the author worked hard and made a consolidated age- and sex-based monthly report of the disease. The data were divided into six age categories, including ≤6 m, >6m ≤ 1y, >1y ≤ 2y, >2y ≤ 5y, >5 ≤ 10y, and >10y ≤ 15y.

Ethical committee approval and consent to participate

The study was approved by the director of DHQ Teaching Hospital D.I. Khan, also in charge of Women and Children Hospital D.I. Khan with reference No. 2754/MD, date May 30, 2022. The author willingly and voluntarily participated in the study.

Statistical analysis

The chi-square test for the association between months and gender is not significant (Pearson X-squared = 12.874, df = 11, p-value = 0.3016), while this test for the association between months and age is significant (Pearson X-squared = 100.69, df = 44, p-value < 0.0001). The Cochran–Mantel–Haenszel test for the association between months and gender, while controlling for age categories, is also not significant (Cochran-Mantel-Haenszel M^2 = 6.3419, df = 4, p-value = 0.175).

Results

Prevalence of measles and children mortality

The overall data showed age/month-wise variation as well as seasonal variation in the prevalence of measles in D.I. Khan **(Table 1)**. The highest prevalence of measles was reported in April (20.1%) followed by March (19.0%) during spring, and the lowest was in September (2.0%), i.e., in the late summer. Age-based prevalence of measles showed the highest prevalence of 28.1% in the age group (>1y≤2y), followed by 27.3% (>6m≤1y), 25.7% (>2y≤5y), 9.9% (>5≤10y), 7.6% (≤6 m), and 1.3% (>10y≤15y). Male children accounted for 58.8%, while female children acconted for 41.2% of overall measles cases **(Table 1)**. Similarly, overall male children also showed a higher prevalence of the disease than female children in all months of the year. Further, for all months, males also demonstrated a higher prevalence of the disease than

female children in the age groups (>6m≤1y and >2y≤5y) and revealed mostly higher prevalence than females in the remaining age groups **(Table 1)**.

Measles showed a higher prevalence in children of age groups (>6m≤1y, >1y≤2y, and >2y≤5y) and comparatively lower rates in the remaining age groups **(Table 1)**. A total of 57 measles cases including males (28) and females (29), were officially recorded as age unknown **(Table 1)**. All 61 children (sex and age not recorded) recorded died of measles in the isolation ward during the study period **(Table 1),** and the highest mortality was recorded in April (15), followed by March (11), while the lowest was in September (0).

Monthly prevalence of measles in different age groups

Age groups (>1y≤2y) showed the highest prevalence of measles in January, May, and July **(Figure 1)**. Similarly, the age group (>6m≤1y) revealed the highest prevalence of measles in April, June, and October through December. While the age group (>2y≤5y) demonstrated comparatively the highest prevalence of the disease during February-March and during August-September. Both the age groups (>6m≤1y and >2y≤5y) were comparable during January through Octobe except June. All the three age groups (>6m≤1y, >1y≤2y and >2y≤5y) showed more or less comparability during February-April. July and October. Similarly age groups (≤6 m and >5≤10y) demonstrated comparable results in April, during June-July and November. **(Figure 1)**.

Relative percentage prevalence of measles over months in different age groups

The age group (≤6 m) showed **(Figure 2)** the highest relative prevalence in April (24.8%), followed by February (24.1%) and March (17%) over months. Age group (>6m≤1y) indicated the highest prevalence (19.7%) in April, followed by 16.9% in March and February (14.3%). The age group (>1y≤2y) revealed the highest prevalence of 18.7% in April, followed by March (18.3%), May (17.1%), February (13.7%), and January (11.7%). The age group (>2y≤5y) demonstrated the highest prevalence, 20.7% in March, followed by April (20.3%) and February (15.2%). The age group (>5≤10y) showed the highest prevalence of 23.5% in April, followed by March (23.0%), May (13.7%), and the age group (>10y≤15y) showed the highest prevalence of 20% each in April and May, followed by March (16.0%) and October (12.0%). All the age groups showed a <10.0% relative prevalence in January and during June-December, except the age group (>1y≤2y) in January (11.7%) and age group (>10y≤15y) in October (12.0%) **(Figure 2)**.

Table 1. Prevalence of measles in children and measles-induced mortality in the District Dera Ismail Khan in 2021

Months	Total age known cases		Age groups (months or years)												T°	T*		T (T°+ T*)	Mortality
			≤6 m		>6m≤1y		>1y≤2y		>2y≤5y		>5≤10y		>10y≤15y						
	M	F	M	F	M	F	M	F	M	F	M	F	M	F		M	F		
Jan	106	68	4	1	30	16	36	25	25	21	11	4	0	1	174	6	4	184	5
Feb	160	109	17	17	50	22	45	26	37	35	10	8	1	1	269	1	4	274	5
Mar	205	143	18	6	56	29	52	43	57	41	20	22	2	2	348	7	6	361	11
Apr	201	174	19	16	54	45	55	42	50	46	19	24	4	1	375	3	4	382	15
May	124	91	7	4	23	15	50	39	27	20	13	12	4	1	215	1	2	218	7
Jun	57	44	4	3	24	18	8	12	15	9	6	2	0	0	101	2	2	105	4
Jul	49	26	2	3	13	6	14	9	13	7	6	1	1	0	75	0	0	75	3
Aug	22	18	1	1	7	6	3	1	8	6	3	4	0	0	40	1	0	41	1
Sep	28	10	0	0	10	2	6	3	8	5	3	0	1	0	38	1	0	39	0
Oct	36	25	1	0	10	9	8	10	12	4	3	1	2	1	61	0	0	61	1
Nov	37	22	3	1	14	8	12	5	5	4	3	2	0	2	59	1	4	64	4
Dec	61	30	9	4	28	8	9	7	11	8	4	2	0	1	91	5	3	99	5
Tot	1086	760	85	56	319	184	298	222	268	206	101	82	15	10	1846	28	29	1903	61

Note: **M** for male and **F** for female, **m** for the month, and **y** for the year. **T** for total measles cases (both age-known and age-unknown), and **T°** for total age-known cases, while **T*** age-unknown cases. The chi-square test for the association between months and gender is not significant ("p-value" = 0.3016). While this test for the association between months and age is significant ("p-value" < 0.0001) (Tukey's HSD, p = 0.05).

Figure 1. Monthl percentage prevalence of measles in different age groups of children in the D.I. Khan in 2021

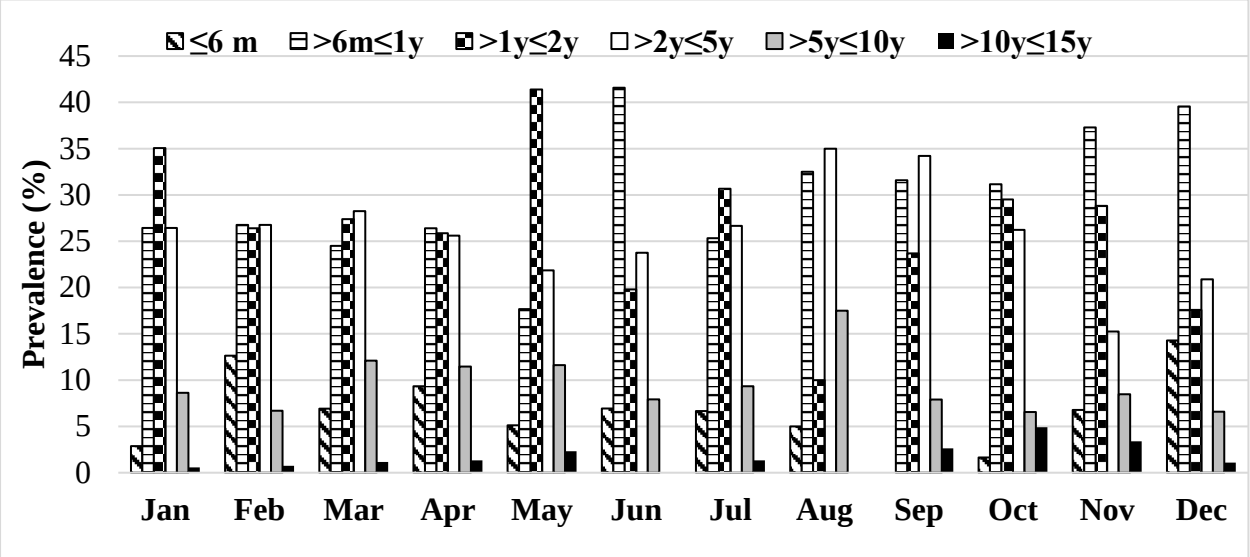
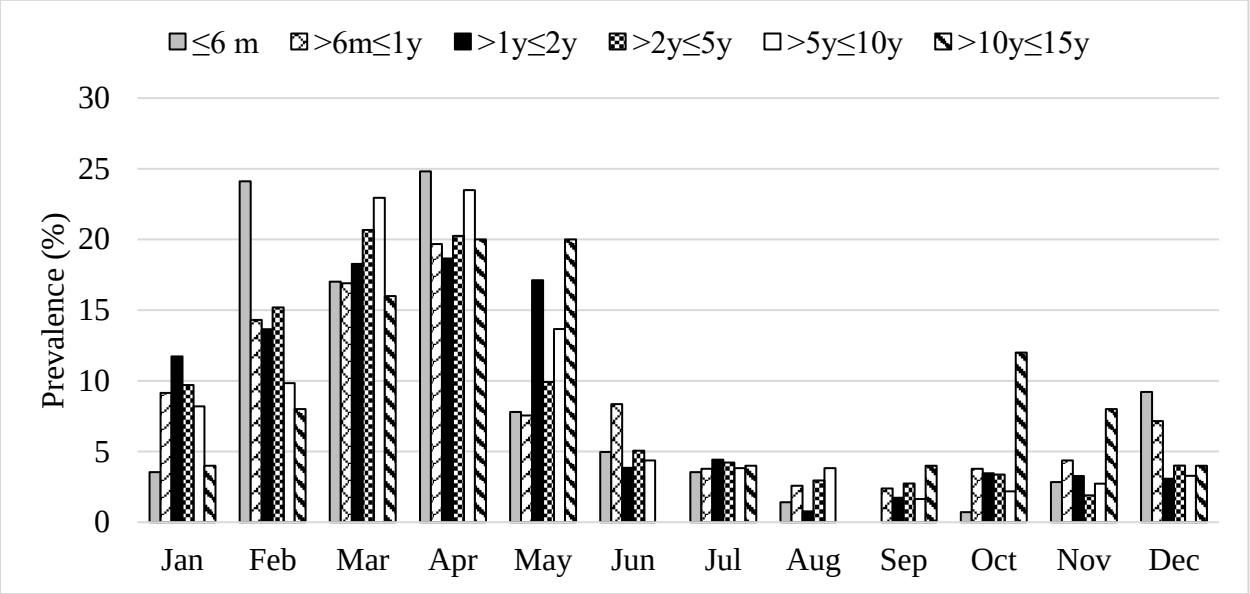


Figure 2. Relative percentage prevalence of measles over months in different age groups in children in the D.I. Khan in 2021.



Discussion

One of the major threats to the well-being of humans and their performance is health-related problems globally [14, 15]. Communicable diseases are the highest cause of death in Pakistan [14]. The high burden of measles in Pakistan is because of the very low measles vaccination coverage for both the 1st dose and booster dose in the country [16]. D.I. Khan showed the highest prevalence of measles (>200 cases) in Pakistan as of 4 June 2021 [1]. Sufficient literature is available on the age-based prevalence of measles. Nevertheless, literature on the comprehensive study of the gender/age-based as well as month-wise/seasonal prevalence of the disease is not available in Pakistan. Therefore the present study is unique in Pakistan.

All age groups showed variation in the prevalence rate of measles from January through December **(Table 1 & Figure 1)**. The higher prevalence of measles in male children (58.8%) than in female children in the current study was supported by Younas et al. [17], Aurangzeb et al. [18], and Khan et al. [19], as they reported males demonstrated a higher prevalence of measles (55.4%), (60.5%), and (53.1%), respectively. Age group (>1y≤2y) showed the highest prevalence, including males (57.3%) and females (42.7%) during the study period, followed by >6m≤1y and

>2y≤5y **(Table 1)**. Fazil [4] reported measles is commonly found in children <5 years of age. Younas et al. [17] also recorded the highest prevalence of measles (46%) in children aged 1≤3 y, followed by 3-4 years. Khan et al. [19] found males accounted for 53.1% of measles prevalence in overall children aged ≤15 years and also reported the highest prevalence of measles (44%) in children aged 3-5 years, followed by 33.6% in those aged (1≤3 y), 12.1% (5-8 y), 6.2% (8-15 y) and 4.2% (<1y) in Bannu.

The higher prevalence of measles **(Table 1 & Figure 1)** in age groups (>6m≤1y, >1y≤2y, and >2y≤5y) is because children of this age have comparatively less immunity power as well as more exposed and vulnerable to the measles compared to children of higher ages who developed more immunity power and are less exposed to measles. The comparatively lower number of measles cases (141) found in children aged ≤6 m **(Table 1)** was due to high immunity developed against the disease by the fact that most mothers can feed their babies in the first few months after their birth in the study area. Male children demonstrated a higher prevalence/risk of measles than female children **(Table 1)** because their higher engagement/social interaction outside their homes contributes relatively more to the prevalence of the disease than females who are mostly confined to their homes. Information on whether the children admitted into the wards were previously vaccinated or not in the present study is not available.

The study showed a relatively higher prevalence and gradual increase in measles from January through April **(Table 1)** is strongly supported by Rana et al. [1] who reported a similar increase in the prevalence of measles from January through April (2021) in Pakistan. Further it showed an overall gradual reduction of measles cases from June through September 2021 and comparatively lower rates of measles during June-December in all age groups in D.I. Khan.

The highest prevalence of measles in Pakistan was recorded in D.I. Khan in 2021 [1] because of a lack of healthcare facilities, no proper sanitation, overcrowdedness, use of unsafe drinking water, unhygienic conditions of life, increase in pollution, malnutrition, parents reluctant to vaccinate their children, complacency, overpopulation, and public ignoring visit to health centers [20-23].

Almost three million children do not undergo the entire course of vaccination and become vulnerable to life-threatening diseases each year in Pakistan because of a lack of parental awareness and education. Low literacy rates, socio-economic disparities, and cultural and religious beliefs have made parents doubtful about vaccinations in Pakistan [24]. Further, some of the other factors for the failure of the EPI of the government of Pakistan against measles may be because of corrupt practices, the influx of unvaccinated refugees, security issues among health workers, poor training regarding vaccine administration, and the ineffective vaccine [25].

Conclusions

Age-wise, month-wise, and seasonal variation in the prevalence of measles in children aged ≤15 years occurred in D.I. Khan in 2021. The disease revealed a relatively higher prevalence from January through May than in the remaining months. Overall each of the three age groups (>6m≤1y, >1y≤2y, and >2y≤5y) demonstrated higher prevalence compared to the remaining age groups and lowest in the age group >10y≤15y. All months showed a higher prevalence of measles in males and all age groups demonstrated a higher or mostly higher prevalence of the disease in males than females. Different age groups showed variation in both monthly/seasonal prevalence as well as in the peak prevalence of the disease. Similarly, age groups also showed variation in the relative prevalence of measles over months. Overall 61 children (sex and age not recorded) died of measles in the study period.

Limitations of the study

The study did not investigate factors responsible for the high prevalence of the disease in the study area and why. Further research is needed to explain, why the study district has the highest measles rate in 2021 in Pakistan.

Recommendations

Proper vaccination, safe drinking water use, sanitation, living standards, and a hygienic lifestyle will certainly reduce the rate of disease in the study area.

Conflict of interest

None

Financial Disclosure

None

Authors' contributions

I am the sole author of this manuscript as solely contributed to the concept and design of study and acquisition of data, interpretation of data, drafting of the article and revising it critically for important intellectual content; and final approval of the version to be published. While, Jos Feys, a senior research fellow at KU Leuven University (Catholic University of Leuven, Belgium) analyzed the data.

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