ORIGINAL ARTICLE

Determinants of measles cases with complications in Selangor, Malaysia from year 2014 to 2023 using e-Measles registry

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ABSTRACT

Introduction: Measles is a highly contagious vaccine-preventable disease endemic to Malaysia. This study aimed to determine the determinants of measles cases with complications in Selangor, Malaysia, from 2014 to 2023.

Materials and Methods: This was a cross-sectional study of confirmed measles cases in Selangor using the secondary surveillance database, Sistem Maklumat Siasatan Measles (SM2). The data were reviewed from April 2024 to June 2024. All registered measles cases in Selangor from 2014 to 2023 were analyzed to determine the determinants of measles cases with complications, the type of measles complications, and the characteristics of those who developed measles complications.

Results: Of 3074 measles cases, 479 (15.6%) developed measles complications, of which diarrhea was the most common complication (87.6%), followed by pneumonia (11.6%), otitis media (0.6%), and subsclerosing panencephalitis (0.2%). The majority of those who developed measles complications were aged less than one year old (42.1%) and 1–6 years (31.4%). The significant determinants of measles cases with complications were non-Malaysian nationality (aOR: 2.1, 95% CI: 1.44, 3.05), cases from urban areas (aOR: 1.8, 95% CI: 1.22, 2.76), cases that fulfilled the measles clinical case definition (aOR: 2.1, 95% CI: 1.59, 2.76), cases with a history of contact with other measles cases (aOR: 4.4, 95% CI: 3.43, 5.67), cases from the measles outbreak (aOR: 1.5, 95% CI: 1.10, 2.19), and cases that were hospitalized (aOR: 5.6, 95% CI: 4.49, 7.07).

Conclusion: Strengthening immunization coverage, particularly among high-risk groups, such as non-Malaysians and young children, is essential. Enhanced surveillance, targeted health education, and improved outbreak response strategies are crucial to reduce measles complications in the community. Further research is needed to explore additional factors contributing to measles complications and to assess the effectiveness of intervention measures.

KEYWORDS:
Measles, measles cases with complication, registry, hospitalization, Selangor

INTRODUCTION

Measles is a highly contagious acute viral disease characterized by fever, maculopapular rashes, cough, runny nose, and conjunctivitis.[1,2] Despite the availability of a safe and effective vaccine, measles remains a significant global health threat, particularly in regions with low vaccination coverage.[3] The disease primarily affects unvaccinated or under-vaccinated children under five years old, leading to severe complications such as diarrhea, pneumonia, otitis media, encephalitis, and blindness.[3] In 2021 and 2022, measles caused an estimated 128,000 and 136,000 deaths, respectively, worldwide.[3] The recent surge of 56,634 cases and four deaths in the WHO European Region in early 2024 highlights the ongoing risk exacerbated by disruptions to routine immunization and healthcare services during the COVID-19 pandemic.[4] Strengthening vaccination programs and ensuring healthcare access are crucial to achieving measles elimination.[5]

Previously, Malaysia had proposed the elimination of measles by the year 2010, but the target year for elimination was pushed to 2025 due to increased measles incidence from 6.1 per million population in 2013 to 52.1 per million population in 2017.[6] There was increased in incidence of measles especially in Selangor from 3.4 per million population in 2021 to 73.1 per million population in 2023.[7] A higher incidence of measles will result in a higher risk of complication, particularly in children and immunocompromised individuals.[8] Identifying factors that contribute to measles cases with complications help to comprehend the overall impact of measles on public health and provide insight into the overall burden of the disease in Selangor.

While previous studies in Malaysia have primarily focused on the incidence and outbreak of measles, research on the specific determinants of measles cases with complications, particularly in urban settings and among non-Malaysian populations, is limited. Given the increasing trend of measles incidence in Selangor, this study aimed to determine the determinants, trends, and types of measles cases with complications in Selangor, Malaysia, from 2014 to 2023. Identifying the determinants of measles cases with complications will help in early detection and management of the disease, leading to better patient outcomes.

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MATERIALS AND METHODS

Study Design

This cross-sectional study used secondary data obtained from e-Measles, also known as Sistem Maklumat Siasatan Measles (SM2), an online database system administered by the Ministry of Health, Malaysia to record all activities of investigation and registration of measles cases. All suspected measles cases registered in the e-Notification system (online infectious disease notification system for Ministry of Health, Malaysia) will be auto-entered into the e-Measles system for further investigation and case registration.

Location and Study Population

This study was conducted in the Selangor State Health Department. Selangor was selected because, compared to other states in Malaysia, Selangor recorded the second highest incidence of measles, 73.1 per million population in 2023.[9] Data collection for this study was carried out from April to May 2024. The study population comprised individuals diagnosed with and reported to have measles in the e-Measles system in Selangor from 2014 to 2023.

Data Collection and Sampling Method

The inclusion criteria were confirmed measles cases in Selangor, including both Malaysian and non-Malaysian, registered in the e-Measles system from 2014 to 2023. This was based on the Ministry of Health's Case Definitions for Infectious Diseases in Malaysia, which defined a confirmed measles case as a laboratory-confirmed case (presence of measles-specific IgM antibodies or presence of measles virus in clinical samples using culture or molecular techniques) or one that met the clinical case definition (any person with fever and maculopapular and either cough, coryza, or conjunctivitis) epidemiologically linked to a laboratory-confirmed case.[1] Exclusion criteria included vaccine-associated measles (VAM), imported measles cases, and cases with incomplete data specifically pertaining to MMR vaccination status and risk factors. Imported measles cases were excluded from the study to maintain a focus on locally transmitted cases and to accurately assess the determinants of measles cases with complications to generate more relevant and specific insights for local health policy and intervention strategies. The sampling method used in this study was universal sampling of secondary data in the e-Measles system.

Operational definition

The outcome in this study, which is measles cases with complications, is defined as confirmed measles cases that were registered as any of the following complications in the e-Measles system: diarrhea, pneumonia, otitis media, or subacute sclerosing panencephalitis (SSPE). The independent variables in this study were divided into three main domains: socio-demographic, clinical-related, and vaccine-related factors. The urban area in this study is defined as gazette areas with their adjoining built-up areas, which had a combined population of 10,000 or more.[10] Apart from that, history of contact with other confirmed measles cases is defined as measles cases with epidemiologically linked with other confirmed measles cases within 21 days before the onset of rashes.[11] Measles outbreak is defined as the occurrence of two or more laboratory-confirmed cases of measles that are linked either epidemiologically or virologically, with the rash onset dates falling within a range of 7 to 21 days apart.[12] Vaccine-associated measles refers to a condition where a person experiences a rash illness, similar to measles, appearing 7 to 14 days after vaccination with a measles-containing vaccine, but without respiratory symptoms.[34]

Sample Size

The sample size for this study was determined using the OpenEpi software version 3.01. The calculation took into account the prevalence of measles cases with complications in Nigeria (31%), which was obtained from the study by Onoja et al.[13] To achieve a statistical power of 80% and significance level (alpha) of 0.05, a sample size of 329 was initially calculated. Considering the potential 20% rate of missing data, the minimum required sample size for this study was 395.

Data Analysis

The collected data were entered into SPSS software version 28.0. Data were summarized using median and interquartile range for continuous variables, and frequency and percentage for categorical variables. Univariate analysis was performed using a simple logistic regression. Only variables with a p-value <0.05 in simple logistic regression were selected for multiple logistic regression (binary) analysis to determine the determinants of measles cases with complications. Differences were considered statistically significant at a p-value of less than 0.05, and adjusted odds ratios (aOR) with 95% confidence intervals (CI) were calculated. All factors underwent an interaction check. Model fit was examined using the Hosmer-Lemeshow goodness of fit, which was considered a good fit with a p-value greater than 0.05. In addition, the Cox and Snell R-squared values were evaluated to further assess model fitness. Multicollinearity among the predictors was also assessed. Finally, the model's predictive accuracy was calculated by determining the percentage of area under the receiver operating characteristic (ROC) curve.

Ethics Approval

This study was registered in the National Medical Research Registry (Ref. No: NMRR ID-24-00319-TTL). Ethical approval for this study was obtained from the Medical Research Ethics Committee (Ref. No: 24-00319-TTL), and the Faculty Research Ethics Committee (Ref. No: 100 - FPR (PT.9/19) (FERC-EX-24-04)). The Selangor State Health Department granted permission to use data in the e-Measles registry for the purposes of this study. This study adhered to the Malaysian Code of Responsible Conduct in Research to ensure data confidentiality and compliance with ethical standards throughout the research. This study utilized anonymized, de-identified secondary aggregated data to prevent re-identification. This method preserves confidentiality and aligns with ethical research standards, thus eliminating the need for informed consent.

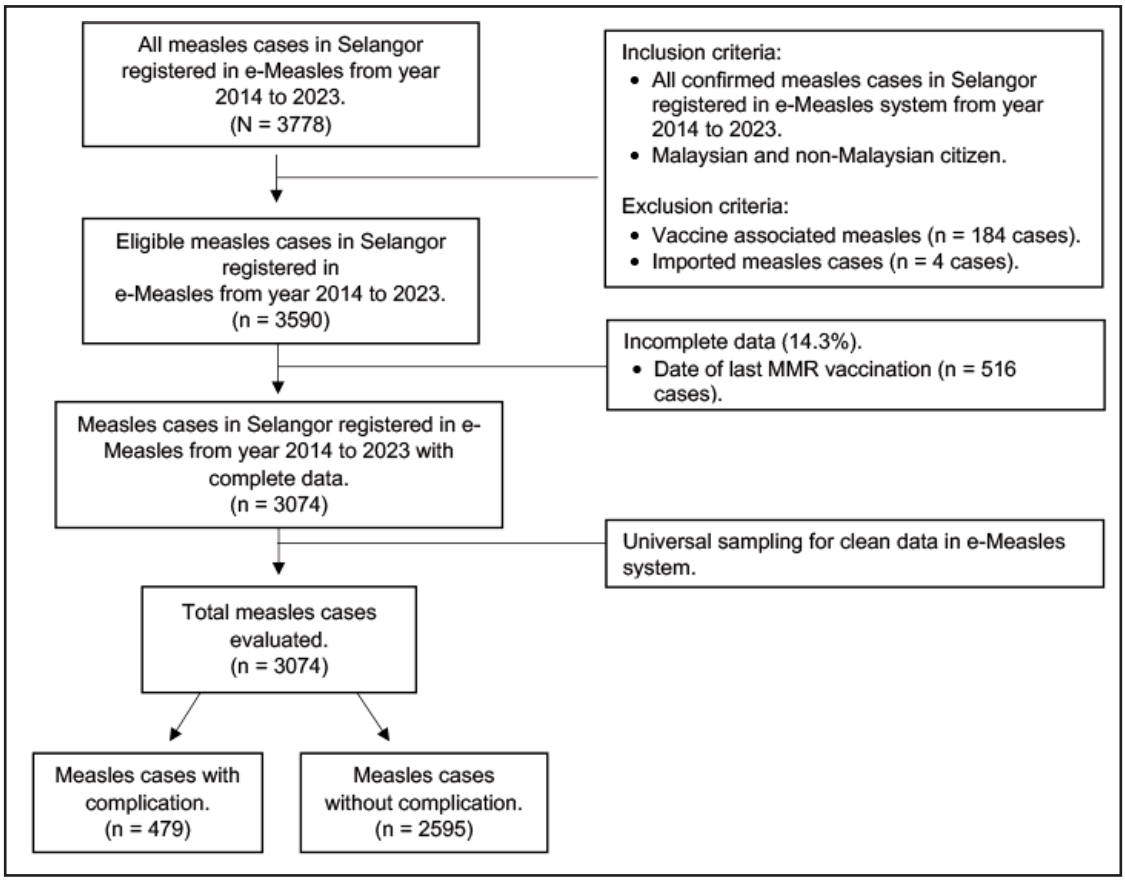

Fig. 1: Flow diagram of data extraction process and sampling.

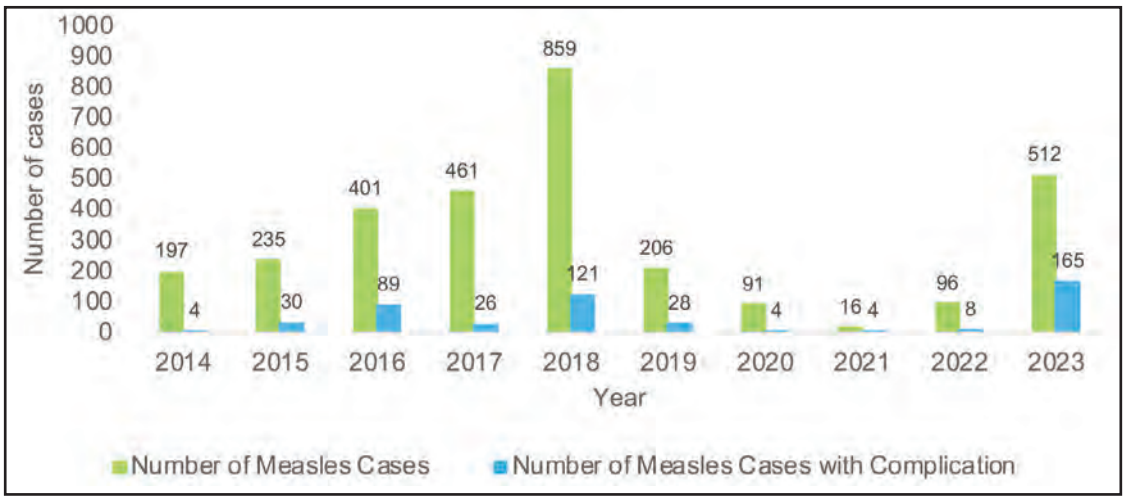

Fig. 2: Trend of measles cases and measles cases with complication in Selangor from year 2014 to 2023.

RESULTS

A total of 3778 confirmed measles cases were registered in Selangor from 2014 to 2023. After applying the exclusion criteria (vaccine-associated measles, imported measles cases, and cases with incomplete data), 3074 confirmed measles cases remained and were therefore included in the final analysis of this study (Fig.1). Among the 3074 measles cases, 479 (15.6%) were reported to have complications. The number of measles cases with complications showed a fluctuating trend from 2014 to 2023, ranging from 4 to 165 cases, with a peak in 2023 (Fig.2). Complications identified were diarrhea (87.6%), pneumonia (11.6%), otitis media (0.6%), and SSPE (0.2%).

Table I shows the sociodemographic characteristics of the measles cases with complications reported in Selangor from

Table I: Socio-demographic characteristic of measles cases with and without complication in Selangor from year 2014 to 2023 (N = 3074)

Variables	Total (N = 3074) n (%)[a]	Measles cases with complication (n = 479) n (%)[b]	Measles cases without complication (n = 2595) n (%) [b]
Socio-demographic factor			
Age (in years)			
<1 year old	1294 (42.1)	182 (38.0)	1112 (42.8)
1 to 6 years old	965 (31.4)	141 (29.4)	824 (31.8)
7 to 12 years old	287 (9.3)	54 (11.3)	233 (9.0)
13 to 17 years	93 (3.0)	14 (2.9)	79 (3.0)
≥18 years old	435 (14.2)	88 (18.4)	347 (13.4)
Gender			
Female	1414 (46.0)	209 (43.6)	1205 (46.4)
Male	1660 (54.0)	270 (56.4)	1390 (53.6)
Nationality			
Malaysian	2883 (93.8)	425 (88.7)	2458 (94.7)
Non-Malaysian	191 (6.2)	54 (11.3)	137 (5.3)
Ethnicity			
Chinese	95 (3.1)	15 (3.1)	80 (3.1)
Indian	71 (2.3)	18 (3.8)	53 (2.1)
Malay	2670 (86.9)	380 (79.3)	2290 (88.2)
Others	238 (7.7)	66 (13.8)	172 (6.6)
District			
Sabak Bernam	18 (0.6)	1 (0.2)	17 (0.7)
Gombak	496 (16.1)	11 (2.3)	485 (18.7)
Hulu Langat	772 (25.1)	62 (12.9)	710 (27.4)
Hulu Selangor	73 (2.4)	3 (0.6)	70 (2.7)
Klang	427 (13.9)	158 (33.0)	269 (10.4)
Kuala Langat	170 (5.5)	16 (3.3)	154 (5.9)
Kuala Selangor	75 (2.4)	11 (2.3)	64 (2.5)
Petaling	896 (29.1)	170 (35.5)	726 (28.0)
Sepang	147 (4.8)	47 (9.8)	100 (3.9)
Locality			
Rural	336 (10.9)	31 (6.5)	305 (11.8)
Urban	2738 (89.1)	448 (93.5)	2290 (88.2)

[a]Within total sample.
[b]Within the measles cases with complication or measles cases without complication group.

2014 to 2023. In terms of sociodemographic factors, the majority of measles cases with complications were age < one year old (38.0%), predominantly male (56.4%), Malaysian (88.7%), and Malay (79.3%). Other ethnicities included in this study comprised indigenous people and non-nationals of diverse socio-economic backgrounds who resided in Malaysia for various reasons. Most measles cases with complications were reported in Petaling District (35.5%), and a large proportion of cases were from urban areas (93.5%). Table II shows the clinical-related and vaccine-related characteristics of measles cases with complications reported in Selangor from 2014 to 2023. Regarding clinical background, majority of measles cases with complications fulfilled the measles clinical case definition (76.2%). Most measles cases with complications were sporadic (85.0%), while few cases were reported from measles outbreaks (15.0%). In terms of vaccine-related factors, 81 patients (16.9%) had complete MMR vaccination, 152 (31.7%) had incomplete MMR vaccination, 152 (31.7%) were not eligible for MMR vaccination, and 94 (19.6%) were not vaccinated. The median and interquartile range (IQR) of the duration between the date of the last MMR vaccination and the onset of rash for measles cases with complication was 16.5 months (57.0).

Table III shows the simple and multiple logistic regression analyses of the determinants of measles cases in Selangor from 2014 to 2023. Univariate analysis using simple logistic regression indicated that several factors were associated with complications in measles cases. These included age, nationality, ethnicity, locality, cases that fulfilled the measles clinical case definition, history of contact with other confirmed measles cases, transmission status, hospitalization status, and MMR vaccination status.

After adjusting for confounders using multiple (binary) logistic regression, the final predictors of increased odds of measles cases with complications were non-Malaysian nationality (aOR: 2.10; 95% CI: 1.44, 3.05), urban locality (aOR: 1.84; 95% CI: 1.22, 2.76), cases that fulfilled the measles clinical case definition (aOR: 2.09; 95% CI: 1.59, 2.76), history of contact with other confirmed measles cases (aOR: 4.41; 95% CI: 3.43, 5.67), hospitalized cases (aOR: 5.63; 95% CI: 4.49, 7.07), and cases from measles outbreaks (aOR: 1.55; 95% CI: 1.10, 2.19).

Table II: Clinical-related and vaccine-related characteristic of measles cases with and without complication in Selangor from year 2014 to 2023 (N = 3074)

Variables	Total (N = 3074) n (%) [a]	Measles cases with complication (n = 479) n (%) [b]	Measles cases without complication (n = 2595) n (%) [b]
Clinical-related factor			
Fulfil clinical case definition			
No	493 (16.0)	114 (23.8)	379 (14.6)
Yes	2581 (84.0)	365 (76.2)	2216 (85.4)
History of contact with measles cases			
No	2453 (79.8)	276 (57.6)	2177 (83.9)
Yes	621 (20.2)	203 (42.4)	418 (16.1)
Transmission status			
Sporadic	2744 (89.3)	407 (85.0)	2337 (90.1)
Outbreak	330 (10.7)	72 (15.0)	258 (9.9)
Hospitalization status			
No	2218 (72.2)	215 (44.9)	2003 (77.2)
Yes	856 (27.8)	264 (55.1)	592 (22.8)
Vaccine-related factor			
MMR vaccination status			
Complete vaccination	684 (22.3)	81 (16.9)	603 (23.2)
Incomplete vaccination	1073 (34.9)	152 (31.7)	921 (35.5)
Not eligible	955 (31.1)	152 (31.7)	803 (30.9)
Not vaccinated	362 (11.8)	94 (19.6)	268 (10.3)
MMR dose received			
2	684 (22.3)	81 (16.9)	603 (23.2)
1	1073 (34.9)	152 (31.7)	921 (35.5)
0	1317 (42.8)	246 (51.4)	1071 (41.3)
Type of health facility providing MMR vaccination (n = 1757)			
Government	1651 (94.0)	214 (91.8)	1437 (94.3)
Private	106 (6.0)	19 (8.2)	87 (5.7)
Duration between date of last MMR and onset of rash (months) [c]	2.0 (26.0)	16.5 (57.0)	1.0 (21.0)

[a]Within total sample.
[b]Within the measles cases with complication or measles cases without complication group.
[c]Median (IQR)

DISCUSSION

The main objective of this study was to determine the determinants of measles cases with complications in Selangor, Malaysia from 2014 to 2023. Based on a representative cross-sectional sample of measles cases in Selangor (N = 3074), significant factors associated with increased odds of measles cases with complications included non-Malaysian nationality, cases from urban localities, cases that fulfilled the measles clinical case definition, cases with a history of contact with other confirmed measles cases, cases from measles outbreaks, and cases that were hospitalized. Age, ethnicity, and MMR vaccination status were identified as statistically significant confounding factors. No significant association was observed between the study outcome with respect to sex, district, number of MMR vaccination doses received, type of health facility providing the MMR vaccination, duration between the date of the last MMR vaccination, and onset of rash.

The higher incidence of complications in 2023 and the lower incidence of complications in 2017, as shown in Figure 2, could be attributed to heightened awareness and surveillance, leading to more thorough reporting of complications, while 2017 might have had underreporting. The increasing trend of measles cases with complications in Selangor post-pandemic COVID-19 was due to measles outbreaks involving schools and pre-schools in 2023.[14] The possible reason for the occurrence of measles outbreaks is reduced MMR vaccination coverage as well as the high measles R naught of 12 to 18, predisposed to the spread of measles infection.[15] This is similar to a study conducted in Nigeria, which reported that the high frequency of outbreaks in Nigeria contributed to an increased incidence of measles, resulting in a higher risk of measles complications.[16] The majority of measles complications reported in this study were diarrhea followed by pneumonia, otitis media, and SSPE, which is similar to a study conducted in Jerusalem.[17]

In this study, non-Malaysian nationality was significantly associated with measles cases with complications, which could be attributed to the distinct socioeconomic barriers faced by non-Malaysians. These barriers include legal concerns, financial status, language barriers and vaccination status.[18] In addition, measles vaccinations in Malaysia have been provided for free to Malaysian citizens under the National Immunization Program (NIP) since the 1950s.[19] This led to poor measles vaccination coverage among this vulnerable population. The association between non-Malaysian nationality and measles cases with complications can be linked to a complex interplay of socioeconomic factors, and addressing these barriers through targeted interventions, culturally sensitive approaches, and equitable

Table III: Analyses of determinants of measles cases with complication in Selangor from year 2014 to 2023 (N = 3074)

Variables	cOR (95% CI) [a]	p-value [a]	aOR (95% CI) [b]	p-value [b]
Socio-demographic factor				
Age (in years)				
<1 year old	1	ref.	1	ref.
1 to 6 years old	1.04 (0.82, 1.32)	0.714	0.96 (0.73, 1.26)	0.792
7 to 12 years old	1.41 (1.01, 1.97)	0.042 *	1.17 (0.80, 1.73)	0.409
13 to 17 years	1.08 (0.60, 1.95)	0.792	0.79 (0.41, 1.51)	0.482
≥18 years old	1.54 (1.16, 2.05)	0.002 *	1.08 (0.79, 1.49)	0.61
Gender				
Female	1	ref.		
Male	1.12 (0.92, 1.36)	0.258		
Nationality				
Malaysian	1	ref.	1	ref.
Non-Malaysian	2.28 (1.63, 3.17)	<0.001 *	2.10 (1.44, 3.05)	< 0.001 *
Ethnicity				
Chinese	1	ref.	1	ref.
Indian	1.81 (0.84, 3.90)	0.13	1.50 (0.65, 3.44)	0.336
Malay	0.88 (0.50, 1.55)	0.67	0.98 (0.53, 1.79)	0.95
Others	2.04 (1.10, 3.80)	0.024 *	1.95 (0.98, 3.86)	0.054
District				
Sabak Bernam	1	ref.		
Gombak	0.38 (0.04, 3.16)	0.375		
Hulu Langat	1.48 (0.19, 11.34)	0.703		
Hulu Selangor	0.72 (0.07, 7.44)	0.789		
Klang	7.98 (0.91, 75.74)	0.062		
Kuala Langat	1.76 (0.22, 14.15)	0.592		
Kuala Selangor	2.92 (0.35, 24.24)	0.321		
Petaling	3.98 (0.52, 30.11)	0.181		
Sepang	5.99 (0.73, 61.84)	0.074		
Locality				
Rural	1	ref.	1	ref.
Urban	1.92 (1.31, 2.82)	<0.001 *	1.84 (1.22, 2.76)	0.003 *
Clinical-related factor				
Fulfill clinical case definition				
No	1	ref.	1	ref.
Yes	1.82 (1.44, 2.31)	<0.001 *	2.09 (1.59, 2.76)	< 0.001 *
History of contact with measles cases				
No	1	ref.	1	ref.
Yes	3.83 (3.10, 4.72)	<0.001 *	4.41 (3.43, 5.67)	< 0.001 *
Transmission status				
Sporadic	1	ref.	1	ref.
Outbreak	1.62 (1.20, 2.12)	0.001 *	1.55 (1.10, 2.19)	0.011 *
Hospitalization status				
No	1	ref.	1	ref.
Yes	4.15 (3.39, 5.08)	<0.001 *	5.63 (4.49, 7.07)	< 0.001 *
Vaccine-related factor				
MMR vaccination status				
Complete vaccination	1	ref.	1	ref.
Incomplete vaccination	1.22 (0.92, 1.64)	0.162	0.89 (0.63, 1.25)	0.505
Not eligible	1.40 (1.05, 1.88)	0.020 *	1.16 (0.84, 1.61)	0.342
Not vaccinated	2.61 (1.87, 3.63)	<0.001 *	1.40 (0.96, 2.04)	0.073
MMR dose received				
2	1	ref.		
1	1.05 (0.72, 1.54)	0.773		
0	0.63 (0.39, 1.01)	0.059		
Type of health facility providing MMR vaccination				
Government	1	ref.		
Private	1.19 (0.71, 1.97)	0.499		
Duration between date of last MMR and onset of rash (months)	1.00 (1.00, 1.05)	0.052		

Note: cOR = crude odds ratio, aOR = adjusted odds ratio, CI = confidence interval, [a]simple logistic regression, [b]multiple logistic regression, *level of significance at α = 0.05. None of the 15 interactions were significant. No multicollinearity among the variables was detected in the final model. The Hosmer-Lemeshow goodness-of-fit test indicated a good model fit (p = 0.113). Pseudo R-square (Cox and Snell) = 19.4%. The area under the Receiver Operating Characteristic (ROC) curve was 76.9%. No influential outlier (Cook's influential statistics).

healthcare access is crucial to improving measles immunization coverage and reducing the burden of measles among non-Malaysian populations.

Apart from that, the odds of measles cases with complications among cases from urban areas were 1.84 compared to cases from rural areas, and this is similar to the study done by Aworabhi-Oki et al. (2020), who found that living in urban areas increased the risk of measles infection.[20] The possible reason is reduced MMR vaccine coverage occurred more in urban areas.[21] However, studies on situational analysis of measles cases with complications, especially in urban areas in Malaysia, remain inadequate. Most published studies and situational analyses have focused only on the number of measles cases and their incidence. It is essential to take action to reduce vaccine hesitancy and increase immunization coverage in urban areas. For example, widespread public education campaigns about vaccine safety and effectiveness should be part of strategies, particularly in urban areas where misinformation may be more common.[22]

Cases that fulfilled the measles clinical case definitions (i.e. cases that had a fever, maculopapular rash and one of the '3Cs' (cough, coryza or conjunctivitis) had 2.09 times higher odds of being measles cases with complication. Studies have shown that the clinical case definition has a high predictive value in diagnosing measles; for example, a study determining the measles clinical case definition in New York City reported the negative predictive value of the case definition at 98%.[23] Therefore, Ministry of Health Malaysia agreed on similar clinical case definitions, as most measles cases fulfilled this definition. Other than that, measles cases that fulfil the clinical case definitions need to be investigated thoroughly, as they are more likely to develop measles complications. Additionally, research has shown that cases meeting the clinical case definition for measles are more likely to have an IgM-positive measles virus, highlighting the significance of the clinical case definition in accurately diagnosing measles.[24]

In Selangor, the odds of measles cases with complications were four times if there was a history of contact with other confirmed measles cases, which is similar to a case-control study done in Ethiopia where people who had contact with measles cases within the last 21 days were 3.4 times more likely to get measles complications compared to those who were not in contact with measles cases.[25] Given that close contacts were the most susceptible group, the findings may be explained by the fact that measles is spread via respiratory droplets and the measles infectivity period is four days before and after the onset of rash.[26] This is in support of the public health preventive measures of keeping children home from daycare centers or schools if they are suspected of having measles. Isolation reduces the likelihood of contact and hence the risk of measles transmission. According to the Malaysian government, parents and other caregivers of children suffering from communicable diseases, such as measles, dengue fever, malaria, chickenpox, diphtheria, and hand foot and mouth (HFMD) disease, are eligible for quarantine leave.[27] This particular work leave facilitates isolation while also minimizing the caregiver's burden.

Moreover, this study found that cases of measles outbreaks were significantly associated with measles cases with complications. Previous study done in Mongolia also had shown the significant association between measles outbreaks and measles complications.[28] During measles outbreaks, vaccination status plays a vital role in determining the risk of complications for example, cases that were not vaccinated were much more likely to develop complications from the disease.[29] The measles vaccination might reduce the chance of complications and the severity of the disease, even if it may not provide full protection against infection.[30] Apart from that, measles outbreaks and subsequent complications have been strongly associated with factors such as vaccine hesitancy and low vaccination coverage.[31] Consequently, in Malaysia, the MMR vaccination continues to be an essential intervention for lowering the risk of complications and lessening the impact of measles outbreaks.

In terms of hospitalization status, inpatient cases were significantly associated with measles cases and complications, with an increased odds of 5.63 times compared to outpatient cases. Several studies have highlighted the association between inpatient cases and measles complications compared to outpatient cases. For example, hospitalized patients with measles tend to have more severe cases with complications, as indicated by a study in the United States.[32] Additionally, a study conducted in Italy reported that a significant proportion of hospitalized measles patients developed complications, with pneumonia being a frequent severe complication.[33] In summary, evidence from various studies supported the findings that inpatient cases of measles were significantly associated with a higher risk of complications compared to outpatient cases, indicating the importance of timely and appropriate medical care for measles patients to prevent adverse outcomes.

Awareness campaigns involving the Malaysian Ministry of Health (MOH), political leaders, and non-governmental organizations (NGOs) need to be strengthened, especially for the non-Malaysian population. Furthermore, future studies focusing on the characteristics of this vulnerable population may improve our understanding of the increased risk of measles with complications.

STRENGTHS AND LIMITATIONS

The strength of this study is that the confirmatory test for measles was performed at the National Public Health Laboratory (MKAK) Malaysia, which is a WHO-recognized laboratory for measles, thereby reducing interlaboratory bias. Furthermore, this is a population-based study compared with hospital-based studies, which can provide a better picture of this disease in a population. One limitation of this study is that the analysis based on surveillance data is limited by the completeness of the data; for example, insufficient data on parents' socio-demographics such as education level, household income, and the reason the children did not receive their vaccinations is not fully explained in the surveillance system. Apart from that, the analysis of the severity level of the inpatient cases was not performed because the data contained insufficient information. Moreover, although this study controlled for age, ethnicity,

and MMR vaccination status, there remains the potential for residual confounding arising from variables not included in this study.

CONCLUSION

Measles complications are still prevalent in Selangor and are expected to increase as the incidence of measles continues to increase. Identifying factors that contribute to measles cases with complications helps to comprehend the overall impact of measles on public health and provide insight into the overall burden of the disease in Selangor, Malaysia, as well as help in early detection and management of the disease, leading to better patient outcomes.

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