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ORIGINAL RESEARCH

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Forty-seven year trend of measles in Iran: An interrupted time series analysis

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Abstract

Background and Aim: Measles is an acute viral infectious disease usually characterized by erythematous maculopapular rash and sometimes pneumonia, diarrhea, and Central Nervous System disturbance. The current study aimed to describe the trend of measles in Iran before and after the 1978 revolution and COVID-19 pandemic.

Methods: In the current quasi-experimental study, we used annual data on confirmed cases of measles in Iran, from 1974 to 2021. Data were extracted from the World Health Organization website. An interrupted time series model was used to assess the effect of different events on the incidence of measles.

Results: The trend of new cases increase every year until 1980 according to the preintervention slope of 2040 (95% confidence interval [CI] = −1965–2045; $p < 0.31$). After Iran's revolution, the occurrence of new cases significantly decreased (−845 [95% CI = −1262 to −432; $p = 0.001$]). After the COVID-19 pandemic, the trend of new cases significantly increased (41 [95% CI = 12–70; $p = 0.006$]).

Conclusion: It seems that social or health-related events are among the effective factors on the incidence of measles. But with maintaining vaccination coverage in the community and vaccination of immigrants, this fluctuation in the disease trend can be decreased.

KEYWORDS
interrupted time series analysis, Iran, measles

1 | BACKGROUND

Measles is an acute viral infectious disease usually characterized by erythematous maculopapular rash and sometimes pneumonia, diarrhea, and Central Nervous System disturbance.[1] This infection is transmitted through respiratory droplets.[2] Measles is a highly contagious disease, with basic reproduction number (R_0) of 12–18,[3] which is higher than the ancestral SARS-CoV-2 virus ($R_0 = 3–4$),[4,5] and the Delta variant of SARS-CoV-2 virus ($R_0 = 3–7$).[6] Measles is a vaccine-preventable disease because it provides lifelong immunity after vaccination.[7] Lack of herd immunity in population due to have not received the measles vaccine can cause measles outbreaks.[2] Unvaccinated children are at the highest risk of infection.[8] Bronchopneumonia, diarrhea, encephalitis, laryngitis, and otitis media are the main measles complications.[9] By the vaccination, the age distribution of measles changes from children to older age groups.[10] According to epidemiological forecasts, if there is no vaccination every 3–5 years due to the accumulation of susceptible people, an epidemic will occur.[11] As the measles vaccine coverage rate increased, the incidence and mortality rate of measles decreased 2000–2016 around the world.[12] However, due to the activities of antivaccination campaigns in many countries, a global resurgence of measles has been observed since 2016.[13] On May 28, 2019, the Islamic Republic of Iran received the certificate of elimination of measles in the Eastern Mediterranean region (EMRO) region.[14] However, due to the inadequate coverage of vaccination in neighboring countries and the movement of their citizens to Iranian cities, it is necessary for officials and policymakers in the field of public health to pay serious attention to the following matters. In 2019, the African and European regions had the highest incidence.[12] This situation may lead to the re-establishment of endemic measles transmission in countries that previously eliminated measles virus.[15] Trend analysis studies are essential to understand the measles landscape. Therefore, we conducted an analysis in 2022 to provide more emphasis on understanding the trends of measles in Iran from 1974 to 2021 at the national level. This paper describes the trend of measles in Iran before and after the 1978 revolution and COVID-19 pandemic.

2 | METHODS

In the current quasi-experimental study, we used annual data on confirmed cases of measles in Iran, from 1974 to 2021. Data extracted from World Health Organization (WHO) [16] website that is available at https://apps.who.int/gho/data/view.main.1540_62?lang=en. Interrupted time series (ITS) model used to assess the effect of different events on the incidence of measles. The ITS is one of the appropriate models that could assess the short and long-term effects of one or more interventions in the quasi-experimental studies. In this model, the dependent variable is measured before and after the intervention. Our data included 48 observations of the confirmed cases occurred in Iran during the mentioned time period. The Iranian Islamic revolution was happened in 1978, also the COVID-19 pandemic was started in December 2019. Segmented regression model and ITS analysis using Newey ordinary least squares (OLS) regression-based methods were used to model the data. The Newey method estimates the coefficients by OLS regression, but the Newey–West standard errors used to handle the possible heteroscedasticity and autocorrelations. The Actest, lag (6) was used to examine autocorrelation and selection of best lags. Due to the presence of autocorrelation error terms at lag 1 ($p < 0.001$), the primary model adjusted with lag (1). The standard ITS regression model was as follows:

$$Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + €_t$$

Y_t represents the aggregated number of cases occurred at each equally spaced time point t, T_t represents the time passed from the start of the study, X_t is a categorical variable representing the intervention (preintervention period 0, otherwise 1), and $X_t T_t$ is an interaction term. The β_0 represents the intercept. β_1 is the slope of the outcome variable before the intervention. β_2 represents the change in the level of the outcome that occurs in the period immediately after the intervention. β_3 represents the difference between preintervention and postintervention slopes of the outcome. A statistically significant β_2 and β_3 indicate an immediate and overtime effect, respectively.[17,18] Also, the autoregressive integrated moving average (ARIMA) model was used to the prediction of the future trends of cases. Data were analyzed using Stata Corp. 2017; *Stata Statistical Software: Release 15*; StataCorp LLC.

3 | RESULTS

The minimum and maximum number of registered cases was 3 (in 2004) and 53,615 (in 1978), respectively. The median (interquartile range) of reported cases was 4376 (17,399–196). Figure 1 depicts the total number of confirmed cases of measles from 1974 to 2021.

3.1 | Effect of Iranian revolution on trend of reported measles cases

The starting point of the registered cases of measles was estimated at 21,959 and the trend of new cases increase every year until 1980 according to preintervention slope of 2040 (95% confidence interval [CI] = −1965–2045; $p < 0.31$). After the Iran's revolution, the occurrence of new cases was significantly decreased (−845 [95% CI = −1262 to −432; $p = 0.001$]) (Table 1). Figure 2 shows the trend of measles-registered cases before and after the Iran's revolution. The trend of new cases of measles was increasing before the Iran's revolution; however, after it the trend is decreasing (Figure 2).

3.2 | Effect of COVID-19 pandemic on trend of reported measles cases

The confirmed cases of measles were showed a decreasing trend during 1980–2019 and this trend was statistically significant ($\beta 1 = -845$ [95% CI = −1262 to −432; $p = 0.001$]). After the COVID-19 pandemic the trend of new cases was significantly increased (41 [95% CI = 12–70; $p = 0.006$]) (Table 1). Figure 2 shows the trend of registered measles cases before and after the COVID-19 pandemic. The trend of new cases of measles was decreasing before the COVID-19 pandemic, however, after it the trend of new cases was increasing (Figure 2).

3.3 | Prediction

In the prediction of the incidence of measles, the results of time series analysis based on the ARIMA model (2, 1, 1) with AR = 2, MA = 1, and Akaike information criterion statistics (AIC) = 157, shows a constant trend in the incidence for the coming years (Figure 1).

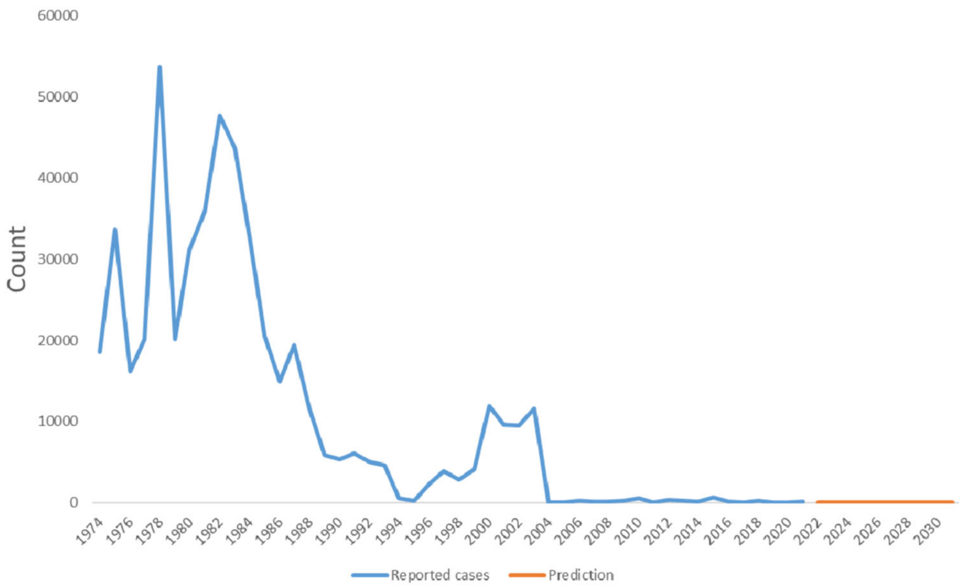

FIGURE 1 The total number of confirmed cases of measles from 1974 to 2021 and predicted values.

TABLE 1 Estimated coefficients of Segmented regression model for new cases of measles in Iran 1974–2021 using the Newey–West standard errors.

Regression with Newey–West standard errors						
Maximum lag: 1	Number of observation = 48		F (5, 42) = 20.10		p = 0.00001	
New cases	Coefficients	Standard error	t	$P > t$	[95% confidence interval]	
			1980			
B_0	21,959	418	5.46	0.001	13,848	30,069
B_1	2040	1984	1.03	0.31	−1965	2045
B_2	−9310	11365	−0.82	0.41	−32,248	−13,626
B_3	−2885	1983	−1.45	0.15	−6888	−1116
Postintervention linear trend	−845	204	−4.13	0.001	−1262	−432
			2019			
B_1	−845	204	−4.13	0.001	−1262	−432
B_2	8086	3040	2.66	0.01	1951	14221
B_3	887	205	4.31	0.001	471	1302
Postintervention linear trend	41	14	2.8	0.006	12	70

4 | DISCUSSION

In Iran, before the Islamic revolution, about 40% of the population at risk had been vaccinated against measles. After the Islamic revolution, measles vaccination coverage increased to 90% by the early 1990s.[19] This action caused a significant reduction in measles.[14] In other words, the high level of immunization coverage in all cities and villages of Iran is one of the main reasons for reducing the incidence of measles based on the risk assessment method of the WHO.[20] However, the WHO reported peaks in places with high total vaccination coverage, such as the USA, Thailand, and Tunisia, because the infection spread rapidly through many groups of unvaccinated people.[21] Also, the implementation of the national measles and rubella immunization campaign in 2003 for all people aged 5–25 years, the target population of which was about 50% of the total population of Iran.[22] As a result of this campaign in 2007, more than 97% of the population aged 5–40 had adequate immunity against measles,[23] but despite this vaccination program, several outbreaks in older age groups have also been reported.[24] The COVID-19 pandemic

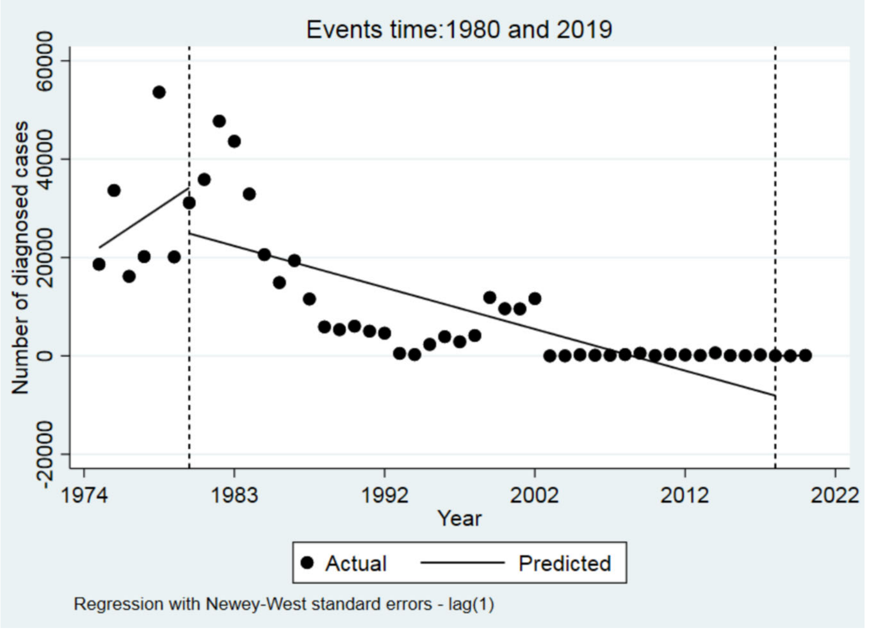

FIGURE 2 Segmented regression model for new cases of measles in Iran 1974– 2021 using the Newey–West standard errors.

can have negative effects on people's access to essential health services and cause an increase in morbidity and mortality from other diseases, especially in vulnerable groups such as children, the elderly and chronic patients. Therefore, essential health services such as the vaccination of children face disruption. People's access to health services during the outbreak of COVID-19 is affected by supply and demand factors. The increase in the number of COVID-19 patients in hospitals and healthcare centers reduces the resources and their employees become infected with this disease. As a result, the resources of the health system transferred to the diagnosis, treatment, and control of the COVID-19, which leads to a reduction of some other health services. On the other hand, patients may not go to healthcare centers due to lack of confidence in the staff of healthcare centers in the prevention and control of infection, fear of contracting the COVID-19 disease, travel restrictions imposed by the government, and financial problems.[25] The WHO conducted a survey in 2020 to determine the effects of COVID-19 on 25 essential health services in 105 countries. About 90% of countries reported disruptions in providing essential health services. Emergency services were disrupted in 16 countries. The member countries of the EMRO had the most disruption in providing basic health services.[26] Vaccination services, diagnosis, and treatment of noncommunicable diseases, family planning services, pregnancy care, and cancer diagnosis and treatment were the most disrupted. Factors such as reduction of outpatient visits, quarantine restrictions, lack of staff and resources, cancellation of nonemergency health services, and financial problems of patients had reduced the use of essential health services. Only 55% of countries implemented measures to ensure the provision of essential health services. In the 2021 survey of the WHO, about 89% of countries had disruptions in the provision of essential health services, which mostly occurred in primary healthcare and rehabilitation and palliative services. Emergency services were disrupted in 20% of countries. Elective surgeries were canceled in two-thirds of the countries.[26] Studies related to vaccination coverage parallel to the COVID-19 pandemic, from March to April 2020 in 208 countries, indicate moderate to severe disruption or complete suspension of vaccination services in more than half of the countries.[27] In fact, due to the reduction of vaccination coverage during the COVID-19 pandemic, in the coming years, the world may witness the resurgence of other infectious diseases including measles. It is necessary to implement the national immunization program for children to achieve high vaccination coverage and increase protection against vaccine-preventable diseases even in the era of COVID-19.[28] Finally, paying attention to the surveillance system and tracing the transmission chains as well as the sources of the infection and case-based surveillance (following-up the all suspected cases) along with maintaining vaccination coverage in the community and vaccination of immigrants is considered one of the important solutions to maintain the status of measles elimination. For successful measles control, we need seroepidemiological studies as well as mass immunization.[29]

5 | LIMITATIONS

A limitation of this study must be noted. Some other potential variables have not been recorded and may have impact on the trend.

6 | CONCLUSION

After the COVID-19 pandemic, the trend of new cases significantly increased. This is a wake-up call for health policymakers to continue the restrictions on measles infection, such as avoiding contact with suspected cases and closely monitoring the migration systems of neighboring countries, which are the most critical factors for the continuation of the measles elimination strategy. It seems that social or health-related events are among the effective factors on the incidence of measles. But with maintaining vaccination coverage in the community and vaccination of immigrants, this fluctuation in the disease trend can be decreased.

AUTHOR CONTRIBUTIONS

Yousef Alimohamadi and Mojtaba Sepandi: Conceptualization; formal analysis; investigation; methodology; writing—original draft; writing—review and editing.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

All data generated during this study are included in this published article.

TRANSPARENCY STATEMENT

The lead author Mojtaba Sepandi affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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