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Research Article

Varicella Trends in Kuwait; A Successful Control

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Abstract

Introduction: Varicella Vaccines introduced in 2017 nationally mandating two doses regimen at age of 1 and 2 years old. **Aim:** Analysis to explore trends in varicella incidence and changes in case characteristics before and after the implementation of varicella vaccination policy. **Method:** This study was an observational ecological study design with a retrospective secondary analysis of reported varicella cases from January 2011 to December 2022. Cases were analyzed according to Vaccine introduction in the following two time periods: 2011–2017 “pre-vaccine” and 2018–2022 “post-vaccine”. **Results:** Varicella infection used to be very high in Kuwait; the annual reported incidence rate reached more than from 250/ 100,000 population peaking during the May and June. Incidence was slightly greater for males than females (M:F ratio 1.2) and cases among Non-Kuwaitis were more than Kuwaitis. The number of reported varicella cases declined (-74.7%) during the 5 years following the introduction of Varicella Vaccination. Cases declined in all age groups (62% – 84%), but the greatest decline was observed in the target age group 1-4 years (-84.1%). Declines observed among the non-targeted population including infants (-78.2%), adolescents and adults (-70.5%) not eligible for vaccination indicating the effect of herd immunity during post-vaccination period. Admission to infectious diseases hospital reflecting severity of cases dropped by -97% from 47.3 in 2011 to 3.4 in 2022 per 100,000 population. Nationality specific incidence rate was higher among Kuwaitis although the number of cases was higher among non-Kuwaitis. **Conclusion:** A study over a 15-year span shed light on Varicella infection epidemiology and the impact of vaccination on disease trends. It is important in developing vaccination strategies and other public health measures to minimize the healthcare and economic impact.

Keywords: Varicella; Vaccine; Epidemiology; Trend

Introduction

Varicella, commonly known as chickenpox, is an acute, highly contagious disease caused by varicella-zoster virus (VZV), a member of the herpesvirus family. Only one serotype of VZV is known, and humans are the only reservoir. Infection characterized by fever, viremia, and scattered vesicular lesions of the skin found mostly on the face, scalp and trunk. It is spread by coughing, sneezing, and direct contact. The virus can also be released into the air from skin lesions [1]. Following primary infection, which usually occurs in childhood, VZV becomes latent in ganglionic neurons and can reactivate in 10-20% to cause herpes zoster (HZ; shingles), which typically manifests as a localized, painful, dermatomal rash [2]. Anyone who has recovered from chickenpox may develop shingles but the risk of the disease increases as a person becomes older. About half of all shingles cases occur among men and women 60 years of age or older [2].

Varicella infection may be fatal, especially in neonates and in immunocompromised persons. The complications of varicella include secondary bacterial skin and soft tissue infections, otitis media, bacteremia, pneumonia, osteomyelitis, septic arthritis, endocarditis, necrotizing fasciitis, toxic shock-like syndrome, hepatitis, thrombocytopenia, cerebellar ataxia, stroke and encephalitis [3]. Varicella increases the risk of severe invasive group A streptococcal infection in previously healthy children by 40- to 60-fold [4]. Complications are more common in adults and immunocompromised people, who have higher rates of pneumonia, encephalitis and death. Congenital varicella syndrome is rare when infection occurs before the 13th or after the 20th week of gestation [5]. The risk is approximately 2% when infection occurs at 13-19 weeks of gestation [6]. Congenital infection results in a wide clinical spectrum, which may include low birth weight, ophthalmic abnormalities, skin scarring, limb atrophy, cerebral atrophy and a variety of other anomalies. Almost one-third of affected infants die early in the second year of life [7]. Maternal varicella occurring in the 5 days before to 2 days after birth is associated with severe neonatal varicella in 17% to 30% of infants, with high case fatality for the newborn [5,6].

VZV vaccine (VV) was developed to prevent the spread of varicella infection in a community and to protect those with weak immune system of developing serious illnesses leading to death. One dose of single-antigen varicella vaccine has been reported to be 85% effective at preventing any form of varicella [8,9], while two doses increasing effectiveness to 98%, with 100% protection against severe varicella [9]. In the pre-vaccine era, most cases of varicella occurred in children, with 50% of children becoming infected by the age of 5 years and 90% by the age of 12 years, but after the introduction of VV a greater number of cases are occurring in adolescents and adults [8,10].

The National Immunization Technical Advisory Committee (NITAC) in Kuwait recommended voluntary VV in private sector in 2005 mainly for high-risk groups (healthcare personnel and family contacts immunocompromised persons… etc.). In 2017, VV became mandatory in the national Expanded Program of Immunization (EPI) as per NITAC recommendation with two doses regimen at age of 1 and 2 years old without catch-up vaccination of susceptible older children. This study analysis intended to explore trends in varicella incidence and changes in case characteristics before and after the implementation of two doses regimen of varicella vaccination nationally.

Methodology

Study area & Immunization Program in Kuwait

Kuwait hosts one of the most modern healthcare infrastructures in the Middle East with well-established immunization program that began in the 1960s, as frequent campaigns against fatal infectious diseases, such as smallpox, polio, and measles, followed by development of the vaccination program in 1972 when the national immunization committee was first established. Vaccination is mandatory for children, adolescents, healthcare workers, food handlers, newly coming expatriates, foreign students, and pilgrims. All vaccines are administered free of charges (FOC) regardless of nationality or area of residence. The coverage levels are calculated annually based on an administrative method and coverage surveys measuring vaccine coverage at the district level every 5 years. Varicella vaccination was first introduced in Kuwait voluntarily in private sector in 2005; vaccination rates were not known accurately. Then VV two doses regimen was added to the national immunization schedule in 2017 to be given to all children at age 1 & 2 years old.

Study Design & Data source

This study was an observational ecological study design with a retrospective secondary analysis of reported varicella cases from January 2011 to December 2022 data available from the Communicable Diseases Department– Public Health Directorate, and VV vaccination data available from the EPI Department – Public Health Directorate. Varicella is a reportable disease according to Kuwait routine surveillance system; cases characteristics can be extracted and studied but investigations as per source of infection, genotyping were not possible. Cases were analyzed according to Vaccine introduction in the following two time periods: 2011–2017 “pre-vaccine” and 2018–2022 “post-vaccine”.

Data management

Extracted data were sorted and cleaned, then relevant variables were reentered using Microsoft Excel. The following variables

used in the final analysis: total monthly doses of VV administered at age 1 and 2 years old nationally according to EPI, reported varicella cases from 2011-2022. Descriptive statistics, including bar charts and line graphs, were plotted to compare number, incidence rates and trends of Varicella before, and after introduction of Varicella vaccination nationally. Given the nature of the aggregated data available, no adjustment for potential confounders or effect modifiers was possible.

Results

Varicella infection used to be very high in Kuwait; Varicella incidence tended to follow a cyclical pattern, with peaks every few years. Despite an overall decline in the incidence of varicella since 2001, occasional outbreaks reported in 2004 & 2005 (IR 232.4/10^5pop. & IR 219.5/10^5pop. respectively) cases of Varicella increased by 50% compared with 2003 (IR 125.7/10^5pop.), also in 2011 (IR 111.8/10^5pop.) Varicella cases increased by 62% compared with 2010 (IR 43.9/10^5pop.). (Figure 1). Cases peaking during the May and June. and slightly greater for males than females (M:F ratio 1.2) and more among Non-Kuwaitis than Kuwaitis. The number of reported Varicella cases and incidence rates significantly declined -74.7% (p-value>0.001) during the 5 years following the introduction of VV in the EPI schedule nationally (Table 1)

	B Coefficient	Standard Error	t	Significance p value	95% Confidence Interval	
					Lower Bound	Upper Bound
Cases	**-.003**	**.001**	**-5.753**	**.000**	**-.004**	**-.002**
IR	**-.082**	**.012**	**-0.846**	**.000**	**-.106**	**-.058**

Table 1: Linear Regression of Varicella Cases & Incidence rates

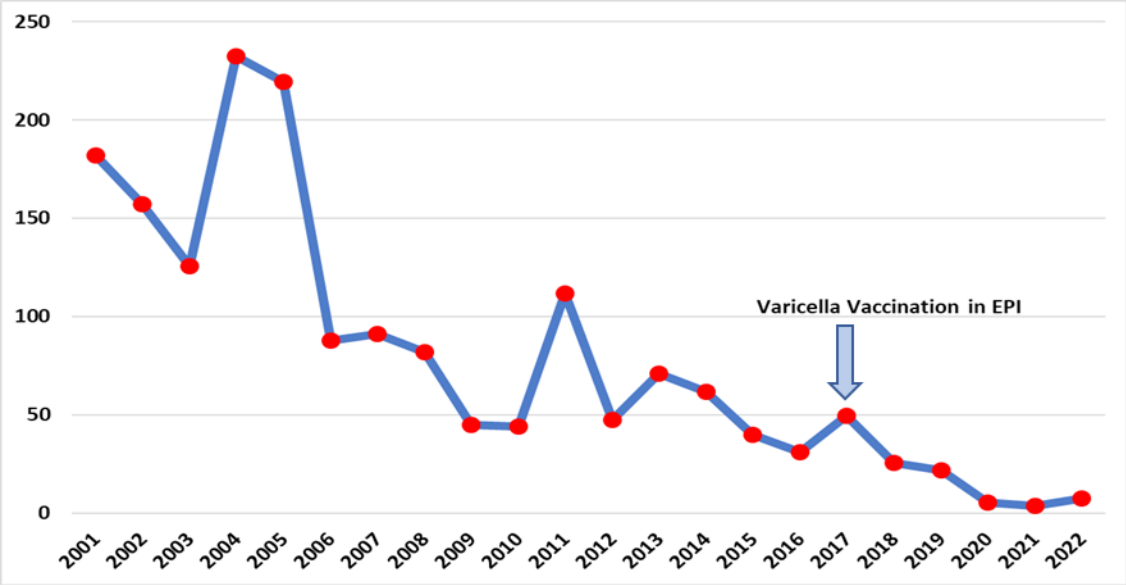

Figure 1: Varicella Incidence Rates per 100,000 population 2001-2022.

Cases declined in all age groups (62% – 84%), but the greatest decline was observed in the target age group 1-4 years -84.1% followed by infants less than 1 year -78.2%, and -70.5% decline observed among the non-targeted population. (Table 2) Prior to introduction of VV (2011–2017), the highest incidence was in the age 1–4-year-olds and this compromised 25-30% of all reported cases. In the following years after immunization this target age group percentage dropped to 7-15% of all reported cases and the highest incidence rate was in infants less than 1 year old. Also, changes noted in other age groups: adolescents 5-9 years old constituted 3-22% , teenagers 10-19 years old represented 6-8%, adult population composed 37-47% of reported cases before vaccination years while after introduction of VV this composition changed to 20-28%, 7-10% & 41-59% respectively (Figure 2).

age group / year	2011	2012	2013	2014	2015	2016	2017	Mean Cases Pre-vaccination Period	2018	2019	2020	2021	2022	Mean cases Post-vaccination Period	Percentage Difference
<1 yr	**237**	**111**	**168**	**159**	**130**	**88**	**129**	**146**	**67**	**60**	**10**	**10**	**12**	**32**	**-78.2%**
1-4yrs (Targeted population	**1052**	**467**	**830**	**756**	**454**	**369**	**632**	**651**	**284**	**154**	**17**	**24**	**38**	**103**	**-84.1%**
5_9y	**710**	**229**	**460**	**455**	**307**	**222**	**488**	**410**	**268**	**210**	**52**	**36**	**101**	**133**	**-67.5%**
10_19y	**319**	**150**	**201**	**214**	**138**	**93**	**131**	**178**	**78**	**95**	**27**	**13**	**36**	**50**	**-72.0%**
20-29y	**702**	**359**	**444**	**340**	**279**	**247**	**324**	**385**	**149**	**183**	**50**	**18**	**55**	**91**	**-76.4%**
30-44y	**947**	**415**	**579**	**474**	**301**	**293**	**431**	**491**	**258**	**265**	**86**	**38**	**96**	**149**	**-69.8%**
>45	**165**	**77**	**128**	**122**	**77**	**61**	**103**	**105**	**75**	**66**	**18**	**19**	**23**	**40**	**-61.6%**
Other Non targeted population (>5 yrs)	**2843**	**1230**	**1812**	**1605**	**1102**	**916**	**1477**	**1569**	**828**	**819**	**233**	**124**	**311**	**463**	**70.5%**
Non targeted population (all except 1-4 yrs)	**3080**	**1341**	**1980**	**1764**	**1232**	**1004**	**1606**	**1715**	**895**	**879**	**243**	**134**	**323**	**495**	**-71.2%**
TOTAL	**4132**	**1808**	**2810**	**2520**	**1686**	**1373**	**2238**	**2367**	**1179**	**1033**	**260**	**158**	**361**	**598**	**-74.7%**

Table 2: Reported Varicella cases according to age group & percentage difference of mean cases during pre & post vaccination periods.

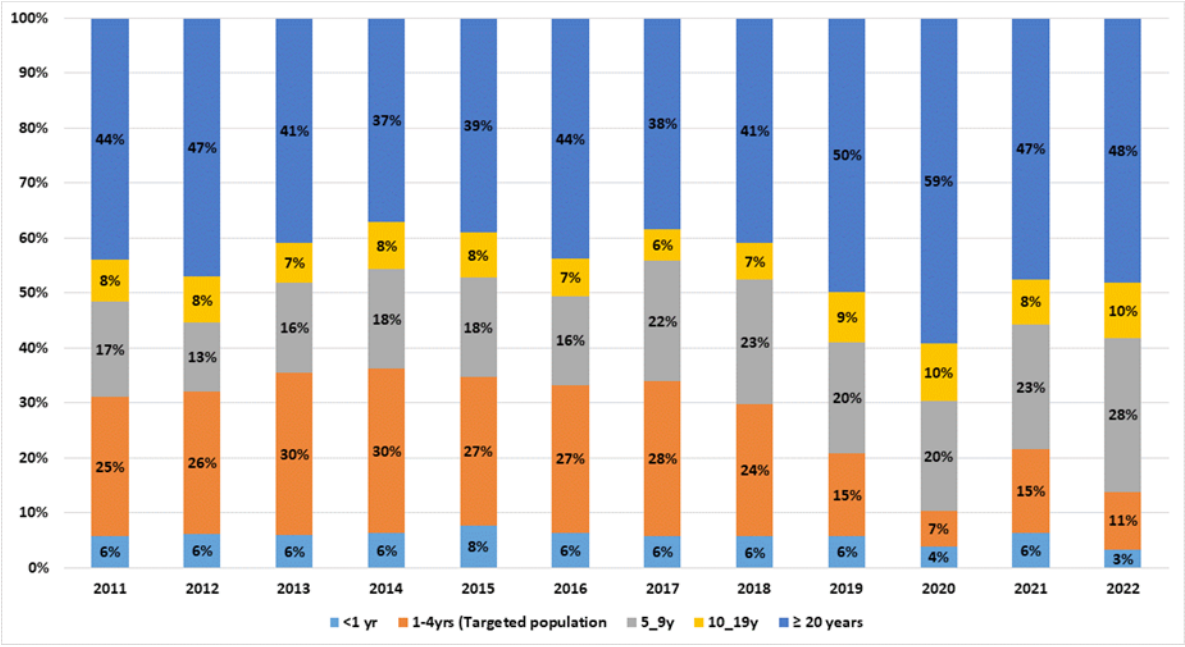

Figure 2: Distribution of Varicella cases according to age group.

Nationality specific incidence rate was higher among Kuwaitis although the number of cases was higher among non-Kuwaitis. (Figure 3a) The incidence rate ratio of Kuwaiti to Non-Kuwaiti in the pre-vaccination period was approximately (1.5 - 2) this ratio became less after vaccination (1.0 - 1.8). (Figure 3b)

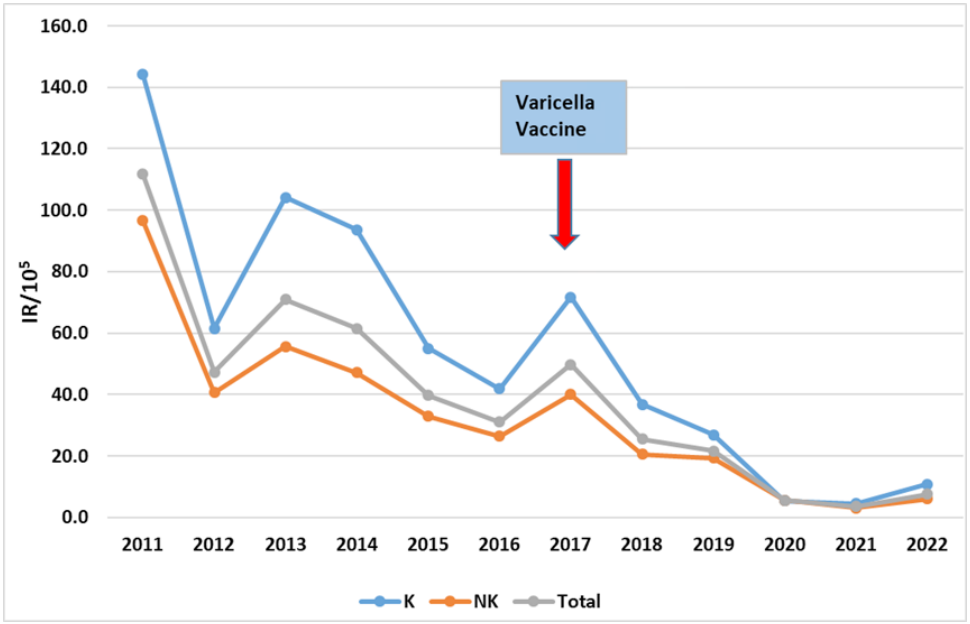

Figure 3a: Nationality specific incidence rates of reported varicella 2011-2022.

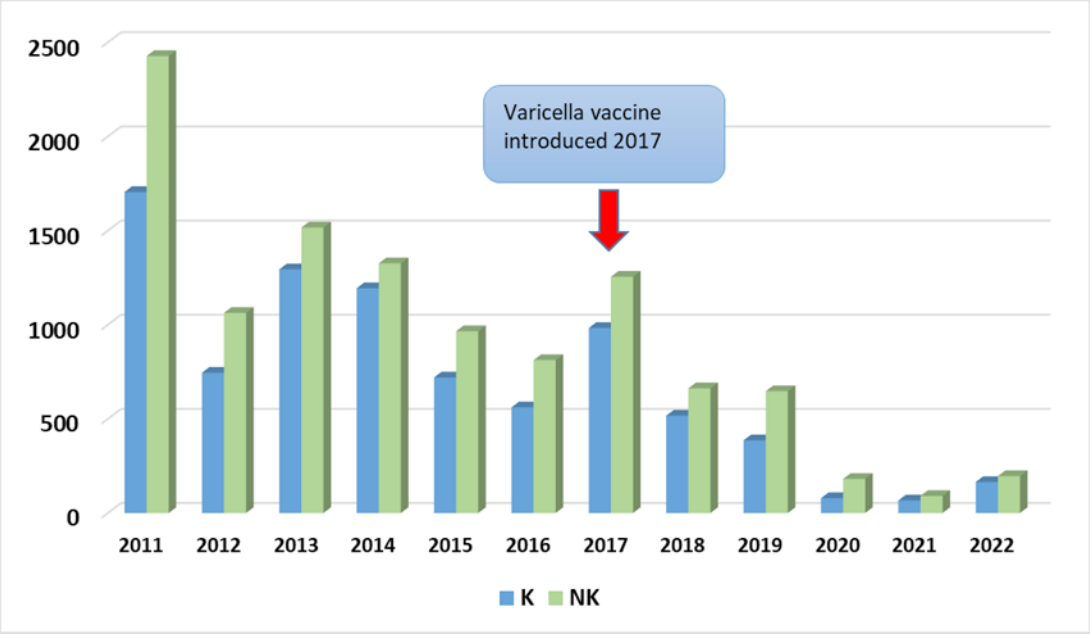

Figure 3b: Reported Varicella according to nationality 2011-2022.

Male gender was a pit more affected than females (M:F ratio1.1-1.2) in the pre-vaccination period 2011-2017. However, males became more inflicted as the number of cases reportedly higher and the gap between Male: Females ratio increased in the years following introduction of VV vaccine was slightly greater for males than females (M:F ratio1.2-1.9) during 2018-2022. (Figure 4)

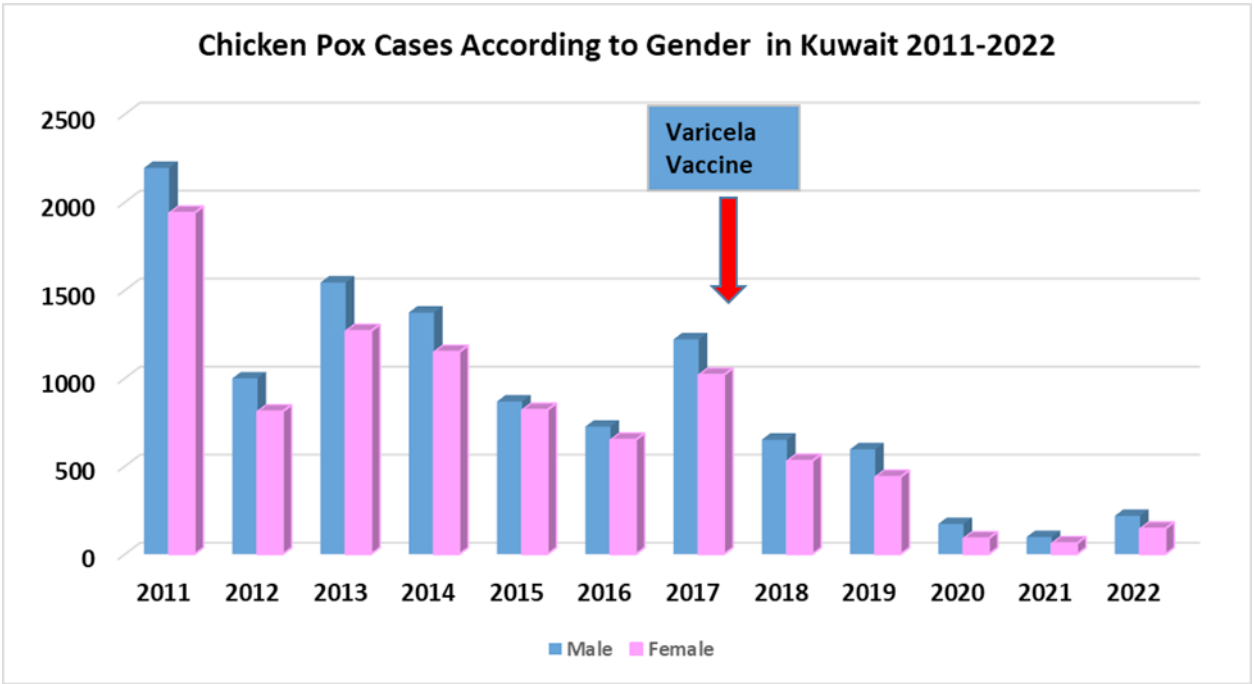

Figure 4: Reported Varicella cases according to gender 2011-2022.

The observed seasonal pattern of infection in the pre-vaccine period typically peaking during May and June was also changed with incidences peaking during March-May and December-January in the post-vaccine period. (Figure 5).

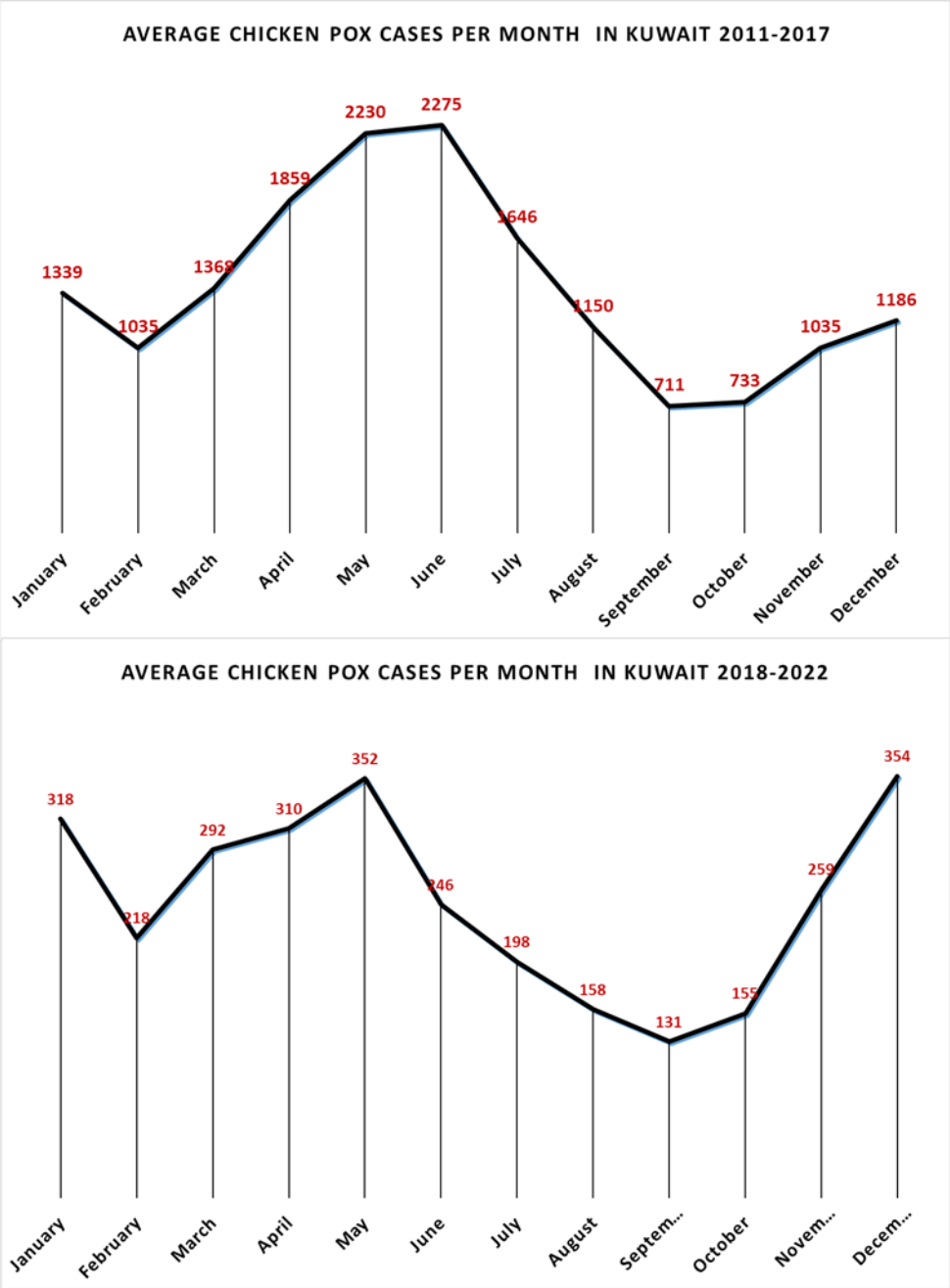

Figure 5: Months of occurrence of reported Varicella cases during Pre & Post Vaccination periods.

Admission to infectious diseases hospital indicating severity of cases dropped by -97% from 47.3 in 2011 to 3.4 in 2022 per 100,000 population. It was clearly noted that among Kuwaiti nationals' children less than 19 years old were more affected and more admitted to hospital, while among Non-Kuwaiti adult population were more affected and admitted to hospital. This has not changed even after introduction of VV. (Table 3). However, the amount of moderate to severe cases that needed admission to infectious diseases hospital increased from (22% - 45%) from all reported cases during pre-vaccination years compared to (27% – 54%) of all reported cases during the five years following vaccination.

Year	Total Cases Reported			children admitted	adult admitted	Total admitted	Admission rate Rate/10^5 pop.*		
	children	Adult	Total				children admitted	adult admitted	Total admitted
2011	2318	1814	4132	556	1193	1749	57.1	43.8	47.3
2012	957	851	1808	248	536	784	24.6	19.0	20.5
2013	1659	1151	2810	467	799	1266	44.6	76.4	31.9
2014	1584	936	2520	335	592	927	30.9	19.7	22.7
2015	1029	657	1686	140	245	385	12.8	7.8	9.1
2016	772	601	1373	136	204	340	12.4	6.2	7.7
2017	1380	858	2238	199	286	485	18.0	8.4	10.8
2018	697	482	1179	89	235	324	8.0	6.7	7.0
2019	519	514	1033	90	295	385	8.2	8.0	8.1
2020	106	154	260	13	127	140	1.2	3.6	3.0
2021	83	75	158	9	54	63	0.8	1.5	1.4
2022	187	174	361	41	125	166	3.7	3.4	3.4

Table 3: Hospitalization of Varicella Cases According to Nationality & Age Group 2011-2022.

Discussion

Despite an overall decline in the incidence of varicella since 2001 in Kuwait, occasional outbreaks were reported. In 2004 & 2005 (IR 232.4/10^5pop. & IR 219.5/10^5pop. respectively) varicella cases increased by 50% compared with 2003 (IR 125.7/10^5pop.), also in 2011 (IR 111.8/10^5pop.) reported varicella increased by 62% compared with 2010 (IR 43.9/10^5pop.). Varicella could cause high economic and psychological burdens to individuals, families, and society [11]. However, the real burden of varicella disease might severely be under-reported, as many people with varicella did not seek care in health facilities. The reported number of cases in any given year likely represents less than 10% of the actual number of cases because of under ascertainment and underreporting [12].

Varicella vaccination is one of the most effective ways to prevent varicella morbidity, hospitalization, and mortality [8-12]. In this population-based longitudinal study we observed a dramatic decline in varicella incidence from 111.8 in 2011 to 7.5 in 2022 per 100,000 population after implementation of the two doses regimen of VV nationally in 2017 with -74.7% during the 5 years following vaccination while achieving immunization coverage levels of 95% to 99% in children aged 1-4 years old. Generally, since the introduction of VV in EPI nationally, the number of outbreaks (characterized as ≥5 epidemiologically linked cases within one incubation period) decreased to

zero (p<.001). Similar reports from neighboring countries as Saudi Arabia reported that the total number of VZV cases decreased from 10,070 in the pre-vaccination period (1998) to 1577 cases in the mandatory vaccination period (2008); with the incidence rate decreasing from 739.8 to 88.1 per 100,000 population between 1994 and 2011 [13]. Also, there was a sharp decrease in VZV incidence rate in Bahrain in 2015, and a decline in the number of cases of VZV in the UAE in 2009 and 2013, which coincide with the introduction of VZV national immunization programs within these countries [13]. Earlier, it was noted in industrialized countries that as the vaccine uptake increased, the varicella incidence tended to decrease over time [9, 14-16]. We have to emphasize that in 2020, these data may be impacted by multiple factors related to the COVID-19 pandemic including a decrease in most communicable disease notifications due to limited healthcare workers and resources, social isolation, interruption of face-to-face attendance of children in nurseries and schools, reduction in outpatient consultations for non-COVID diseases, and increased use of hygiene measures [17].

In this longitudinal study, the greatest decline in varicella incidence was observed in the children targeted for vaccination aged 1–4 years -84.1% (from 437.3 in 2011 to 17.0 in 2022 per 100000 population). The reported cases in the target age group (1-4 years old) were exclusively never vaccinated, it is well known that two-doses vaccination is required to reduce breakthrough infections, and control outbreaks and one-dose varicella vaccination confers only short-lived protection against varicella [18,19].

The indirect benefits of vaccination were also observed in the overall population, including infants (410.5 in 2011 to 25.2 in 2022 per 100000 population), adolescents and adults not eligible for vaccination. This finding indicates the effect of herd immunity during the post VV implementation period. The age at disease onset shifted upwards; a greater number of cases are occurring in adult (≥20 years old) populations (41-59% of cases), although the overall incidence in this age group has been greatly reduced from 66.6 in 2011 to 4.7 in 2022 per 100000 population.

Varicella-related hospitalization reflecting severity of the disease dropped dramatically -97% from 47.3 in 2011 to 3.4 in 2022 per 100,000 population following VV relieving a great burden on health system . However, it was noted that the percentage of hospitalized patients out of total reported cases increased from (22% - 45% of total reported cases) in pre vaccination period to (27% – 54%) in the post vaccination period this is expected as more adult population are affected usually presented with moderate to severe case.

Previous studies have shown consistent and marked seasonality of varicella in most countries [20,21].This seasonality effect was also observed in Kuwait markedly in April-June in the pre-VV period) while a slight shift noted in the peak in the post-VV (March-May). However, a longer follow-up period is needed to better understand the impact of VV on the seasonality of varicella.

Conclusion & recommendations

In this Primer study over a 15-year span, we shed light on the disease's epidemiology and the impact of vaccination on disease trends. In summary, Varicella used to be very common but mostly self-limiting. It was important to implement vaccination strategies of two doses regimen of VV to minimize the healthcare and economic impact. High levels of VV coverage proved to be a successful control measure of Varicella infection. It is important to maintain substantial levels of herd immunity against Varicella to prevent importation of VZV from countries that do not vaccinate and zoster caused by reactivation of latent wild-type virus. We strongly recommend applying vaccination defaulters tracing policies consistently. and a screening policy for evidence of varicella immunity for newly coming expatriates and vaccination of susceptible persons definitely will have the potential for further cases reduction, mitigate the impact of future outbreaks and reduce resources necessary to manage cases and outbreaks.

Strengths & limitations

Data collected from infectious diseases surveillance system in Kuwait over a 15-year span, are assumed to be both sensitive and specific. Nevertheless, only notified cases were included many mild to moderate cases usually do not seek medical care with the assumption that notification rates were constant over time and did not change with the introduction of VV in the national EPI. and vaccination coverage rates were available as aggregated data and not linked to individual patient records. This population-level effects of VV may be different from individual-level effects known to occur due to ecological fallacy.

Statements and Declarations

Ethical consideration

This study was conducted in accordance with the declaration of Helsinki. The Ethics Committee for Medical Research at the Ministry of Health – State of Kuwait research provided approval for the study (ID #: MOH/2582/2024) on June 6, 2024. Data extracted from the officially dispatched monthly and annually reports of the Communicable Diseases Department – Public Health Directorate. The confidentiality of participants was secured by de-identifying all data included in the analysis. Data were kept in an encrypted file and saved on a computer, which was accessible to the principal investigator only.

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Disclosure of relationships and activities (conflict of interests)

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

All authors work in the public health field in Kuwait, they share the same career activities in vaccination field and control of communicable diseases.

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Authors' contributions

NA is the first author & the corresponding author had substantial contributions to the conception or design of the work; the acquisition, analysis, interpretation of data for the work; AND drafting the work or revising it critically for important intellectual content; AND the final approval of the version to be published. The other Coauthors LQ, SA, FA, FG & HA all contributed equally the conception or design of the work; the acquisition, analysis, interpretation of data for the work.

References

1. Gershon AA, Gershon MD (2013) Pathogenesis and current approaches to control of varicella-zoster virus infections. Clin Microbiol Rev 26: 728-743.
2. Parija SC (2023) Herpesviruses, in Textbook of Microbiology and Immunology. Springer. 751-773.
3. Peterson CL, Mascola L, Chao SM, Lieberman JM, Arcinue EL, et al. (1996) Children hospitalized for varicella: a prevaccine review. J Pediatr 129: 529-536.
4. Coleman S (2016) The association between varicella (chickenpox) and group A streptococcus infections in historical perspective. SAGE Open Medicine 4: 2050312116658909.
5. Varicella (Chickenpox). 2023-07-11 [cited 2023 2.12.2023].
6. Koren G (2003) Risk of varicella infection during late pregnancy. Can Fam Physician 49: 1445-1446.
7. Hammad E, Pacsa IHA (1989) Early pregnancy varicella and associated congenital anomalies. Acta Pædiatr Scand 78: 963-964.
8. Vaccine Preventable Disease: Surveillance Report to December 31, 2019. 2019 5.12.2023.
9. Prevention (2023) C.f.D.C.a. Chickenpox Vaccine Saves Lives and Prevents Serious Illness infographic.
10. Giglio N, Lasalvia P, Pawaskar M, Parellada CI, Rojas YG, et al. (2022) Trends in varicella burden of disease following introduction of routine childhood varicella vaccination in Argentina: a 12-year time series analysis. Vaccines 10: 1151.
11. Feng H (2023) National and provincial burden of varicella disease and cost-effectiveness of childhood varicella vaccination in China from 2019 to 2049: a modelling analysis. Lancet Reg Health–West Pac 32: 100639.
12. Campbell A, S Ismail, Tan B (2010) Literature Review on One-Dose and Two-Dose Varicella Vaccination: An Advisory Committee Statement (ACS)• National Advisory Committee on Immunization (NACI). Can Commun Dis Rep 36(ACS-10): 1-24.
13. Badur S, Ozudogru O, Khalaf K, Ozturk S, Albreiki S, et al. (2023) Epidemiology of varicella zoster virus and herpes zoster virus in gulf cooperation council countries: a review of the literature. Infect Dis Ther 12: 81-93.
14. Kupek E, Tritany EF (2009) Impact of vaccination against varicella on the reduction of the disease incidence in children and adolescents from Florianópolis, Brazil. J pediatr 85: 365-368.
15. Neyro S, Rancaño C, Iglesias M, Katz N, Valle Juarez, et al. (2018) 2476. Impact of the vaccination strategy on varicella burden disease in Argentina. in Open Forum Infectious Diseases. Oxford University Press.
16. Guris D, Jumaan AO, Mascola L, Watson BM, Zhang JX, et al. (2008) Changing varicella epidemiology in active surveillance sites—United States, 1995–2005. J infect dis 197: S71-S75.
17. Formenti B, Gregori N, Crosato V, Marchese V, Tomasoni LR, et al. (2022) The impact of COVID-19 on communicable and non-communicable diseases in Africa: a narrative review. Infez Med 30: 30-40.
18. Chaves SS, Gargiullo P, Zhang JX, Civen R, Guris D, et al. (2007) Loss of vaccine-induced immunity to varicella over time. N Engl J Med 356: 1121-1129.
19. Choi UY, Huh DH, Kim JH, Kang JH (2016) Seropositivity of Varicella zoster virus in vaccinated Korean children and MAV vaccine group. Human vaccin immunother 12: 2560-2564.
20. Gershon AA, Breuer J, Cohen JI, Cohrs RJ, Gershon MD, et al. (2015) Varicella zoster virus infection. Nat Rev Dis primers 1:15016.
21. Lolekha S, Tanthiphabha W, Sornchai P, KosuwanP, Sutra S, et al. (2001) Effect of climatic factors and population density on varicella zoster virus epidemiology within a tropical country. Am J Trop Med Hyg 64: 131-136.