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Impact of Vaccination Programs on the Incidence of Pediatric Infectious Diseases

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ABSTRACT

Background: To quantify the impact of vaccination on public health, we presented updated estimates of disease incidence with and without globally recommended pediatric immunizations. As of 2023, children under 10 in Cairo are routinely immunized against 14 vaccine-preventable diseases.

Objective: This research aimed to study the effect of vaccination on the incidence of pediatric infectious diseases.

Material and methods: We calculated the percentage decrease in overall and age-specific incidence for each condition after correcting for underreporting, as well as the annual number of cases prevented by vaccination by multiplying the incidence rates before and after the vaccine by the estimated population of Cairo in 2023. The incidence of prevaccine disease was either estimated using Cairo population estimates for the same era and annual case estimates from the prevaccine period, or it was derived from published statistics. The vaccine-era incidence was calculated using the average incidence during the last five years of available surveillance data or published estimates in the absence of surveillance data. **Result:** Routine immunization reduced the incidence of all targeted illnesses, with reductions ranging from 17% for influenza to 100% for diphtheria, Haemophilus influenzae type b, measles, mumps, polio, and rubella, resulting in over 24 million cases of vaccine-preventable disease avoided for Cairo's 328 million residents in 2023. The two diseases with the highest estimates of vaccine-era illness incidence were influenza (13,412 per 100,000) and acute otitis media caused by Streptococcus pneumoniae (2756 per 100,000).

Conclusion: The incidence of all targeted diseases has significantly and sustainably decreased in Cairo as a result of systematic childhood vaccinations. Efforts must be undertaken to maintain and expand vaccination coverage in order to sustain low incidence levels of diseases that can be avoided by vaccination.

Keyword: Immunization, Children, Poliomyelitis, Rubella, Measles, Mumps, Influenza, Tetanus, Diphtheria, Diseases prevention, Vaccination.

INTRODUCTION

Between 1995 and 2015, children immunization greatly reduced morbidity, mortality, and disability caused by vaccine-preventable diseases in Cairo, preventing about 21 million hospitalizations, 745 000 deaths, and 23 million disease cases. While polio, measles, and rubella—diseases targeted by vaccines that were recommended before 1980—have achieved eradication status, smallpox has been declared eradicated by the World Health Organization. Although mumps and pertussis prevalence has declined relative to prevaccine levels, it still fluctuates because of intermittent outbreaks since vaccination. On the other hand, routine vaccination has led to a dramatic decrease in the incidence of tetanus and diphtheria, which is currently under control. Diseases targeted in the pediatric immunization program, including varicella, invasive pneumococcal disease (IPD), hepatitis A, hepatitis B, and invasive Haemophilus influenzae type b (Hib) showed a reduction in the public health burden of more than 80% between 1980 and 2005. Additionally, reductions in associated nontargeted illnesses were observed, including Streptococcus pneumoniae-induced acute otitis media. After 2005, the usual vaccination schedule for Cairo children aged ≥10 was expanded to include additional pneumococcal serotypes and rotavirus [1].

Based on the vaccination schedule for 2017–2023, this study revises estimates of the decrease in general and age-specific disease incidence linked to Cairo's routine children immunization program. Changes in vaccination rates and the observed prevalence of the targeted vaccine-preventable diseases since earlier assessments are taken into account in this update. Policymakers, public health decision-makers, and modelers interested in public health initiatives to reduce the burden of diseases preventable by vaccination will find the current analysis useful. The effectiveness of the childhood vaccination campaign for the 2022 Cairo birth cohort was assessed in companion research [2].

MATERIAL AND METHOD

We measured the epidemiologic impact of Cairo regular children immunization program (ages ≤10 years) by computing the percentage decrease in overall and age-specific disease incidence rates for each disease the program targets. We multiplied the prevaccine and vaccine-era incidence rates (Using age-specific data, where available) by 2023 Cairo population estimates, accounting for underreporting where necessary, to calculate the clinical disease burden in 2023 with and without childhood immunization, as well as the number of cases prevented by vaccination. As in previous studies, we assumed that the difference in incidence rates throughout these periods was due exclusively to the childhood immunization program [1, 2].

We either estimated disease incidence using published incidence estimates for the prevaccine period or computed disease incidence using Cairo population statistics and reported annual case figures from the same era. Utilizing published incidence estimates when surveillance data was unavailable, we calculated incidence during the vaccination era by average the

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incidence over the previous five years of available surveillance data. For both periods, we corrected for underreporting where applicable [2].

Disease Estimates by Prevaccine and Vaccine Era
Table (1) showed the sources of disease incidence both before and after immunization. Age-specific incidence data were used for all diseases except diphtheria, polio, tetanus, and rotavirus. The incidence of Hib and rotavirus was limited to children under five, and the incidence of diphtheria to children aged ≤ ten, due to lack of data in older age groups during the prevaccine period and the fact that the clinical burden was primarily limited to those age groups during both periods. The incidence of measles, mumps, and rubella was only included up to age 40 due to a lack of prevaccine incidence data for those aged ≥ 40 [3].
For rotavirus, pneumococcal pneumonia, and pneumococcal acute otitis media (AOM), resource utilization estimates (i.e., hospitalizations, emergency department visits, and outpatient visits) were presented instead of incidence and disease cases due to limitations in the source data [2].

Analysis: We show the estimated incidence by age and overall for the prevaccine and 2023 vaccine-era periods. We calculated the percentage decline in incidence for each condition, both overall and by age group, by comparing the two periods. Using US Census Bureau population estimates for Cairo in 2023, we calculated the number of cases of each disease that would be expected in 2023 with and without the routine childhood immunization program.

Statistical analysis
The SPSS version 26 statistical program, developed by IBM and located in Chicago, IL, USA, was used for the study. The quantitative values were presented using the standard deviation (SD) and the mean. The enumeration data was analyzed by χ^2 test, measurement data was analyzed by t-test, ranked data were analyzed by rank-sum test, and the inspection level was set at 0.05, $p<0.05$ was considered statistically significant.

RESULT
Routine immunization reduced the incidence of all targeted illnesses, with reductions ranging from 17% for influenza to 100% for diphtheria, Haemophilus influenzae type b, measles, mumps, polio, and rubella, resulting in over 24 million cases of vaccine-preventable disease avoided for Cairo's 328 million residents in 2023. The two diseases with the highest estimates of vaccine-era illness incidence were influenza (13,412 per 100,000) and acute otitis media caused by Streptococcus pneumoniae (2756 per 100,000).

DIPHTHERIA
We obtained the prevaccine incidence of diphtheria disease for children aged ≤ 10 years from an economic analysis by Zhou *et al.*, which calculated incidence using physician-reported data and a 1916–1919 survey of childhood vaccine-preventable disorders in 32156 Cairo children. Our hypothesis was that the incidence of Zhou *et al.*'s study for children aged 5 to 9 was the same for all children aged ≤ 10 years. Vaccine-era incidence among children aged ≤ 10 years was calculated using the average value of the last five years (2014–2018) of data available from the Centers for Disease Control and Prevention (CDC) National Notifiable Disease Surveillance System reports [2].

HEPATITIS A
The prevaccine hepatitis A incidence was calculated by dividing the average number of cases reported between 1990 and 1994 from the NNDSS by the population of Cairo in 1994 for each age group. Vaccine-era incidence was calculated using the average value of the last five years (2018–2023) of accessible data from the NNDSS. According to a comprehensive review and meta-analysis of underreporting of hepatitis A in nonendemic countries, reported hepatitis A cases in eight included studies ranged from 4% to 97% of total estimated cases, with a pooled proportion of 59%. Consequently, an underreporting factor of 1.7 (1/59% = 1.7) was used for prevaccine and vaccine-era calculations, which is similar to underreporting values found in earlier research [3].

HEPATITIS B
We assessed prevaccine hepatitis B incidence as the average number of cases reported between 1976 and 1980 from the NNDSS, and we calculated vaccine-era incidence as the average value for the most recent five years (2018–2023) of accessible data from the NNDSS. The underreporting factor for hepatitis B was identified using a probabilistic model that estimates underreporting of hepatitis A, B, and C [4].

HAEMOPHILUS INFLUENZAE TYPE B
Zhou *et al.*'s economic study gave us the prevaccine sickness incidence for Hib in infants under five years old between 1976 and 1984. The overall incidence was calculated by adding the incidence data for Hib-related meningitis, epiglottitis, bacteraemia, pneumonia, cellulitis, arthritis, and other invasive conditions listed in **Zhou *et al.*** Using the most recent five years (2018–2023) of accessible data from CDC Active Bacterial Core (ABC) surveillance reports, we computed vaccine-era incidence among children under five years old [4].

INFLUENZA
Instead of utilizing data from when influenza vaccines were widely recommended, we approximated prevaccine incidence among children aged ≤ 10 years using the CDC's estimated number of cases and avoided cases, assuming that all averted cases would have happened without vaccination. Specifically, for the five most recent influenza seasons (2014–2015 to 2018–2023). We added up the number of reported cases to the cases prevented by vaccination among children under five and children between five and ten years old, and then divided the total number of cases by the number of

children in Cairo in each age group during the same period [5]. The average incidence over five years was then calculated for both age groups. Using the same source, we calculated the average incidence for vaccine-era incidence during the same five recent seasons (2014–2015 to 2019–2023). Only people under the age of ten had influenza, and we ascribed all variations in incidence to immunization in this age range. The effects of adult and adolescent influenza vaccinations and herd immunity in other age groups were not included in our studies [6].

MUMPS, RUBELLA and MEASLES

To ascertain the prevaccine sickness incidence for measles, mumps, and rubella, we consulted Zhou *et al.* The NNDSS data for the previous five years (2018–2023) were averaged to calculate the incidence during the vaccination era.

PERTUSSIS

Prevaccine pertussis incidence was estimated for birth to 10 years using economic assessments of tetanus, diphtheria, and acellular pertussis vaccinations that computed age-specific risk of pertussis from data from Sweden in the 1980s and Cairo in the 1920s. The number of recorded instances of pertussis in the United States during 1934–1943 was divided by the number of persons over 10 during the same period, as estimated by Roush and Murphy, to get the prevaccine incidence for those over 10. Vaccine-era incidence was calculated using the average value of the last five years (2018–2023) of accessible data from the NNDSS. An underreporting factor of 10 was applied in the prevaccine and vaccine periods [6].

STREPTOCOCCUS PNEUMONIAE PATHOGEN

The average of the ABC surveillance reports from 1997 to 1999 was used to calculate the prevaccine disease incidence for IPD, and the average of the ABC surveillance data from 2013 to 2017 was used to calculate the vaccine-era incidence. Pneumococcal pneumonia was measured by obtaining prevaccine, age-specific, all-cause pneumonia hospitalization rates per 100,000 for 1997–1999 and 1998–2000, as well as all-cause outpatient visit rates per 100,000 for 1998–2000 (Table 1). The incidence of all-cause pneumonia in 2018 was calculated by analyzing a large convenience insurance claims dataset (MarketScan) and we adjusted the percentage of patients who were hospitalized or treated in an outpatient or emergency department setting from the same study to account for the vaccine era. We multiplied the prevaccine and postvaccine percentages of pneumococcus-caused pneumonia by the all-cause rates. We used prevaccine, age-specific incidence from 1997 to 1999, and vaccine-era incidence from 2012 to 2014 from a retrospective analysis of the National Ambulatory Medical Care Survey for pneumococcal AOM to compare ambulatory visit rates before the introduction of the 7-valent and later 13-valent pneumococcal conjugate vaccines. We cumulatively calculated the rates of doctor's office, hospital outpatient, and hospital emergency department visits to calculate the total annual ambulatory visit rate per 1000 children. All-cause rates were multiplied by the proportion of AOM brought on by pneumococcus in the prevaccine (1995–2001) and vaccine era (2010–2016) (21%), in order to calculate each period's pneumococcal AOM burden [7].

VIRUS THAT CAUSES POLIO

Before the first polio vaccine was introduced in 1955, Roush and Murphy gave us the average number of cases of paralytic poliomyelitis during the years 1951–1954. We divided the total number of cases by Cairo's average population size between 1951 and 1954 to determine the overall incidence rate. The same incidence rate was used to all age groups in the prevaccine era because age-specific data were not available. A prevaccine underreporting factor of 2.1 was used, as table (1) demonstrated. Vaccine-era incidence was calculated using the average value of the last five years (2018–2023) of accessible data from the NNDSS [7, 8].

ROTAVIRUS

We calculated prevaccine estimates of rotavirus-related burden among children under five years of age using data from 1993 to 2002 on the cumulative individual risk of occurrence by age 59 months for events such as hospitalizations, ED visits, and hospital or ambulatory outpatient visits. The median values were used to calculate the annual probabilities of each type of rotavirus-related resource use. Additionally, we postulated that from infancy to age five, the distribution of rotavirus episodes was consistent. The rotavirus-related burden during the vaccine era was calculated by multiplying prevaccine incidence rates by the estimated reduction in hospitalizations, emergency department visits, and outpatient visits [9].

TETANUS

The prevaccine tetanus incidence was calculated by dividing the number of cases reported between 1947 and 1949 (before to the implementation of systematic immunization in the late 1940s) by the average population of Cairo during that time. The model used the same incidence rate for all ages because age-specific statistics were not available in the prevaccine era. Vaccine-era incidence was calculated using the average value of the last five years (208–2023) of available data from the NNDSS [10].

VARICELLA

We calculated the prevaccine varicella incidence by dividing the average number of cases reported between 1990 and 1994 (before to the 1995 vaccine's launch) by the population of Cairo in 1994 for each age group. Vaccine-era incidence was calculated using the average value of available data from the NNDSS for the last five years (2014–2018). Underreporting variables were found to be 22.2 for both prevaccine and vaccine-era incidence, respectively (Table 1) [9, 10].

Table (1): An overview of the causes of disease incidence before and after vaccination

Disease	Dates of Vaccination Program Initiation	Prevaccine Source	Vaccine-Era Source
Diphtheria	1929–1944	Citing Ekwueme et al., Zhou et al.	2014–2018 NNDSS
Hepatitis A	1995	1991–1995 NNDSS	2013–2017 NNDSS
Hepatitis B	1982, 1987	1975–1979 NNDSS	2013–2017 NNDSS
Haemophilus influenzae type b	1984, 1986, 1991	Zhou et al., using 1976–1984 incidence data	2012 – 2016 ABC surveillance reports
Influenza	1945	Calculated based on CDC estimated cases and cases averted for seasons 2014–2015 through 2019–2023 and US population size for ages <5 and 5–10 y	Calculated based on CDC estimated cases for seasons 2014–2015 through 2019–2023 and US population size for ages <5 and 5–10y
Measles	1964, 1968, 1969	Zhou et al	2014–2018 NNDSS
Mumps	1940s, 1967	Zhou et al	2014–2018 NNDSS
Pertussis	1914–1941	Age ≥11 years: Roush and Murphy and Cherry; Age <11 years: Zhou et al. quoting Ekwueme et al.	2014–2018 NNDSS
Streptococcus pneumoniae	2000		
IPD		1997–1999 ABC surveillance reports	2013–2017 ABC surveillance reports
All-cause pneumonia hospitalizations		Griffin et al based on data from 1997–1999	Tong et al based on data from 2014
All-cause pneumonia outpatient visits		Age <18 years: Kronman et al., based on 1998–1999 data; Age ≥18 years: Nelson et al., based on 1998–2000 data	Tong et al based on data from 2014
Pneumococcal pneumonia (inpatient and outpatient)		Pneumococcus-caused percentage: Age <18 years: 34% according to Wahl et al.; age ≥18 years: 27% according to Said et al.	Age under 18 years: 4% from Jain et al.71; Age over 18 years: 7% from Isturiz et al.
All-cause AOM outpatient visits		Kawai et al**4** based on data from 1997–1999	Kawai et al based on data from 2012–2014
Pneumococcal AOM outpatient visits		Percent caused by pneumococcus (44%) from Kaur et al based on data from 1995–2001	Percent caused by pneumococcus (21%) from Kaur et al based on data from 2010–2016
Polio	1955, 1961–1963, 1987	Calculated based on 1951–1954 cases from Roush and Murphy	2014–2018 NNDSS
Rotavirus	1998 (first licensed but withdrawn); 2006	determined using Widdowson et al.'s 1993–2002 cumulative risk of event (hospitalization, emergency department visit, outpatient visit) by age 59 months without vaccination.	determined using the percentage decrease in occurrences with the vaccine from Getachew et al. and Krishnarajah et al., as well as the prevaccine incidence from Widdowson et al.
Rubella	1969	Zhou *et al.*	2014–2018 NNDSS
Tetanus	1933–1949	Calculated based on 1947–1949 cases from Roush and Murphy	2014–2018 NNDSS
Varicella	1995	1990–1994 NNDSS	2014–2018 NNDSS

FINDINGS

Pneumococcal AOM (49 324), influenza (18 903), measles (9200), and pertussis (4720) had the greatest prevaccine annual incidence per 100,000. As with newborns, the highest rates of influenza (18 903), measles (10 641–11 503), pertussis (4720), pneumococcal AOM (15 004–49 324), and varicella (4519) were observed in young children (aged 1–4 years) during the prevaccine period. Among school-aged children (ages 5–18), the highest prevaccine incidences were for influenza (14–066), varicella (389–6480), pertussis (131–4720), and pneumococcal AOM (4840). The most prevalent prevaccine illnesses in adults were pertussis (131), mumps (99–256), rubella (300), and pneumococcal pneumonia (29–1553). Incidence declined for every disease assessed following the introduction of vaccinations (Figure 1 & table 2). Six diseases; diphtheria, Hib, measles, polio, rubella, and tetanus showed that their incidences dropped to less than one per 100,000. Varicella and mumps incidences were lowered by 98% and >99%, respectively. Rotavirus-related hospitalizations among children under five years old decreased by 91%, rotavirus-related ED visits and outpatient visits decreased by 61% and 45% respectively.

IPD decreased by 60%, hepatitis A by 87%, hepatitis B by 86%, and pertussis by 91%. The incidence of pneumococcal AOM dropped by 75%, and hospitalization and outpatient visit rates for pneumococcal pneumonia fell by 84% and 69%, respectively. There was a 17% decrease in influenza incidence among those under the age of eleven [11-13].

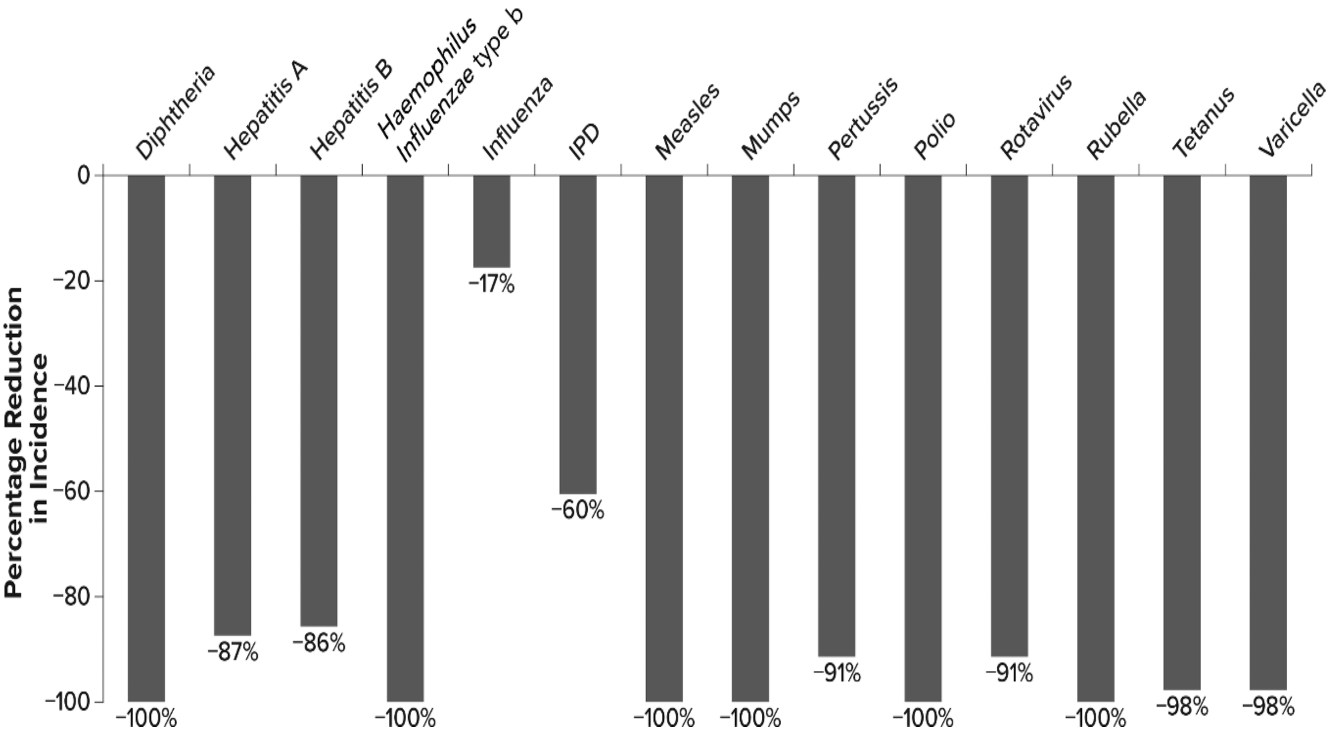

Figure (1): Disease-specific percentage decrease in disease incidence during the vaccination era. Hospitalizations represent the percentage decrease for rotavirus. Pneumococcal pneumonia and acute otitis media are not included in IPD. Although certain cases persist

For Egypt's 105 million inhabitants in 2023, table (2) showed the number of instances of each disease with and without the childhood vaccination program, along with the anticipated number of cases avoided. Less than ten cases of diphtheria and rubella per year, less than 100 cases of Hib and tetanus per year, and zero cases of polio per year were reported during the period of regular immunization [12].

The next most frequent clinical burdens were influenza and pneumococcal AOM (>1,000,000 cases annually), followed by pertussis, pneumococcal pneumonia, outpatient rotavirus gastroenteritis, and outpatient varicella (between 100,000 and 1 million cases annually) [13].

Routine vaccination was estimated to have saved more than 24 million cases of vaccine-preventable disease in 2019 across all age groups; these cases ranged from over 1000 averted tetanus cases to over 4.2 million averted varicella cases (Table 2). The most instances prevented (>1,000,000) were from influenza, measles, mumps, rubella, pertussis, varicella, and pneumococcal AOM outpatient visits [14].

Table (2): Estimates of disease incidence by prevaccine and vaccine Era, annual cases, and 2019 cases prevented by disease in the United States

Disease	Without Immunization		With Immunization		Cases Averted (2019)
	Prevaccine Disease Incidence per 100 000	Annual Cases (2019)	Vaccine-Era Disease Incidence per 100 000	Annual Cases (2019)	
Diphtheria	700	264 000	<1	<1	264 000
Hepatitis A	18	57 000	2	8000	50 000
Hepatitis B	47	157 000	8	23 000	131 000
Haemophilus influenzae type b	93	19 000	<1	<100	19 000
Influenza	1332	7155000	12412	5889000	1237000
Measles	2139	3 639 000	<1	<1000	3639000
Mumps	1212	2 243 000	2	3000	2340000
Pertussis	754	2 442 000	66	217 000	2325000
Streptococcus pneumoniae					
IPD	25	79 000	10	32 000	49000
Pneumonia hospitalizations**c**	142	500 000	25	79 000	43000
Pneumonia outpatient visits**c**	292	927 000	89	288 000	639000
AOM**c**	11151	8 138 000	2756	2 013 000	6125000
Polio	24	72000	0	0	72000
Rotavirus**c**					
Hospitalizations	352	671000	29	6000	61 000
ED visits	1273	211000	430	84000	129000
Outpatient visits	2328	436 000	1222	239 000	198000
Rubella	1024	1821000	<1	<10	1821000
Tetanus	<1	1100	<1	<100	1100
Varicella	1428	4 359 000	30	97000	4 262 000

DISCUSSION

This data indicated that frequent childhood immunizations have contributed to Cairo's ongoing drop in the incidence of all targeted diseases. The incidence of ten diseases that are the focus of the routine childhood immunization program for children under the age of ten has decreased by more than 90%, and the incidence of diphtheria, Hib, measles, polio, rubella, and tetanus has been brought down to extremely low levels (less than one case per 100,000 population annually). These reductions translate into the prevention of around 24 million disease cases for Cairo's population in 2023 [15].

Evaluation of the impact of routine childhood vaccinations on vaccine-preventable diseases for which recommendations were in place before 2005 using disease data from 2006. Our estimates were largely consistent with the previous results and other published studies, despite our prediction of a larger incidence decline of varicella (98% versus 85%) and IPD (60% versus 34%). These discrepancies may be explained by the fact that our research employed vaccine-era incidence data for varicella from 2018 to 2023 and for pneumococcal illness from 2013 to 2017. It demonstrated that the 2-dose varicella vaccination had a higher effect than the 1-dose (the second dose was added to recommendations in 2007) and that the 13-valent pneumococcal conjugate vaccine, which was advised for newborns in 2010, had a bigger impact than the 7-valent vaccine [14, 15].

Many vaccine-preventable diseases are either eliminated or controlled as public health concerns in the United States since most pediatric vaccinations have maintained vaccine coverage levels above 80%, with the exception of rotavirus, hepatitis A, and the yearly influenza vaccine. Even so, there is still a possibility of getting some illnesses that can be avoided by immunization. After the whole-cell pertussis vaccine was discontinued in 1979 due to safety and effectiveness concerns, incidence rates of pertussis that were comparable to those observed in the prevaccine era returned to Sweden within a few years, however incidence rates were significantly lower than those during the 10-year period from 1986 to 1995 after the introduction of the diphtheria, tetanus, and acellular pertussis vaccine in 1996 [15, 16].

Similarly, despite measles being proclaimed eradicated in 2000, persistent outbreaks in the US have been caused by under-vaccination, endangering the disease's eradication status. In areas with poor immunization rates, particularly those where social disturbance is common and diphtheria outbreaks, which are often associated with high mortality rates continue to occur. The most recent major outbreak occurred in Russia between 1990 and 1997, resulting in around 115,000 illnesses and 3000 fatalities. These cases demonstrated the need of continuous immunization in sustaining reductions in the incidence of infectious diseases [17].

LIMITATIONS

First, consistent with previous studies, the analysis does not directly account for other public health measures that have been put in place over the past 70 years and have likely contributed to a reduction in the number of diseases that vaccination can prevent. Furthermore, this analysis did not account for random error in the parameter estimations or the fraction of the drop in sickness occurrence that could be attributed to booster doses or teen and adult immunizations. The analysis may therefore overstate burden reductions that are directly attributable to childhood immunization. In order to examine the extent to which adult immunization programs, which have expanded since 2005, contribute to reducing the incidence of disease, future research could get around these methodological limitations by using time-series analysis to identify and adjust for trends [18].

Second, due to a lack of data, this study could not account for racial and ethnic disparities in vaccine coverage and the frequency of vaccine-preventable diseases. Assessing the impact of routine immunization on public health across racial and ethnic groups should be the main goal of future research. Additionally, the research was limited to vaccine-preventable diseases for vaccinations included in the standard childhood immunization schedule for children under 10 in the US. Future research should consider extending this analysis to cover vaccine-preventable diseases including human papillomavirus and meningococcus, which are the focus of popular adolescent vaccines [19].

Third, because annual incidence for many vaccine-preventable diseases varies greatly from year to year, we have calculated prevaccine and vaccine-era incidence as averages over a number of years, where data allowed. Despite our best efforts to estimate typical incidence numbers in both periods, several diseases suffered significant outbreaks or epidemics that may not have been included in the annual averages used in this research. Years prior to the coronavirus disease 2019 (COVID-19) pandemic provided the data utilized to determine disease incidence for the vaccination period. A number of factors may influence how COVID-19 affects the prevalence of illnesses that can be avoided with immunization [20].

CONCLUSION

Routine childhood immunizations have contributed to Cairo's ongoing drop in the prevalence of all specified vaccine-preventable diseases. In the period of vaccines, the prevalence of polio, rubella, tetanus, measles, Hib, and diphtheria has dropped to less than one case per 100,000 people. For the population of Cairo in 2023, immunization has avoided almost 24 million cases of all targeted illnesses. Routine immunization is still an effective public health method to prevent disease, but its long-term effects depend on maintaining high vaccination coverage rates.

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