Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Original Research

Impact of the COVID-19 lockdown on routine childhood vaccination coverage rates in Catalonia (Spain): a public health register–based study

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ABSTRACT

Objective: The aim of this study was to determine the impact of the lockdown measures adopted during the COVID-19 pandemic on routine childhood vaccination coverage rates in Catalonia (Spain) and to estimate its recovery once the progressive return to 'normalcy' had begun.
Study design: We conducted a public health register–based study.
Methods: Routine childhood vaccination coverage rates were analysed in three periods: a first pre-lockdown period (from January 2019 to February 2020), a second lockdown period with full restrictions (from March 2020 to June 2020), and, finally, a third post-lockdown period with partial restrictions (from July 2020 to December 2021).
Results: During the lockdown period, most of the coverage rates remained stable, concerning the pre-lockdown period; however, when comparing the vaccination coverage rates in the post-lockdown period to the pre-lockdown period, we observed decreases in all types of vaccines and doses analysed, except for coverage with the PCV13 vaccine in 2-year-olds, which experienced an increase. The most relevant reductions were observed in measles-mumps-rubella and diphtheria-tetanus-acellular pertussis vaccination coverage rates.
Conclusions: Since the beginning of the COVID-19 pandemic, there has been an overall decline in routine childhood vaccine coverage rates, and the pre-pandemic rates have not yet been recovered. Immediate and long-term support strategies must be maintained and strengthened to restore and sustain routine childhood vaccination.

Introduction

On 11 March 2020, in response to the increase in SARS-CoV-2 infections globally, the World Health Organization (WHO) declared that the situation could be considered a pandemic.[1] Since then, countries have adopted different prevention and control measures depending on their resources and epidemiological situation.[2] In Spain, as in other countries, between March 2020 and May 2021, among other measures, two periods of lockdown were established, of approximately 3 and 6 months, respectively, with severe restrictions on mobility and access to different services, including health services. Moreover, the COVID-19 pandemic challenged healthcare services in most European countries to transform and adapt their activities to maintain essential (non-COVID) health care while contributing to the emergency response to the pandemic.[3,4]

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In public and community health, vaccines are one of the most effective tools for disease prevention. However, the benefits of vaccination are significantly reduced if vaccination schedules are delayed or not completed. Therefore, WHO and United Nations Children's Fund established that routine vaccination must remain a priority during the COVID-19 response to limit preventable communicable diseases.[5] Accordingly, most countries carried out and maintained efforts at routine vaccination during the pandemic, especially for pregnant women and children.[6] However, despite these efforts, more countries worldwide have been forced to interrupt, delay, re-organise or completely suspend routine childhood vaccinations during lockdown.[6,7]

In Catalonia, Spain's second most populated autonomous community with more than 7.7 million inhabitants, and as in the rest of Spain, vaccination services were high on the list of priorities for primary health care (PHC).[8] During the initial period of full lockdown (March to June 2020), the Public Health Agency of Catalonia prioritized the immediate vaccination of children aged up to 15 months, pregnant women and persons with high-risk conditions. Furthermore, during the various de-escalation phases,[9] active recruitment of unvaccinated children and adults was recommended to gradually return to 'normalcy'. Measures for safe vaccination in primary care centres (PCCs) were also implemented.[8] In addition, the Catalan government published the plan to strengthen and transform PHC in September 2020, securing additional funding until 2022 to support this essential healthcare service beyond the impact of COVID-19.[10]

Nevertheless, despite these strategies, in 2020, vaccination coverage rates decreased in all Spanish autonomous communities depending on age and type of vaccine.[8,11] The COVID-19 pandemic is a reminder of the importance of vaccination as a critical public health strategy for preventing and controlling communicable diseases. Recovery of vaccination coverage rates in children should be carried out in the shortest possible time. Therefore, this study aimed to determine, based on the analysis of data available in a public health registry, the impact of the lockdown measures adopted during the COVID-19 pandemic on routine childhood vaccination coverage rates in Catalonia (Spain) and to estimate its recovery once the progressive return to 'normalcy' had begun.

Methods

Study design and setting

We carried out a public health register–based study in February 2022. The study is reported in accordance with the STrengthening the Reporting of OBservational studies in Epidemiology guidelines.[12]

The Catalan Health System has universal coverage with free access to health care for the entire population, public financing, integration of different health service networks and an entry point system based on PHC, which includes health care, prevention, health education, health promotion and community care. Therefore, PHC is structured in PCCs or organisational units with human, physical and financial resources that can be dedicated to the general population (including children or not) or exclusively to the child population. Each of these PCCs is assigned a geographically delimited population.[13] Furthermore, around 35% of the population contracts an additional private insurance company or health maintenance organization, especially maternal and child healthcare services.[14]

The Catalan Department of Health purchases and distributes vaccines to public and private centres to ensure full accessibility. Vaccines included in the routine childhood vaccination schedule are primarily administered by PHC services. Therefore, PHC professionals also go to schools to vaccinate children and adolescents. This strategy aims to maintain the highest possible vaccination coverage and to guarantee the continuity of care and the follow-up of Catalonia's systematic vaccination schedule. The vaccines administered are recorded in the shared public electronic health record if PHC services administer them or if the families contact PHC services for any reason and show their vaccination card with the vaccines administered in private centres.

Participants

In Catalonia, there are currently 393 PCCs, of which data from 375 (95.4%) of them were included in the study, which are those using the same server-based electronic health record system. We analysed the recorded vaccination coverage rates of the attended child population, the assigned population with at least one face-to-face or remote contact during the last year with the PCC. The percentage of the assigned child population attended is estimated to be around 89%.

Variables and data sources

Data were obtained from the Catalan Primary Care Services Information System (SISAP).[15] SISAP is a stable public structure created in 2006 to provide information for the different health services and professionals of the Catalan Health System. The main source of data used by SISAP is the PHC electronic health records. In accordance with the recommendations of the routine vaccination schedule (see Supplementary File 1), the recorded vaccination coverage rates grouped by month and year for the following vaccines: diphtheria-tetanus-acellular pertussis (DTaP/Tdap) vaccine, measles-mumps-rubella (MMR), meningococcal C conjugate (MenC) and pneumococcal conjugate vaccine (PCV13). The vaccination coverage rates in three periods were analysed: a first pre-lockdown period (from January 2019 to February 2020), a second lockdown period with full restrictions (from March 2020 to June 2020) and a third post-lockdown period with partial restrictions (from July 2020 to December 2021).

Vaccination coverage rates were estimated according to the following criteria: (1) DTaP or Tdap vaccination, coverage with two doses in 1-year-old children, three doses in 2-year-old children and a booster dose in 7-year-old children; (2) MMR vaccination, coverage with one dose in 2-year-old children and two doses in 4- and 8-year-old children; (3) MenC vaccination, one dose in 1-year-old children or one dose in 2-year-old children; and, finally, (4) PCV13 vaccination, two doses in 1-year-old children and three doses in 2-year-old children. Vaccine coverage for each period and vaccine evaluated was calculated using as the numerator the attended child population who met the age and doses criteria described earlier divided by the denominator of the attended child population who met the age criteria. Hence, both numerators and denominators were dynamic, as they referred to the number of children who had reached that age within the study's time interval (month or quarter).

Statistical methods

We used the Chi-squared tests for trend test to compare the recorded vaccination coverage rates between different quarters of the same year and between the same quarters of each year. We determined the mean rate of recorded vaccination coverage rates in the pre-lockdown (T1), the lockdown (T2) and the post-lockdown (T3) periods and calculated the differences in percentages between T2 and T1 and between T3 and T1. A P value ≤ 0.05 was interpreted as being statistically significant. Data were analysed

using SPSS version 27 (IBM Corp. Released 2020. IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp).

Results

Table 1 presents the number of children vaccinated and the recorded vaccination coverage rates by year, quarter, age, type of vaccine and dose.

In 2019, a statistically significant, decreasing trend in vaccination coverage rate was only observed with the Tdap booster dose after 6 years old; in contrast, vaccination coverage (for 2-year-olds) with three doses of DTaP vaccine, with one dose of MenC vaccine and with three doses of PCV13 vaccine showed a statistically significant, increasing trend. Vaccination coverage rates remained stable for all other vaccine types and doses analysed. In 2020, all vaccination rates analysed showed a statistically significant, decreasing trend. Finally, in 2021, only the vaccination rate with

Table 1
Recorded vaccination coverage rates in the attended child population by quarter and year.

Vaccines/doses/age group	Number of children (%)				*P*-value[b]
	First quarter	Second quarter	Third quarter	Fourth quarter	
DTaP/Tdap vaccine					
Two doses (1-year-old)					
2019	44,124 (95.5)	43,632 (95.5)	43,166 (95.4)	42,859 (95.7)	0.175
2020	42,854 (95.9)	42,327 (96.0)	41,644 (95.5)	40,901 (95.1)	<0.001
2021	40,010 (95.0)	39,275 (95.2)	38,201 (94.5)	37,138 (94.0)	<0.001
P-value[a]	0.001	0.106	<0.001	<0.001	
Three doses (2-years-old)					
2019	44,719 (94.5)	44,585 (94.6)	44,225 (94.7)	44,129 (94.9)	0.035
2020	43,495 (94.9)	42,851 (94.8)	42,123 (94.1)	41,323 (94.0)	<0.001
2021	40,786 (93.8)	40,699 (93.8)	40,183 (93.8)	39,800 (93.1)	<0.001
P-value[a]	<0.001	<0.001	<0.001	<0.001	
One booster dose after 6 years (7-years-old)					
2019	39,957 (80.8)	39,523 (80.4)	39,468 (80.3)	39,707 (80.2)	0.019
2020	38,367 (80.1)	36,184 (79.6)	35,515 (78.3)	35,186 (76.3)	<0.001
2021	35,244 (75.9)	37,678 (76.8)	37,793 (77.0)	38,142 (76.8)	0.001
P-value[a]	<0.001	<0.001	<0.001	<0.001	
MMR vaccine					
One dose (2-years-old)					
2019	44,522 (94.1)	44,382 (94.2)	44,020 (94.3)	43,920 (94.4)	0.071
2020	43,314 (94,5)	42,666 (94.4)	41,912 (93.6)	41,073 (93.4)	<0.001
2021	40,539 (93,3)	40,530 (93.4)	39,941 (93,2)	39,587 (92.6)	<0.001
P-value[a]	<0.001	<0.001	<0.001	<0.001	
Two doses (4-years-old)					
2019	42,097 (88.7)	42,086 (88.9)	42,067 (88.9)	42,639 (88.8)	0.861
2020	42,731 (88.9)	41,574 (88.4)	41,224 (87.4)	40,489 (86.6)	<0.001
2021	40,276 (86.6)	41,109 (87.0)	40,380 (86.8)	40,354 (86.3)	0.121
P-value[a]	<0.001	<0.001	<0.001	<0.001	
Two doses (8-years-old)					
2019	47,745 (94.8)	47,572 (94.9)	47,468 (94.8)	46,629 (94.8)	0.589
2020	46,688 (94.6)	44,689 (94.4)	44,082 (93.7)	44,536 (92.6)	<0.001
2021	43,933 (92.1)	45,164 (92.3)	44,703 (92.3)	45,070 (92.0)	0.738
P-value[a]	<0.001	<0.001	<0.001	<0.001	
MenC vaccine					
One dose (1-year-old)					
2019	44,081 (95.4)	43,603 (95.4)	43,128 (95.4)	42,814 (95.6)	0.212
2020	42,800 (95.7)	42,287 (95.9)	41,619 (95.5)	40,883 (95.0)	<0.001
2021	40,013 (95.0)	39,316 (95.3)	38,211 (94.6)	37,135 (94.0)	<0.001
P-value[a]	0.006	0.631	<0.001	<0.001	
One dose after the first year of life (2-years-old)					
2019	43,154 (91.2)	43,123 (91.5)	42,869 (91.8)	42,830 (92.1)	<0.001
2020	42,264 (92.2)	41,615 (92.1)	40,879 (91.3)	40,060 (91.1)	<0.001
2021	39,492 (90.9)	39,455 (91.0)	39,001 (91.0)	38,684 (90.5)	0.111
P-value[a]	0.061	0.003	<0.001	<0.001	
PCV13 vaccine					
Two doses (1-year-old)					
2019	43,803 (94.8)	43,329 (94.8)	42,869 (94.8)	43,588 (95.1)	0.062
2020	42,590 (95.3)	42,104 (95.5)	41,436 (95.0)	40,736 (94.7)	<0.001
2021	39,827 (94.5)	39,083 (94.7)	37,977 (94.0)	36,891 (93.4)	<0.001
P-value[a]	0.128	0.855	<0.001	<0.001	
Three doses (2-years-old)					
2019	43,280 (91.5)	43,451 (92.2)	43,168 (92.4)	43,104 (92.7)	<0.001
2020	42,534 (92.8)	41,995 (92.9)	41,411 (92.5)	40,664 (92.5)	0.014
2021	40,094 (92.2)	40,053 (92.3)	39,500 (92.2)	39,088 (91.5)	<0.001
P-value[a]	<0.001	0.474	0.157	<0.001	

DTaP, diphtheria-tetanus-acellular pertussis; MMR, measles-mumps-rubella; MenC, meningococcal C conjugate vaccine; PCV13, pneumococcal conjugate vaccine; Tdap, tetanus-diphtheria-acellular pertussis.
[a] Chi-squared test for trend test to compare recorded vaccination coverage rates between quarters within the same year.
[b] Chi-squared test for trend test to compare recorded vaccination coverage rates between quarters within each year.

MMR vaccine for 4- and 8-year-olds and with MenC vaccine for 2-year-olds maintained a stable trend. The rest of the vaccination rates analysed showed a statistically significant, decreasing trend.

Regarding the trends observed between the same quarters of each year, a stable trend was observed in the first quarter for vaccination coverage with MenC vaccine for 2-year-olds with the PCV13 vaccine at 1 year of age, in the second quarter for vaccination coverage with the DTaP vaccine, the MenC vaccine and PCV13 vaccine for 1-year-olds, and with the PCV13 vaccine for 2-year-olds, and in the third quarter for vaccination coverage with the PCV13 vaccine for 2-year-olds. A statistically significant, increasing trend in vaccination coverage with the PCV13 vaccine for 2-year-olds was observed only in the first quarter. For all other vaccine types and doses, vaccination coverage showed a statistically significant decreasing trend in each of the four quarters.

Table 2 and Figs. 1–4 show and compare the percentage of recorded vaccination coverage rates according to pre-lockdown, lockdown and post-lockdown periods. Three (30%) of the vaccination coverage rates analysed in the lockdown period were lower than in the pre-lockdown period, and nine (90%) of those analysed in the post-lockdown period were lower than in the pre-lockdown period. The most substantial declines were observed when comparing post-lockdown and pre-lockdown vaccination coverage rates, namely, with Tdap vaccination for 7-year-olds (see Fig. 1) and with MMR vaccination for 4- and 8-year-olds (see Fig. 2).

Discussion

This study aimed at assessing the impact of the lockdown measures adopted to deal with the COVID-19 pandemic on routine childhood vaccination coverage rates and to estimate its recovery once the gradual return to 'normalcy' had begun. During the lockdown period, most of the coverage rates remained stable concerning the pre-lockdown period; however, when comparing the vaccination coverage rates in the post-lockdown period to the pre-lockdown period, decreases were observed in all types of vaccines and doses analysed, except for coverage with the PCV13 vaccine for 2-year-olds, which experienced an increase.

Consistent with the literature, this research found that there has been an overall decline in routine childhood vaccination coverage rates since the onset of the COVID-19 pandemic.[16–19] The most substantial declines have occurred with MMR vaccination for 4- and 8-year-olds and with the Tdap booster vaccination for 7-year-olds. These results reflect those of a study published with data on vaccine administration in 170 countries collected by the different WHO regions from December 2019 to December 2020.[20] This study shows a decrease of 33% fewer vaccinations for three doses of DTaP, with a variable range among different WHO regions from 9% in Africa to 57% in South-East Asia. In addition, data from a modelling study using data from vaccines administered[21] show a global reduction of 7.7% in coverage with three doses of DTaP and 7.9% for one dose of measles-containing vaccines compared with expected coverage in the absence of a pandemic in 2020. This means that, due to the pandemic, an estimated 8.5 million children would not have received all three doses of DTaP, and 8.9 million children would not have received the first dose of the measles vaccine in 2020. Although the month with the most significant reduction was April 2020, there was a recovery until December 2020, unlike the data obtained in the present study, where the decline in coverage rates has been maintained throughout 2021. However, this continued decline in vaccine coverage rates has also been reported by Rachlin et al.[19] who found that the estimated global coverage with three doses of DTaP vaccine, as well as the first dose of measles vaccine, declined to 81% in 2021, the lowest rate since 2008.

Nevertheless, an increase was found in vaccination coverage rates with the PCV13 vaccine. This finding was also reported in other studies.[22,23] This result may be explained by possible public confusion between COVID-19 pneumonia and pneumococcal vaccination caused by information overload, especially false or misleading information, during the pandemic.[24] This "infodemic" may have contributed to the public perception of a possible protective effect of the PCV13 vaccination against COVID-19.[22]

This study has some limitations. First, vaccination coverage rates were calculated for the different indicators based on age and monthly doses, and only the impact on these could be assessed. No data were available regarding the reasons for non-vaccination or delay. Second, we calculated the vaccination coverage rates in the attended child population, and therefore, the vaccination coverage in the assigned child population not attended is unknown. However, it should be noted that despite the restrictions and transformations due to the pandemic, 94.3% of the population of Catalonia (Spain) has been attended at least once during the year 2021 in the public health service.[25] Third, we have not analysed the full routine childhood vaccination schedule. The study focused on analysing the vaccination coverage with those vaccines that are considered to be indicators of a routine vaccination programme performance and indicators for the Sustainable Development Goals.[19] However, in Catalonia, the DTaP vaccine is part of the

Table 2
Recorded vaccination coverage rates (%) in the attended child population across pre-lockdown, lockdown, and post-lockdown.

Vaccines/doses/age group	Pre-lockdown (T1)	Lockdown (T2)	Post-lockdown (T3)	T2-T1	T3-T1
DTaP/Tdap vaccine					
Two doses (1-year-old)	95.5%	95.9%	95.0%	0.40%	−0.50%
Three doses (2-years-old)	94.7%	94.8%	93.9%	0.10%	−0.80%
One booster dose after 6 years (7-years-old)	80.3%	79.8%	77.0%	−0.50%	−3.30%
MMR vaccine					
One dose (2-years-old)	94.3%	94.4%	93.4%	0.10%	−0.90%
Two doses (4-years-old)	88.9%	88.6%	86.9%	−0.30%	−2.00%
Two doses (8-years-old)	94.8%	94.5%	92.6%	−0.30%	−2.20%
MenC vaccine					
One dose (1-year-old)	95.5%	95.9%	95.0%	0.40%	−0.50%
One dose after the first year of life (2-years-old)	91.7%	92.1%	91.1%	0.40%	−0.60%
PCV13 vaccine					
Two doses (1-year-old)	94.9%	95.4%	94.6%	0.50%	−0.30%
Three doses (2-years-old)	92.0%	92.8%	92.3%	0.80%	0.30%

DTaP, diphtheria-tetanus-acellular pertussis; MMR, measles-mumps-rubella; MenC, meningococcal C conjugate vaccine; PCV13, pneumococcal conjugate vaccine; Tdap, tetanus-diphtheria-acellular pertussis.

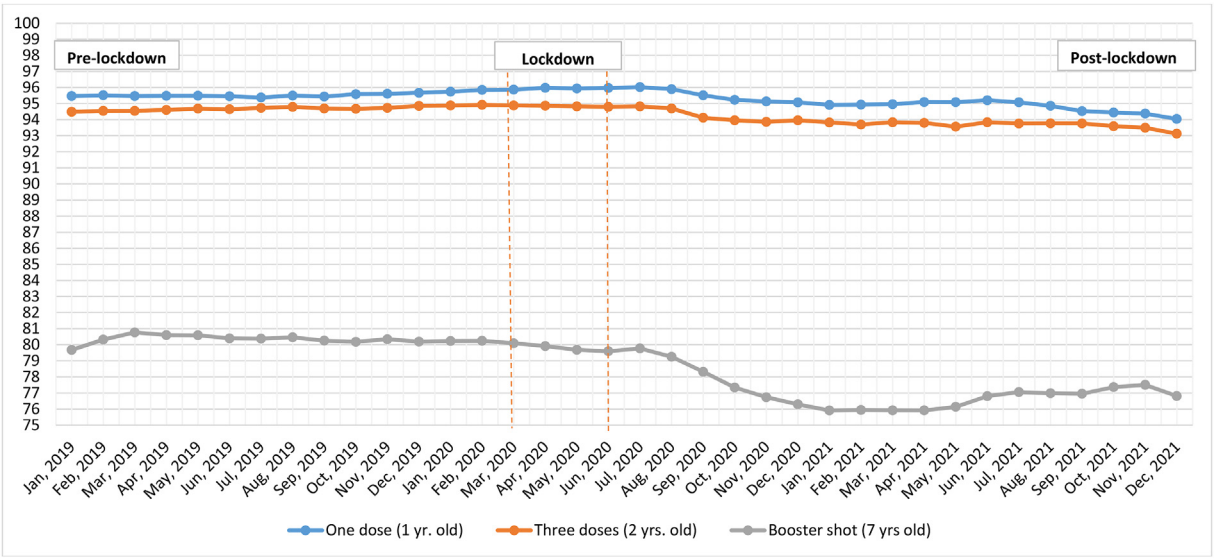

Fig. 1. Recorded vaccination coverage rate (percentage) with DTaP or Tdap vaccines in attended child population. DTaP, diphtheria-tetanus-acellular pertussis; Tdap, tetanus-diphtheria-acellular pertussis.

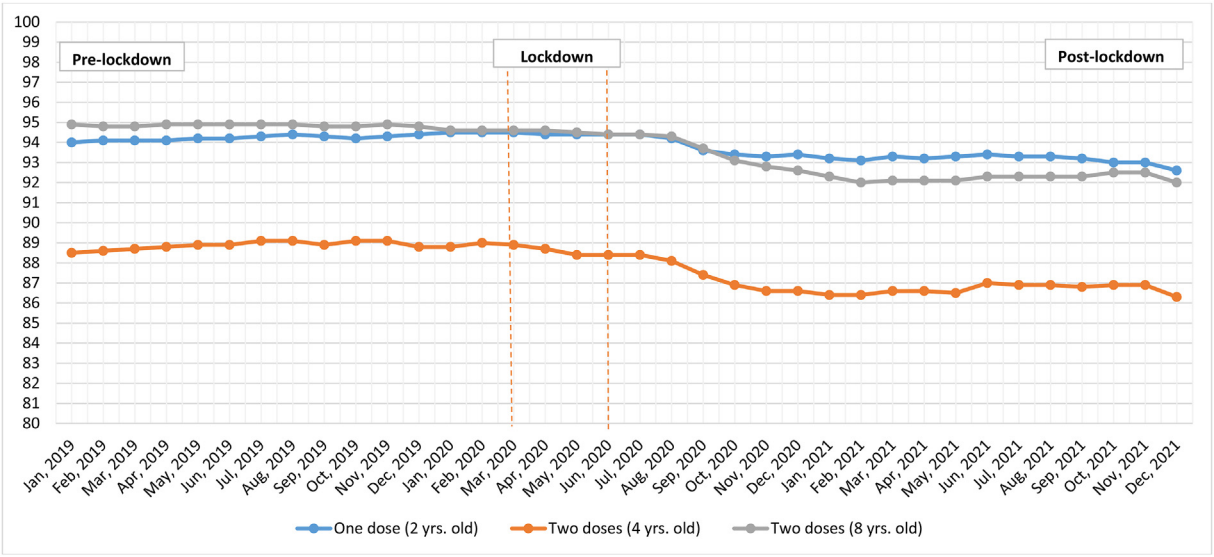

Fig. 2. Recorded vaccination coverage rate (percentage) with MMR vaccine in attended child population. MMR, measles-mumps-rubella.

hexavalent vaccine, which combines six antigens (DTaP-hepatitis B–inactivated poliovirus-*Haemophilus influenzae* type b; see in Supplementary File 1) and is administered to children aged <12 months. Therefore, the findings observed for the DTaP vaccination reflect vaccination against hepatitis B, poliomyelitis and the haemophilus influenzae type B disease. Finally, it was not possible to analyse information from 18 PCCs, representing 4.6% of the total, as they did not yet have access to the public registry system, nor did they have access to information on the population who seek vaccinations in the private healthcare system. In this regard, a tool for registering vaccines administered in private centres was implemented in November 2021. This registry will provide more comprehensive information on vaccination coverage.

Routine childhood vaccination programmes save millions of lives annually and are an essential public health function. The COVID-19 pandemic has highlighted the vulnerability of these programmes worldwide.[20] This study shows that despite strengthening vaccination strategies and ensuring the continuity of vaccination services, gaps in routine childhood vaccination remained after the most severe periods of the pandemic. A return to "normalcy" cannot be achieved without high and sustainable, routine vaccination coverage rates. It is, therefore, necessary to reinforce existing initiatives and establish new ones to return to the vaccination coverage rates of the past and achieve higher rates in the coming years. The current pandemic is a reminder of the ever-present threat of communicable diseases. Failure to restore and increase these vaccination coverage rates may contribute to new outbreaks of communicable diseases and increased morbidity and mortality from vaccine-preventable diseases. There is an acute need to use short- and long-term strategies to restore, maintain and sustain routine childhood vaccination.[26] Sustained catch-up programmes, especially those targeting the most

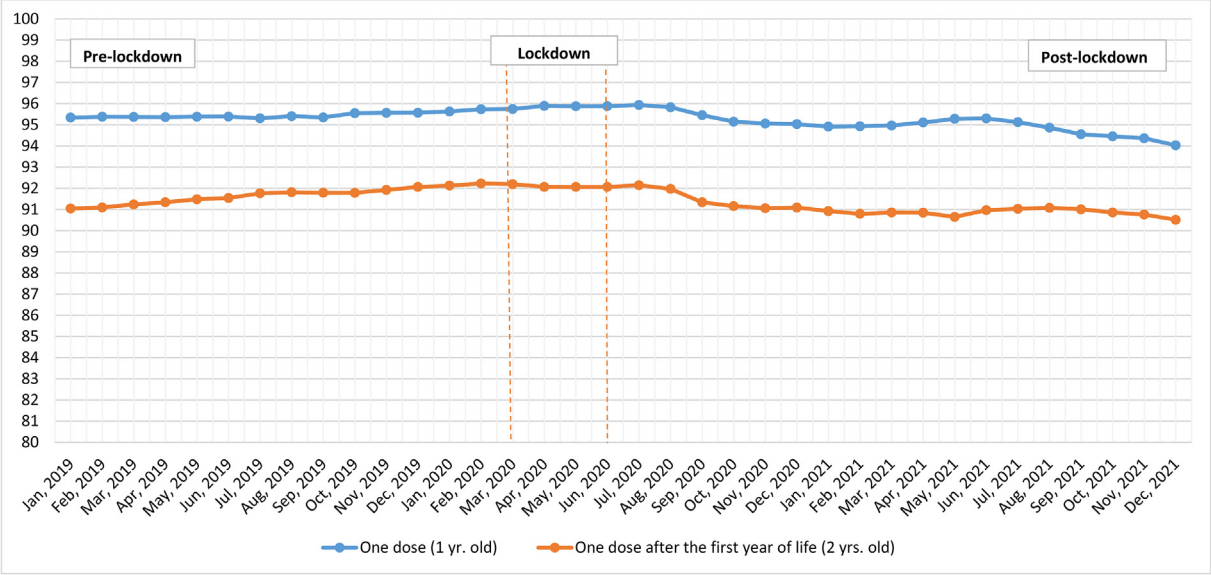

Fig. 3. Recorded vaccination coverage rate (percentage) with meningococcal vaccine in attended child population.

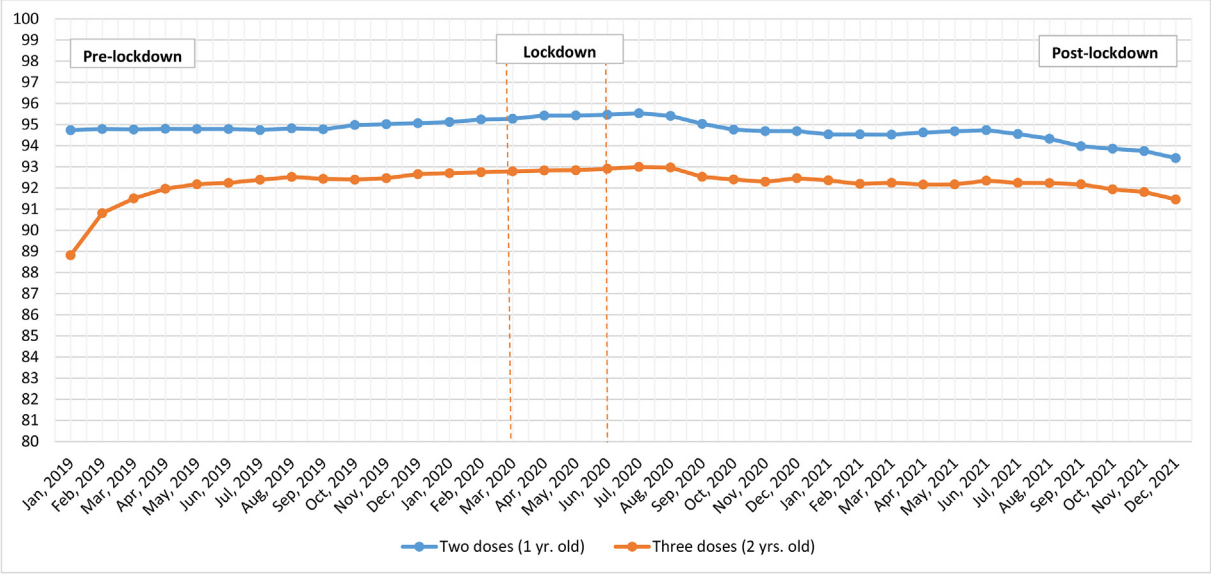

Fig. 4. Recorded vaccination coverage rate (percentage) with pneumococcal vaccine in attended child population.

vulnerable children, need to continue as before. There is also a need to maintain established strategies and develop new ones, if necessary, to make vaccination as easy as possible by ensuring optimal accessibility to vaccination centres, addressing parental concerns and fears and enhancing vaccine availability. Continuous improvement of vaccination information systems is also needed.

The COVID-19 pandemic has highlighted the importance of vaccination as a key public health strategy for preventing and controlling communicable diseases. Despite the significant efforts made by the Catalan Health System, there has been a general decline in the routine childhood vaccination coverage rates since the start of the COVID-19 pandemic, and the pre-pandemic rates have not yet been recovered. Immediate and long-term support strategies must be maintained and strengthened to restore and sustain routine vaccination.

Author statements

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Ethical approval

All data collection and analysis were performed at the autonomous community level. According to the Ethics Committee of the Fundació Institut Universitari per a la recerca a l'Atenció Primària de Salut Jordi Gol i Gurina, there was no ethical approval required for this study.

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Competing interests

The authors have no relevant financial or non-financial interests to disclose.

Authors' contributions

M.M.-M. contributed to conceptualisation, methodology, validation, formal analysis, investigation, data curation, writing the original draft, visualisation, supervision and project administration. E.Z.-d.-O. contributed to methodology, formal analysis, reviewing and editing and visualisation. E.-L.G.-D. contributed to reviewing and editing the article and supervision. A.R.-R. contributed to reviewing and editing the article. C.C.-P. contributed to conceptualisation, methodology, reviewing and editing the article and supervision.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and material

The data supporting this study's findings are available from the corresponding author upon reasonable request.

Code availability (software application or custom code)

Not applicable.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2023.02.017.

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