smw · swiss medical weekly

Original article | Published 17 December 2025 | doi:https://doi.org/10.57187/s.4525
Cite this as: Swiss Med Wkly. 2025;155:4525

Impact of the COVID-19 pandemic on routine childhood immunisation coverage and timeliness in Switzerland: a retrospective analysis using data from the Swiss National Vaccination Coverage Survey, 2019–2023

Vasiliki Baroutsou[a], Monica N. Wymann[b], Jan S. Fehr[a], Phung Lang[a]

[a] Department of Public and Global Health, Epidemiology, Biostatistics and Prevention Institute (EBPI), University of Zurich, Zurich, Switzerland
[b] Communicable Diseases Division, Federal Office of Public Health (FOPH), Bern, Switzerland

Summary

BACKGROUND: The coronavirus disease 2019 (COVID-19) pandemic has disrupted healthcare systems worldwide, leading to concerns about reduced access to routine childhood immunisations. However, comprehensive data on how the pandemic specifically impacted paediatric vaccination coverage in Switzerland remain limited across the country. The present study provides an analysis of the timeliness and coverage of routine childhood immunisations in Switzerland before and during the COVID-19 pandemic, offering insights into potential fluctuations in coverage.

AIMS: To assess the impact of the COVID-19 pandemic on routine childhood immunisation in Switzerland by comparing vaccination coverage and timeliness for children under 35 months of age before and during the pandemic. Additionally, the study seeks to identify factors associated with the likelihood of children receiving vaccinations, considering demographic and geographic variables.

METHODS: We used 2019–2023 data from the Swiss National Vaccination Coverage Survey (SNVCS), a cross-sectional survey that collected immunisation information of children under 35 months of age from a nationally representative sample of households. Children who were eligible for a vaccine from March 2020 to March 2021 were considered as the COVID-affected group and those eligible for a vaccine before this date were included in the pre-COVID-19 cohort. Coverage of the following vaccine doses was considered: diphtheria at one, two and three doses (Di1, Di2, Di3); pneumococcus at one, two and three doses (PCV1, PCV2, PCV3); and measles first and second dose (MCV1, MCV2). Vaccine timeliness was defined as receiving a dose on time with a tolerance period of 30 days. We used logistic regression models to identify and understand the factors that might influence vaccination rates.

RESULTS: For the diphtheria vaccines (Di1, Di2, Di3), while coverage remained high, there was a slight decrease observed in timely vaccination rates for some doses, with reductions of around 1% to 3% compared to pre-COVID-19 levels. The impact on PCV1, PCV2 and PCV3 showed similar trends, with slight reductions in coverage during the pandemic, but these differences were not statistically significant. For measles-containing vaccines (MCV1 and MCV2), coverage during the pandemic was higher compared to pre-COVID-19 rates. Geographic and demographic factors, such as an urban setting, nationality and linguistic region, significantly influence childhood vaccination rates in Switzerland.

CONCLUSION: While minor declines in vaccine timeliness were observed (diphtheria vaccine, pneumococcal conjugate vaccine), the overall likelihood of vaccination was not significantly affected by the COVID-19 pandemic. However, changes in vaccination recommendations introduced in 2019 may have influenced these trends.

Introduction

The coronavirus disease 2019 (COVID-19) pandemic and the measures taken to control its spread have greatly affected healthcare services globally, including routine childhood vaccinations. Since the start of the pandemic, there has been a marked decline in childhood vaccine administration and vaccination coverage in several countries [1–4]. Estimates of vaccination coverage in 2020 suggested that 23 million children missed out on basic childhood vaccines

ABBREVIATIONS

Di1	diphtheria vaccine, first dose
Di2	diphtheria vaccine, second dose
Di3	diphtheria vaccine, third dose
MCV1	measles-containing vaccine, first dose
MCV2	measles-containing vaccine, second dose
PCV1	pneumococcal conjugate vaccine, first dose
PCV2	pneumococcal conjugate vaccine, second dose
PCV3	pneumococcal conjugate vaccine, third dose

Phung Lang, PhD
Department of Public and Global Health, Epidemiology, Biostatistics and Prevention Institute
University of Zurich
CH-8001 Zurich
phung.lang[at]uzh.ch

[5]. This decline raises concerns about the potential resurgence of vaccine-preventable diseases.

Outbreaks of vaccine-preventable diseases could severely strain healthcare systems, increasing illness and death, especially among vulnerable groups. However, several obstacles have impacted child immunisation efforts during the pandemic, such as parental and provider concerns about COVID-19 exposure, limitations on transportation and the reallocation of healthcare resources to combat the virus. While immunisation programmes faced significant disruption in 2020, the complete extent of the impact and its consequences remain uncertain [6–9]. Reporting delays, incomplete data and limited information on catch-up efforts are of great importance in monitoring vaccination coverage. Recognising these concerns, Swiss public health authorities have emphasised the importance of maintaining routine immunisation services during the pandemic period.

In Switzerland, vaccinations for children under two years old are usually administered by primary care providers, especially paediatricians, during regular visits and documented in the children's vaccination card. According to both the 2020 and 2025 Swiss National Immunisation Plans (table 1), the immunisation schedule recommends vaccines in the first 24 months of life against diphtheria, tetanus and pertussis (DTP), the Haemophilus influenzae type b (Hib) vaccine, the hepatitis B (HBV) vaccine, the measles, mumps and rubella (MMR) vaccine, the pneumococcal conjugate vaccine (PCV), the poliomyelitis vaccine (IPV) and the varicella (Var) vaccine. The 2025 immunisation plan introduced several updates compared to the 2020 version, most remarkably the inclusion of vaccines against meningococcal serogroup B (4CMenB), meningococcal conjugate ACWY (Men-ACWY) and rotavirus (RV) [10].

However, there is a lack of comprehensive data on how the pandemic has specifically impacted paediatric immunisation coverage in Switzerland and whether certain groups of children have faced greater barriers to vaccination access. This study aims to address these gaps by analysing vaccination timely uptakes and comparing immunisation coverage for children under 35 months of age before and during the COVID-19 pandemic.

Materials and methods

Data source

For this analysis, we used data sourced from the Swiss National Vaccination Coverage Survey (SNVCS). The SNVCS is a population-based, cross-sectional survey to determine vaccination coverage in children aged 2, 8 and 16 years in Switzerland and is coordinated by the Epidemiology, Biostatistics and Prevention Institute (EBPI) of the University of Zurich as a mandate for the Swiss Federal Office of Public Health (FOPH) and Swiss cantons [11]. Since 2005, the survey has been collecting data at the cantonal level using a rolling 3-year cycle. Around a third of Switzerland's 26 cantons participate every year according to a predefined rotating sampling schedule such that all cantons are included over any 3-year period; this allows for regionally representative monitoring of vaccination coverage across the country [12]. All families of selected children are invited to participate in the study by letter, which includes a detailed explanation of the study's purpose and procedures. Parents are asked to submit either the original vaccination card of the selected child or a copy. Since 2017, they have also had the option to securely upload a photo or scanned copy of the vaccination card via an online platform accessible via a link and also, since more recently, a QR code. If there is no response within five to six weeks, a reminder letter is sent. If there is still no reply, a third follow-up letter is sent, and in some cantons, parents may also be contacted by telephone. Participation in the survey is voluntary. While the SNVCS primarily reports vaccination coverage at 2, 8 and 16 years of age, the full immunisation history is available through these submitted records, allowing us to determine the exact age at which each dose was administered.

Study population

We created different cohorts of children aged under 35 months using the following eligibility criteria:

- Documented vaccination record – only children whose parents or guardians provided a copy of the official vaccination card were included. These cards had to contain clearly legible documentation of administration dates for at least one of the vaccines analysed in this study.
- Valid date of birth – the child's date of birth was defined as a complete and plausible calendar date (day, month

Table 1:
Simplified routine immunisation schedule for children under 2 years old in Switzerland according to the Swiss National Immunisation Plans 2020 and 2025.

Vaccine	Age of child					
	2 months	3 months	4 months	5 months	9 months	12 months
Diphtheria, tetanus and pertussis (DTP)	X		X			X
Haemophilus influenzae type b (Hib)	X		X			X
Hepatitis B (HBV)	X		X			X
Measles, mumps and rubella (MMR)					X	X
Meningococcal serogroup B (4CMenB) *		X		X		X
Meningococcal conjugate (Men-ACWY) *						X
Pneumococcal conjugate vaccine (PCV)	X		X			X
Poliomyelitis (IPV)	X		X			X
Rotavirus (RV) *	X		X			
Varicella (Var)					X	X

* Vaccine introduced by the 2025 vaccination plan.

and year). Entries with missing or partial dates (e.g. only month/year) were excluded.

Statistical analysis

Timely vaccination coverage

We defined vaccinations as timely if they were administered at the recommended age specified in the national immunisation schedule with an added tolerance period of 30 days for all doses: diphtheria 1st , 2nd and 3rd doses (Di1, Di2, Di3); pneumococcal 1st, 2nd and 3rd doses (PCV1, PCV2, PCV3); measles-containing vaccine 1st and 2nd doses (MCV1, MCV2).

We calculated the tolerance period as the average of days per month in one year. A delay of vaccination was defined as a vaccine administered after the recommended age outlined in the national immunisation schedule, plus the tolerance period. Previous studies have used a similar 30-day tolerance to assess vaccination timeliness [13–17].

To evaluate the impact of the COVID-19 pandemic on childhood vaccination coverage, we focused on children who were eligible to receive their vaccines either just before or during the pandemic period. By including only these recent cohorts, we aimed to detect potential changes in vaccination uptake specifically related to the pandemic. Earlier cohorts were excluded because their vaccination patterns might have been influenced by other factors, such as updates to the national immunisation schedule, making it harder to isolate the effect of the pandemic.

We designated the “COVID-19 (impact) period” as the period from March 2020 to February 2021 and the “pre-COVID-19” period as the 1-year period immediately preceding the “COVID-19 impact period”, i.e. March 2019 to February 2020. Both periods were designed to be equal in duration to allow for direct comparison. More specifically, to assess the impact of the pandemic on timely vaccination coverage, we constructed specific birth cohorts for each vaccine based on the recommended ages for vaccination in the Swiss national immunisation schedule. Children in each birth cohort reached their recommended vaccination age either during the pre-COVID-19 period or the COVID-19 impact period. This ensured that each cohort was “at risk” of receiving the vaccine during the respective time period.

Diphtheria and pneumococcal vaccination

The recommended age for administering Di1, Di2 and Di3 and administering PCV1, PCV2 and PCV3 is 2, 4 and 12 months of age, respectively for both vaccines. Based on these age targets, we constructed the cohorts as follows:

- Di1 / PCV1: the pre-COVID-19 cohort included children born between 01 Jan 2019 and 31 Dec 2019 and the “COVID-19 (impact) period” cohort included children born between 01 Jan 2020 and 31 Dec 2020.
- Di2 / PCV2: the pre-COVID-19 cohort included children born between 01 Nov 2018 and 31 Oct 2019 and the COVID-19 cohort included children born between 01 Nov 2019 and 31 Oct 2020.
- Di3 / PCV3: the pre-COVID-19 cohort included children born between 01 Mar 2018 and 28 Feb 2019 and the COVID-19 cohort included children born between 01 Mar 2019 and 28 Feb 2020.

Measles vaccination

The recommended age for administering MCV1 and MCV2 is 9 and 12 months of age, respectively. Based on these age targets, we defined the cohorts for measles-containing vaccine (MCV) as follows:

- MCV1: the pre-COVID-19 cohort included children born between 01 Jun 2018 and 31 May 2019 and the COVID-19 cohort included children born between 01 Jun 2019 and 31 May 2020.
- MCV2: the pre-COVID-19 cohort included children born between 01 Mar 2018 and 28 Feb 2019 and the COVID-19 cohort included children born between 01 Mar 2019 and 28 Feb 2020.

We calculated vaccination coverage for each vaccine for pre-COVID-19 and COVID-19 cohorts using the R package *survey* [18]. To assess timely vaccination uptake, we also calculated catch-up vaccination coverage exactly one year after the recommended vaccination age, allowing for a 30-day tolerance period beyond the scheduled date. This corresponded to the observed vaccination status at approximately 15 months (for Di1/ PCV1), 17 months (for Di2/ PCV2), 22 months (for MCV1) and 25 months (for Di3/ PCV3/MCV2), which allowed assessment of whether children who missed timely vaccination later caught up within a 1-year window.

The children were selected via simple random sampling in each canton. Weights were calculated to account for the sampling method and non-participation, after which the data were post-stratified by the child’s nationality, sex and geographic setting within each canton (i.e. the survey strata).

Factors associated with the likelihood of children receiving vaccination during the COVID-19 pandemic

We used multivariable logistic regression models to assess any associations between vaccination and sex, nationality (Swiss/non-Swiss, as shared by the canton), geographic setting (city/rural, as shared by the canton), the COVID-19 pandemic (eligibility for vaccination in pre-COVID-19/ COVID-19 period) and major geographic regions (as defined by the Swiss Federal Statistical Office [SFSO], which represents the 7 major regions of Switzerland, namely Lake Geneva, Espace Mittelland, Northwestern Switzerland, Eastern Switzerland, Ticino, Central Switzerland and Zurich). Major geographic regions in Switzerland often coincide with different healthcare administrative units, which can have unique vaccination policies, outreach programmes and resource allocation and provide a broader granularity, capturing subtle differences in vaccination coverage [19]. To estimate the association between vaccination uptake and each of the selected variables described above, adjusted odds ratios (aORs) with 95% confidence intervals (CIs) were calculated. Statistical significance was set at $p \leq 0.05$.

Statistical analyses were conducted in R (version 4.2.1). For the creation of the graphs (see appendix section), we used MS Excel 2021.

Ethical considerations

In accordance with national regulations including the Human Research Act and the Swiss Federal Law on data protection, formal ethics approval was obtained for the SNVCS. The study was acknowledged by the Office of Data Protection at the cantonal level and approved by the Ethics Committee of the Canton of Zurich (PB_2016-02684).

Results

Participation

A total of 6163 children aged up to 35 months of age were included in our study population, comprising 51% boys and 49% girls. The majority of children lived in an urban area (65%) and in the Espace Mittelland region (23%) (table 2).

Timely vaccination coverage

Diphtheria and pneumococcal conjugate vaccination

The vaccination coverage for diphtheria remained high during both the COVID-19 and pre-COVID-19 periods. For the first dose (Di1), the COVID-19 cohort had 87.4% vaccinated before 3 months of age, compared to 90.0% in the pre-COVID-19 cohort. Similarly, for the second dose (Di2), 86.0% of the COVID-19 cohort were vaccinated before 5 months of age, while the pre-COVID-19 cohort was at 87.2%. For the third dose (Di3), 75.8% were vaccinated before 13 months of age, compared to 77.7% in the pre-COVID-19 cohort. The proportions of children vaccinated before 15, 17 and 25 months of age at all 3 doses and for both cohorts ranged between 95% and 97% (table 3).

Pneumococcal conjugate vaccine (PCV) vaccination coverage showed varying trends between the COVID-19 and the pre-COVID-19 cohorts (table 4). For the first dose (PCV1), the COVID-19 cohort had a vaccination coverage of 84.1% before three months of age. In contrast, the pre-COVID-19 cohort had a slightly higher coverage of 86.4%. Before five months of age, the COVID-19 cohort had a vaccination coverage of 82.1%, while the pre-COVID-19 cohort showed a rate of 83.7%. For the third dose (PCV3), the COVID-19 cohort had a vaccination rate of 67.4% before 13 months of age, compared with 66.3% in the pre-COVID-19 cohort. The differences in proportions of toddlers vaccinated before 15 and 17 months of age between the COVID-19 and the pre-COVID-19 cohorts were much greater for the first two doses (90.1% and 94.1%, respectively, at PCV1; 90.5% and 93.2%, respectively, at PCV2) than for PCV3 (89.1% and 88.1%, respectively). The confidence intervals for all three doses overlap, indicating that the observed differences are not statistically significant.

Table 2:
Characteristics of the study population.

All included children (n = 6163)		n (%)
Birth year	2018	1323 (21.4)
	2019	3171 (51.5)
	2020	1669 (27.1)
Sex	Female	3044 (49.4)
	Male	3119 (50.6)
Nationality	Swiss	4676 (75.9)
	Non-Swiss	1487 (24.1)
Geographic setting	Urban	3985 (64.7)
	Rural	2178 (35.3)
Major region*	Lake Geneva	1132 (18.4)
	Espace Mittelland	1425 (23.1)
	Northwestern Switzerland	644 (10.4)
	Eastern Switzerland	1366 (22.2)
	Ticino	237 (3.8)
	Central Switzerland	1107 (18.0)
	Zurich	252 (4.1)

* The table S1 in the appendix outlines the major regions along with their respective cantons included in the analysis.

Table 3:
Diphtheria vaccination (Di) coverage at the 1st, 2nd and 3rd dose.

Dose	Period	Sample n	Proportion of children vaccinated before ...	Proportion of children vaccinated before ...
Di1			... 3 months of age	... 15 months of age
	COVID-19	1669	87.4% (85.1–89.6%)	96.2% (94.8–97.3%)
	Pre-COVID-19	3171	90.0% (88.5–91.3%)	97.4% (96.6–98.0%)
Di2			... 5 months of age	... 17 months of age
	COVID-19	1855	86.0% (83.7–88.1%)	95.9% (94.5–97.0%)
	Pre-COVID-19	3031	87.2% (85.4–88.8%)	96.4% (95.5–97.2%)
Di3			... 13 months of age	... 25 months of age
	COVID-19	2598	75.8% (73.4–78.1%)	94.7% (93.5–95.7%)
	Pre-COVID-19	2250	77.7% (75.2–80.0%)	95.2% (93.9–96.4%)

Measles vaccination

Vaccination coverage for the first and second doses of the measles-containing vaccine (MCV1 and MCV2, respectively) during the COVID-19 pandemic were notably higher compared to the pre-COVID-19 period (table 5). For MCV1, the COVID-19 cohort had a vaccination coverage of 79.7% before 10 months of age. In contrast, the pre-COVID-19 cohort showed a coverage of 71.6% before 10 months of age. Similarly, for MCV2, the COVID-19 cohort had a vaccination coverage of 34.9% before 13 months of age, whereas the pre-COVID-19 cohort had a coverage of 31.5% before 13 months of age. Before 22 and 25 months of age, there was no difference in the proportion of children vaccinated between the two cohorts for MCV1 and MCV2.

Factors associated with the likelihood of children receiving vaccination during the COVID-19 pandemic

Three different multivariable logistic regression models were conducted to explore factors associated with the likelihood of children receiving the first dose of the diphtheria vaccine, pneumococcal conjugate vaccine and measles-containing vaccine, adjusting for several independent variables: nationality, major region (seven different regions of Switzerland), urban vs rural setting, the child's sex and the COVID-19 pandemic (eligibility for vaccination during the COVID-19 vs pre-COVID-19 period).

Non-Swiss toddlers were significantly more likely to receive Di1 vaccination compared to their Swiss counterparts (aOR = 1.66, p <0.05), as shown in table 6. Compared to toddlers from the Lake Geneva region, those from three other regions were significantly less likely to receive Di1 vaccination, namely Espace Mittelland (aOR = 0.18, p <0.001), Northern Switzerland (aOR = 0.14, p <0.05) and Central Switzerland (aOR = 0.18, p <0.001); in contrast toddlers living in Eastern Switzerland showed a higher likelihood of receiving the vaccination (aOR = 0.14, p <0.001). Living in an urban area was associated with a higher likelihood of receiving the vaccination (aOR = 1.56, p <0.05). The time period in relation to the COVID-19 pandemic did not significantly affect the likelihood of receiving the vaccination (aOR = 0.98, p = 0.90).

In the second model (table 7), non-Swiss toddlers were significantly more likely to receive the vaccination than Swiss toddlers (aOR = 1.81, p <0.001). Children living in the Espace Mittelland, Northwestern Switzerland, Eastern Switzerland and Central Switzerland regions were significantly less likely to receive the vaccination compared to the reference region (Espace Mittelland: aOR = 0.40, p <0.001; Northwestern Switzerland: aOR = 0.56, p <0.05; Eastern Switzerland: aOR = 0.31, p <0.001; Central Switzerland: aOR = 0.39, p <0.001). Living in an urban area was associated with a higher likelihood of receiving the vaccination (aOR = 1.81, p <0.001). There was no significant effect of either sex or the COVID-19 pandemic on vaccination uptake (aOR = 0.98, p = 0.866 and aOR = 0.87, p = 0.20, respectively).

The MCV1 model (table 8) showed that non-Swiss toddlers were significantly more likely to receive the vaccination compared to toddlers with Swiss nationality (aOR = 1.58, p <0.05). Those living in Espace Mittelland (aOR = 0.63, p <0.05) and Eastern Switzerland (aOR = 0.66, p <0.05) were significantly less likely to receive the vaccination than toddlers in the Lake Geneva region. Living in an urban area was associated with a higher likelihood of receiving the vaccination (aOR = 1.63, p <0.001). However, sex and the COVID-19 pandemic did not significantly affect the likelihood of receiving the vaccination (aOR = 1.04, p = 0.74 and aOR = 0.89, p = 0.41, respectively).

Discussion

The vaccination coverage for all three doses of diphtheria remained consistently high during both the COVID-19 pandemic and the pre-COVID-19 period, demonstrating

Table 4:
Pneumococcal conjugate vaccine (PCV) vaccination coverage at the 1st, 2nd and 3rd dose.

Dose	Period	Sample n	Proportion of children vaccinated before ...	Proportion of children vaccinated before ...
PCV1			... 3 months of age	... 15 months of age
	COVID-19	1669	84.1% (81.6–86.4%)	90.1% (88.0–92.0%)
	Pre-COVID-19	3171	86.4% (84.7–87.9%)	94.1% (93.1–95.0%)
PCV2			... 5 months of age	... 17 months of age
	COVID-19	1855	82.1% (79.7–84.4%)	90.5% (88.6–92.2%)
	Pre-COVID-19	3031	83.7% (81.8–85.5%)	93.2% (91.9–94.3%)
PCV3			... 13 months of age	... 25 months of age
	COVID-19	2598	67.4% (64.9–69.8%)	89.7% (88.1–91.1%)
	Pre-COVID-19	2250	66.3% (63.5–69.1%)	88.1% (86.1–90.0%)

Table 5:
Measles vaccination coverage (MCV) at the 1st and 2nd dose.

Dose	Period	Sample n	Proportion of children vaccinated before ...	Proportion of children vaccinated before ...
MCV1			... 10 months of age	... 22 months of age
	COVID-19	2354	79.7% (77.4–81.9%)	94.9% (93.6–96.0%)
	Pre-COVID-19	2560	71.6% (69.0–74.1%)	94.9% (93.6–96.0%)
MCV2			... 13 months of age	... 25 months of age
	COVID-19	2598	34.9% (32.3–37.5%)	90.8% (89.2–92.2%)
	Pre-COVID-19	2250	31.5% (28.8–34.3%)	90.6% (88.7–92.2%)

resilience in the vaccination programme. For the diphtheria vaccine, first dose (Di1), the COVID-19 cohort had a vaccination rate that was slightly lower than the pre-COVID-19 rates. This marginal decline is consistent with findings in other studies, such as those by Santoli et al. and Bramer et al., which reported minor disruptions in routine vaccinations during the early stages of the pandemic but a recovery in vaccination coverage later in the year [20–23].

Table 6:
Multivariable logistic regression analysis for diphtheria vaccination at 1st dose.

Variable		Estimate	Adjusted odds ratio (95% CI)	SE	z-value	p-value (>|z|)
Nationality (non-Swiss = 1)		0.509	1.66 [1.06, 2.74]	0.240	2.119	0.03*
Major regions (ref. = Lake Geneva)	…Espace Mittelland	−1.743	0.18 [0.07, 0.37]	0.418	−4.171	<0.001***
	…Northwestern Switzerland	−1.194	0.30 [0.11, 0.75]	0.472	−2.529	0.01*
	…Eastern Switzerland	1.949	0.14 [0.06, 0.30]	0.408	−4.771	<0.001***
	…Ticino	12.508	270.5 [3.07^{e+33}, 1.75^{e+105}]	574.70	0.022	0.98
	…Central Switzerland	−0.955	0.18 [0.07, 0.40]	0.215	−4.439	<0.001***
	…Zurich	−1.711	253.228 [5.45^{e+44}, 2.15^{e+145}]	0.430	−3.974	<0.001***
Geographic setting (urban = 1)		0.442	1.56 [1.11, 2.18]	0.172	2.574	0.01*
Sex (male = 1)		−0.019	0.98 [0.71, 1.35]	0.164	−0.117	0.91
COVID-19		−0.023	0.98 [0.70, 1.37]	0.172	−0.131	0.90

CI: confidence interval; ref.: reference category; SE: standard error.

Level of statistical significance: * for p <0.05; ** for p <0.01; *** for p <0.001.

Table 7:
Multivariable logistic regression analysis for pneumococcal vaccination at 1st dose.

Variable		Estimate	Adjusted odds ratio (95% CI)	SE	z-value	p-value (>|z|)
Nationality (non-Swiss = 1)		0.592	1.81 [1.35, 2.47]	0.154	3.836	<0.001***
Major regions (ref. = Lake Geneva)	…Espace Mittelland	−0.912	0.40 [0.27, 0.60]	0.206	−4.422	<0.001***
	…Northwestern Switzerland	−0.581	0.56 [0.35, 0.90]	0.242	−2.396	0.02*
	…Eastern Switzerland	−1.159	0.31 [0.21, 0.46]	0.197	−5.872	<0.001***
	…Ticino	13.145	511.4 [2.92^{e+107}, 1.10^{e+73}]	347.4	0.038	0.97
	…Central Switzerland	−0.955	0.39 [0.25, 0.58]	0.215	−4.439	<0.001***
	…Zurich	13.053	466.6 [0, 5.09^{e+32}]	488.1	0.027	0.98
Geographic setting (urban = 1)		0.593	1.81 [1.46, 2.25]	0.111	5.321	<0.001***
Sex (male = 1)		−0.018	0.98 [0.80, 1.21]	0.106	−0.169	0.87
COVID-19		−0.144	0.87 [0.70, 1.08]	0.112	−1.294	0.20

CI: confidence interval; ref.: reference category; SE: standard error.

Level of statistical significance: * for p <0.05; ** for p <0.01; *** for p <0.001.

Table 8:
Multivariable logistic regression analysis for measles vaccination at 1st dose.

Variable		Estimate	Adjusted odds ratio (95% CI)	SE	z-value	p-value (>|z|)
Nationality (non-Swiss = 1)		0.461	1.58 [1.12, 2.30]	0.183	2.519	0.012*
Major regions (ref. = Lake Geneva)	…Espace Mittelland	−0.457	0.63 [0.41, 0.97]	0.221	−2.071	0.04*
	…Northwestern Switzerland	−0.069	0.93 [0.54, 1.68]	0.289	−0.239	0.81
	…Eastern Switzerland	−0.423	0.66 [0.43, 0.99]	0.216	−1.962	0.05*
	…Ticino	−0.394	0.68 [0.33, 1.53]	0.387	−1.016	0.31
	…Central Switzerland	−0.301	0.74 [0.47, 1.17]	0.235	−1.280	0.20
	…Zurich	0.019	1.02 [0.43, 3.02]	0.490	0.038	0.97
Geographic setting (urban = 1)		0.491	1.63 [1.23, 2.17]	0.144	2.574	0.001***
Sex (male = 1)		0.044	1.04 [0.81, 1.35]	0.132	0.330	0.74
COVID-19		−0.116	0.89 [0.67, 1.18]	0.142	−0.817	0.41

CI: confidence interval; ref.: reference category; SE: standard error.

Level of statistical significance: * for p <0.05; ** for p <0.01; *** for p <0.001.

In our analysis, however, the overlapping confidence intervals for all three vaccines suggest that the observed differences were not statistically significant, indicating stability in vaccination rates despite the pandemic; moreover, our results also showed that before 25 months of age, differences in vaccination coverage between the two cohorts became minimal. For the diphtheria vaccine, second dose (Di2) and diphtheria vaccine, third dose (Di3), the vaccination coverage was relatively similar in the COVID-19 and pre-COVID-19 cohorts.

Pneumococcal conjugate vaccine vaccination rates presented mixed trends between the COVID-19 cohort and the pre-COVID-19 cohort but were relatively similar. The overlapping confidence intervals for all three vaccines suggest that the observed differences were not statistically significant, indicating stability in vaccination coverage despite the pandemic. Interestingly, despite both Di1 and pneumococcal conjugate vaccine, first dose (PCV1) typically being administered during the same consultation, we observed differences in uptake, such as higher coverage for Di1 but lower for PCV1. One possible explanation for this discrepancy is the difference in how these vaccines are perceived by parents. As observed in studies from other settings, such as Bonanni and Bergammi [24] in Italy, vaccines classified as mandatory (e.g. diphtheria) tend to have higher parental acceptance, while facultative vaccines (e.g. pneumococcal conjugate vaccine) may be perceived as less essential. This difference in perception may lead to greater adherence to the former, even when both are offered simultaneously. However, this discrepancy cannot be further investigated within the scope of our study, as the SNVCS does not collect information on the specific vaccine product or combination administered, nor on vaccine availability.

In contrast to diphtheria, vaccination coverage estimates for MCV1 and MCV2 were higher during the COVID-19 pandemic compared to the pre-COVID-19 period. These higher proportions in the COVID-19 cohort suggest an improvement in vaccination uptake during the pandemic period. However, it is important to consider that changes to the national immunisation schedule introduced in 2019 may have contributed to this finding. Specifically, in 2019, the Swiss FOPH updated the immunisation schedule to recommend earlier administration of both the first and second doses of the measles-containing vaccine: MCV1 was moved from 12 to 9 months of age and MCV2 from 15–24 months to 12 months of age [25]. As the COVID-19 cohort was more likely to be vaccinated under these updated recommendations, this policy change may partially explain the increased coverage observed in our analysis [26]. In contrast, the pre-COVID-19 cohort only partially overlapped with the implementation of the updated recommendation, leading to lower adherence in that group. Therefore, the recommendation policy change should be considered when interpreting differences between the cohorts in measles vaccination coverage during this period.

Urban areas typically offer easier access to healthcare facilities, paediatricians and vaccination services, which can facilitate timely immunisation [27–29]. This pattern was also reflected in our findings: logistic regression analysis showed that both an urban setting and nationality were linked to a higher likelihood of receiving measles-containing vaccination. This is consistent with previous findings before the pandemic in which toddlers in urban areas and those of non-Swiss nationality were more likely to receive timely measles-containing vaccinations compared to their counterparts [12–14].

Cultural attitudes and health prevention activities towards vaccination may also differ across linguistic and regional lines. Studies have shown higher levels of vaccine hesitancy in German-speaking regions than in French-speaking areas [30–32]; this regional disparity has also been observed in the uptake of other vaccines, such as pneumococcal and influenza vaccines [33, 34]. Specifically, children living in the Lake Geneva region (French-speaking cantons) generally had a higher probability of being vaccinated than those in most German-speaking regions. By focusing on Switzerland's major geographic regions rather than purely linguistic divisions (German-, French- and Italian-speaking regions), we were able to capture more granular variations in vaccination coverage with greater precision.

Socioeconomic status, although not directly assessed in our study, has also been shown in other studies to influence vaccination uptake, with higher-income or better-educated households potentially having greater health literacy or trust in vaccines [35–37]. These hypotheses warrant further investigation in future studies incorporating individual- and household-level socioeconomic data.

Interestingly, the COVID-19 pandemic did not have a significant impact on the likelihood of receiving any of the vaccinations we examined, which confirmed our results showing no difference in vaccination uptake between COVID-19 and pre-COVID-19 cohorts. It is important to note that during the early COVID-19 pandemic period, many countries, including Switzerland, saw decreased reporting of measles infections [38–40]. However, in 2023, the CDC documented a resurgence of measles in several countries, including the United States, Ethiopia, Yemen and Afghanistan, attributing the increase in part to pandemic-related disruptions in routine immunisation programmes [41, 42]. This trend continued into 2024, with the WHO reporting that Europe experienced its highest number of measles cases in the past 28 years [43].

Measles incidence has seen a notable increase in Switzerland: the Swiss FOPH recorded for Switzerland and the Principality of Liechtenstein only 1 case in 2022, 38 in 2023, increasing to 98 confirmed cases by 2024 – though still well below the 2019 peak of over 220 cases. An example of measles activity in Switzerland is the outbreak in the canton of Vaud between January and March 2024, where 51 cases were reported following an imported index case. Remarkably, 72.5% of these cases occurred in individuals who had received at least MCV1, with 61% fully vaccinated with two doses. This phenomenon of "breakthrough" infections in a highly vaccinated population reflects what is known as Orenstein's paradox, where a highly effective vaccine combined with very high coverage results in a larger proportion of cases among vaccinated individuals [44]. This event underlines the complexity of measles control even in countries with high vaccination coverage like Switzerland, revealing vulnerabilities in outbreak containment and the need for vigilance.

Surveillance data in Switzerland has also indicated that invasive pneumococcal disease cases declined sharply during the COVID-19 pandemic, dropping from 862 cases in 2019 to 549 in 2020 and 518 in 2021. This decline likely reflects reduced transmission due to public health measures such as masking and social distancing. Overall, there has been a substantial reduction in almost all recorded infectious diseases in the 2020 period as compared with earlier years [45]. Following the easing of restrictions, case numbers began to rebound, with 869 cases reported in 2022, 939 in 2023 and peaking at 1056 in 2024. A minor diphtheria cluster occurred in an asylum seeker reception centre in late 2022, but this was rapidly contained and did not spread widely [46]. Diphtheria case numbers in Switzerland remained so far low from 2015 to 2021, with annual cases ranging between 2 and 10. However, a sharp increase was observed in 2022, with 128 reported cases – representing a significant anomaly [38]. This spike likely reflects increased international travel and migration in the post-pandemic period, as seen across Europe, rather than a decline in domestic childhood vaccination coverage. By 2023, the number of cases fell to 29, and further declined to 6 in 2024.

A limitation of this study is the reliance on cross-sectional data from the Swiss National Vaccination Coverage Survey, which restricts the ability to establish causal relationships between the COVID-19 pandemic and observed vaccination coverage trends. The 3-year rolling nature of the survey may introduce biases related to temporal differences in data collection across different cantons. Due to the small number of observations in certain geographic regions, such as Ticino and Zurich, the logistic regression model for Di1 and PCV1 produced inflated aOR estimates for these categories. This likely reflects data sparsity, where vaccination coverage appeared to be 100% for some specific vaccines within the defined time cohorts, resulting in no unvaccinated children in these subgroups. These findings should therefore be interpreted with caution, as they may reflect data sparsity rather than true regional differences in vaccination behaviour. Furthermore, while the study adjusts for variables such as nationality and geographic setting, it does not account for other potential confounders like socioeconomic status or healthcare access, which may have influenced vaccination timeliness. Finally, the non-availability of data for children vaccinated after the pandemic period may limit the generalisability of the findings.

Conclusion

Our study demonstrates that timely vaccination coverage for diphtheria, pneumococcal conjugate and measles vaccination remained relatively stable during the COVID-19 pandemic. Although there were slight non-significant declines in vaccinations for diphtheria and pneumococcal conjugate vaccines, children tended to catch up on their vaccinations over time, which is a positive sign of the robustness of the vaccination programme. Also, the COVID-19 pandemic period itself did not significantly affect vaccination likelihood. Similar to previous analyses by the SNVCS, nationality and regional disparities in vaccination coverage persisted, highlighting the need for targeted interventions to address these imbalances.

Data sharing statement

The participants of this study did not give written consent for their data to be shared publicly, so due to the sensitive nature of the research, supporting raw data are not available.

Acknowledgments

We would like to thank all the families, healthcare providers and cantons who participated in the surveys. Finally, we would like to thank Nora Baer for her help with data collection and organisation during the study.

Financial disclosure

The current analysis was supported by the Swiss Federal Office of Public Health (FOPH). The Swiss National Vaccination Coverage Survey (SNVCS) is funded by the cantons and the Federal Office of Public Health (FOPH).

Potential competing interests

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. Jan S. Fehr reports an allowance fee from the Federal Commission for Vaccination Recommendation (EKIF) as well as research grants to his institution from Gilead Sciences, MSD and ViiV Healthcare, all unrelated to this article. No other potential conflict of interest related to the content of this manuscript was disclosed.

References

1. Castrejon MM, Leal I, de Jesus Pereira Pinto T, Guzmán-Holst A. The impact of COVID-19 and catch-up strategies on routine childhood vaccine coverage trends in Latin America: A systematic literature review and database analysis. Hum Vaccin Immunother. 2022 Nov;18(6):2102353. http://dx.doi.org/10.1080/21645515.2022.2102353.
2. Dalton M, Sanderson B, Robinson LJ, Homer CS, Pomat W, Danchin M, et al. Impact of COVID-19 on routine childhood immunisations in low- and middle-income countries: A scoping review. PLOS Glob Public Health. 2023 Aug;3(8):e0002268. http://dx.doi.org/10.1371/journal.pgph.0002268.
3. Causey K, Fullman N, Sorensen RJ, Galles NC, Zheng P, Aravkin A, et al. Estimating global and regional disruptions to routine childhood vaccine coverage during the COVID-19 pandemic in 2020: a modelling study. Lancet. 2021 Aug;398(10299):522–34. http://dx.doi.org/10.1016/S0140-6736(21)01337-4.
4. Ghaznavi C, Eguchi A, Suu Lwin K, Yoneoka D, Tanoue Y, Kumar Rauniyar S, et al. Estimating global changes in routine childhood vaccination coverage during the COVID-19 pandemic, 2020-2021. Vaccine. 2023 Jun;41(28):4151–7. http://dx.doi.org/10.1016/j.vaccine.2023.05.034.
5. Unicef: COVID-19 pandemic leads to major backsliding on childhood vaccinations. 2021. Available from: https://www.unicef.org/press-releases/covid-19-pandemic-leads-major-backsliding-childhood-vaccinations-new-who-unicef-data
6. Shet A, Carr K, Danovaro-Holliday MC, Sodha SV, Prosperi C, Wunderlich J, et al. Impact of the SARS-CoV-2 pandemic on routine immunisation services: evidence of disruption and recovery from 170 countries and territories. Lancet Glob Health. 2022 Feb;10(2):e186–94. http://dx.doi.org/10.1016/S2214-109X(21)00512-X.
7. National Centre for Immunisation Research and Surveillance. Impact of COVID-19 on School-based Vaccination Programs Module 1, 2 & 3: Final report. 2023. Available from: https://ncirs.org.au/sites/default/files/2023-04/COVID%20impact%20on%20schools_Final%20report_April%202023.pdf
8. SeyedAlinaghi S, Afsahi AM, MohsseniPour M, Behnezhad F, Salehi MA, Barzegary A, et al. Late Complications of COVID-19; a Systematic Review of Current Evidence. Arch Acad Emerg Med. 2021 Jan;9(1):e14. http://dx.doi.org/10.22037/aaem.v9i1.1058.
9. Ogundele OA, Omotoso AA, Fagbemi AT. COVID-19 outbreak: a potential threat to routine vaccination programme activities in Nigeria. Hum Vaccin Immunother. 2021 Mar;17(3):661–3. http://dx.doi.org/10.1080/21645515.2020.1815490.
10. Bundesamt für Gesundheit und Eidgenössische Kommission für Impffragen. Schweizerischer Impfplan 2025. Available from: https://www.bag.admin.ch/bag/de/home/gesund-leben/gesundheitsfo-

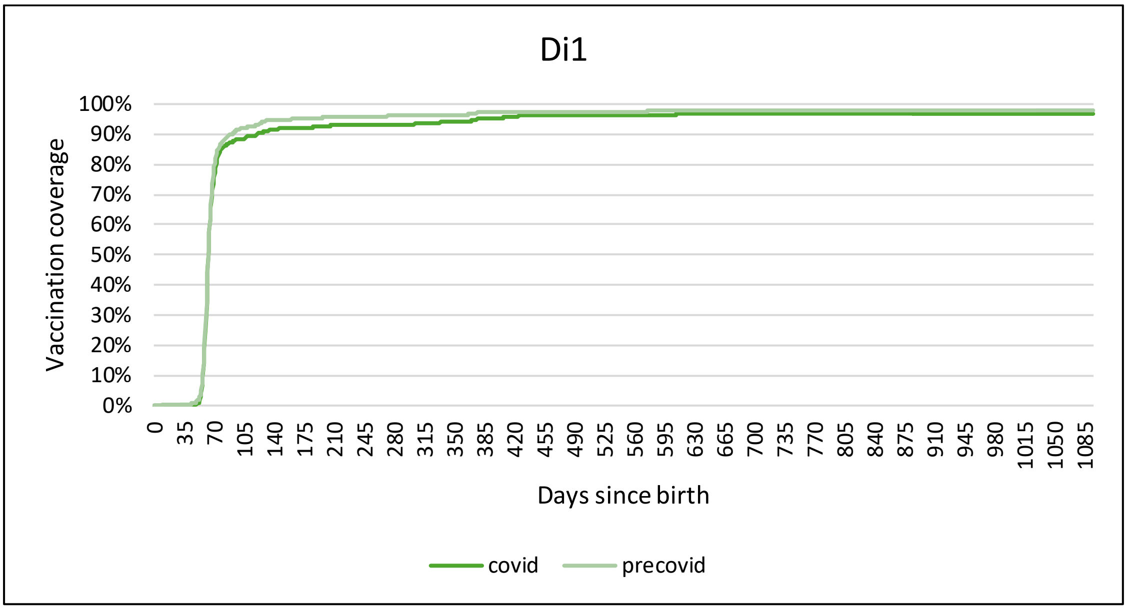
erderung-und-praevention/impfungen-prophylaxe/schweizerischer-impfplan.html
11. Bundesamt für Gesundheit: Kantonales Durchimpfungsmonitoring Schweiz Available from: https://www.bag.admin.ch/bag/de/home/gesund-leben/gesundheitsfoerderung-und-praevention/impfungen-prophylaxe/schweizerischer-impfplan.html [accessed 18 July 2025]
12. Lang P, Zimmermann H, Piller U, Steffen R, Hatz C: The Swiss National Vaccination Coverage Survey, 2005-2007. Public Health Rep 2011, 126 Suppl 2(Suppl 2):97-108. http://dx.doi.org/10.1177/00333549111260S212.
13. Luman ET, Barker LE, Shaw KM, McCauley MM, Buehler JW, Pickering LK. Timeliness of childhood vaccinations in the United States: days undervaccinated and number of vaccines delayed. JAMA. 2005 Mar;293(10):1204–11. http://dx.doi.org/10.1001/jama.293.10.1204.
14. Baroutsou V, Wymann M, Zens K, Sinniger P, Fehr J, Lang P. National and regional variations in timely adherence to recommended measles vaccination scheme in 2-years old in Switzerland, 2005-2019. Vaccine. 2022 May;40(22):3055–63. http://dx.doi.org/10.1016/j.vaccine.2022.04.008.
15. Akmatov MK, Kretzschmar M, Krämer A, Mikolajczyk RT. Timeliness of vaccination and its effects on fraction of vaccinated population. Vaccine. 2008 Jul;26(31):3805–11. http://dx.doi.org/10.1016/j.vaccine.2008.05.031.
16. Wariri O, Utazi CE, Okomo U, Metcalf CJ, Sogur M, Fofana S, et al. Mapping the timeliness of routine childhood vaccination in The Gambia: A spatial modelling study. Vaccine. 2023 Sep;41(39):5696–705. http://dx.doi.org/10.1016/j.vaccine.2023.08.004.
17. Kiely M, Boulianne N, Talbot D, Ouakki M, Guay M, Landry M, et al. Impact of vaccine delays at the 2, 4, 6 and 12 month visits on incomplete vaccination status by 24 months of age in Quebec, Canada. BMC Public Health. 2018 Dec;18(1):1364. http://dx.doi.org/10.1186/s12889-018-6235-6.
18. Lumley T. Analysis of Complex Survey Samples. J Stat Softw. 2004;9(8):1–19. http://dx.doi.org/10.18637/jss.v009.i08.
19. Bundesamt für Raumplanung. Die sieben Grossregionen der Schweiz Die Schweiz im europäischen Regionalsystem. 1999. Available from: https://www.admin.ch/gov/de/start/dokumentation/medienmitteilungen.msg-id-10585.html
20. Bramer CA, Kimmins LM, Swanson R, Kuo J, Vranesich P, Jacques-Carroll LA, et al. Decline in Child Vaccination Coverage During the COVID-19 Pandemic - Michigan Care Improvement Registry, May 2016-May 2020. MMWR Morb Mortal Wkly Rep. 2020 May;69(20):630–1. http://dx.doi.org/10.15585/mmwr.mm6920e1.
21. Santoli JM, Lindley MC, DeSilva MB, Kharbanda EO, Daley MF, Galloway L, et al. Effects of the COVID-19 Pandemic on Routine Pediatric Vaccine Ordering and Administration - United States, 2020. MMWR Morb Mortal Wkly Rep. 2020 May;69(19):591–3. http://dx.doi.org/10.15585/mmwr.mm6919e2.
22. Ackerson BK, Sy LS, Glenn SC, Qian L, Park CH, Riewerts RJ, et al. Pediatric Vaccination During the COVID-19 Pandemic. Pediatrics. 2021 Jul;148(1):e2020047092. http://dx.doi.org/10.1542/peds.2020-047092.
23. Teasdale CA, Borrell LN, Shen Y, Kimball S, Zimba R, Kulkarni S, et al. Missed routine pediatric care and vaccinations in US children during the first year of the COVID-19 pandemic. Prev Med. 2022 May;158:107025. http://dx.doi.org/10.1016/j.ypmed.2022.107025.
24. Bonanni P, Bergamini M. Factors influencing vaccine uptake in Italy. Vaccine. 2001 Oct;20 Suppl 1:S8–12. http://dx.doi.org/10.1016/S0264-410X(01)00284-5.
25. Bundesamt für Gesundheit: Anpassung des Impfplans für Säuglinge und Kinder bis 2 Jahre: Zusammenfassung und praktische Umsetzung. https://www.infovac.ch/docs/public/-main/anpassung-des-impfplans-fu--r-sa--uglinge-und-kinder-bis-2-jahre--zusammenfassung-und-praktische-umsetzung.pdf
26. Bundesamt für Gesundheit. Versorgungsengpass bei Impfstoffen: Ersatzempfehlungen für die Impfung gegen Masern, Mumps und Röteln (MMR). 2019. Available from: https://www.bag.admin.ch/dam/bag/de/dokumente/mt/i-und-b/impfstoffversorgung/vergangen/lieferunterbruch-mmr.pdf.download.pdf/lieferunterbruch-mmr-de.pdf
27. Freeman RE, Leary CS, Graham JM, Albers AN, Wehner BK, Daley MF, et al. Geographic proximity to immunization providers and vaccine series completion among children ages 0-24 months. Vaccine. 2023 Apr;41(17):2773–80. http://dx.doi.org/10.1016/j.vaccine.2023.03.025.
28. Albers AN, Thaker J, Newcomer SR. Barriers to and facilitators of early childhood immunization in rural areas of the United States: A systematic review of the literature. Prev Med Rep. 2022 Apr;27:101804. http://dx.doi.org/10.1016/j.pmedr.2022.101804.
29. Ménétrey A, Landolt MA, Buettcher M, Neuhaus TJ, Simma L. Vaccine Hesitancy in Central Switzerland: Identifying and Characterizing Undervaccinated Children in a Pediatric Emergency Department. Pediatr Rep. 2023 Dec;15(4):710–21. http://dx.doi.org/10.3390/pediatric15040064.
30. Ammeter T, Lang P, Czock A. Overview of the influenza vaccination activities and legal frameworks in 26 Swiss cantons during the influenza season 2019/20. Vaccine. 2022 Mar;40(12):1702–6. http://dx.doi.org/10.1016/j.vaccine.2022.02.009.
31. Ruckstuhl L, Czock A, Haile SR, Lang P. Influence of cantonal health policy frameworks & activities on the influenza vaccination rate in patients with non-communicable diseases in Switzerland. Vaccine. 2022 Oct;40(44):6326–36. http://dx.doi.org/10.1016/j.vaccine.2022.09.038.
32. Riesen M, Konstantinoudis G, Lang P, Low N, Hatz C, Maeusezahl M, et al. Exploring variation in human papillomavirus vaccination uptake in Switzerland: a multilevel spatial analysis of a national vaccination coverage survey. BMJ Open. 2018 May;8(5):e021006. http://dx.doi.org/10.1136/bmjopen-2017-021006.
33. Lang P, Wu CT-S, Le-Nguyen AF, Czock A: Influenza Vaccination Behaviour of Healthcare Workers in Switzerland: A Cross-Sectional Study. Int J Public Health. 2023 Mar 10;68:1605175. http://dx.doi.org/10.3389/ijph.2023.1605175.
34. Oyewole OR, Lang P, Albrich WC, Wissel K, Leib SL, Casanova C, et al. The Impact of Pneumococcal Conjugate Vaccine (PCV) Coverage Heterogeneities on the Changing Epidemiology of Invasive Pneumococcal Disease in Switzerland, 2005-2019. Microorganisms. 2021 May;9(5):1078. http://dx.doi.org/10.3390/microorganisms9051078.
35. Endrich MM, Blank PR, Szucs TD. Influenza vaccination uptake and socioeconomic determinants in 11 European countries. Vaccine. 2009 Jun;27(30):4018–24. http://dx.doi.org/10.1016/j.vaccine.2009.04.029.
36. Jary H, Pullen A, Howett D, Hani E, Suleman S, Byrne L, et al. Sociodemographic inequalities in the epidemiology and vaccine uptake within a large outbreak of measles in Birmingham, England, 2023 to 2024. Euro Surveill. 2025 Apr;30(16):2400652. http://dx.doi.org/10.2807/1560-7917.ES.2025.30.16.2400652.
37. Larson HJ, Jarrett C, Eckersberger E, Smith DM, Paterson P. Understanding vaccine hesitancy around vaccines and vaccination from a global perspective: a systematic review of published literature, 2007-2012. Vaccine. 2014 Apr;32(19):2150–9. http://dx.doi.org/10.1016/j.vaccine.2014.01.081.
38. Bundesamt für Gesundheit. Zahlen zu Infektionskrankheiten. 2024. Available from: https://www.bag.admin.ch/bag/de/home/zahlen-und-statistiken/zahlen-zu-infektionskrankheiten.exturl.html/aHR0cHM6Ly9tZWxkZXN5c3RlbWUuYmFnYXBwcy5jaC9pb-mZyZX/BvcnRpbmcvZGF0ZW5kZXRhaWxzL2QvbWFzZXJuL-mh0bWw_d2Vi/Z3JhYj1pZ25vcmU=.html
39. Torjesen I. Measles outbreaks likely as covid pandemic leaves millions of world's children unvaccinated, WHO warns. BMJ. 2021 Nov;375(2755):n2755. http://dx.doi.org/10.1136/bmj.n2755.
40. European Centre for Disease Prevention and Control. Measles: Annual Epidemiological Report for 2023. 2024. Available from: https://www.ecdc.europa.eu/en/publications-data/measles-annual-epidemiological-report-2023
41. Centres for Disease Prevention and Control. Global Measles Outbreaks. 2024. Available from: https://www.cdc.gov/global-measles-vaccination/data-research/global-measles-outbreaks/index.html
42. Centres for Disease Prevention and Control. Increase in Global and Domestic Measles Cases and Outbreaks: Ensure Children in the United States and Those Traveling Internationally 6 Months and Older are Current on MMR Vaccination. 2023. Available from: https://emergency.cdc.gov/han/2024/han00504.asp
43. World Health Organization. European Region reports highest number of measles cases in more than 25 years –UNICEF, WHO/Europe. 2023. Available from: https://www.who.int/europe/news/item/13-03-2025-european-region-reports-highest-number-of-measles-cases-in-more-than-25-years---unicef--who-europe
44. Cassini A, Cobuccio L, Glampedakis E, Cherpillod P, Crisinel PA, Pérez-Rodríguez FJ, et al. Adapting response to a measles outbreak in a context of high vaccination and breakthrough cases: an example from Vaud, Switzerland, January to March 2024. Euro Surveill. 2024 May;29(22):2400275. http://dx.doi.org/10.2807/1560-7917.ES.2024.29.22.2400275.
45. Steffen R, Lautenschlager S, Fehr J. Travel restrictions and lockdown during the COVID-19 pandemic-impact on notified infectious diseases

in Switzerland. J Travel Med. 2020 Dec;27(8):taaa180. http://dx.doi.org/10.1093/jtm/taaa180.

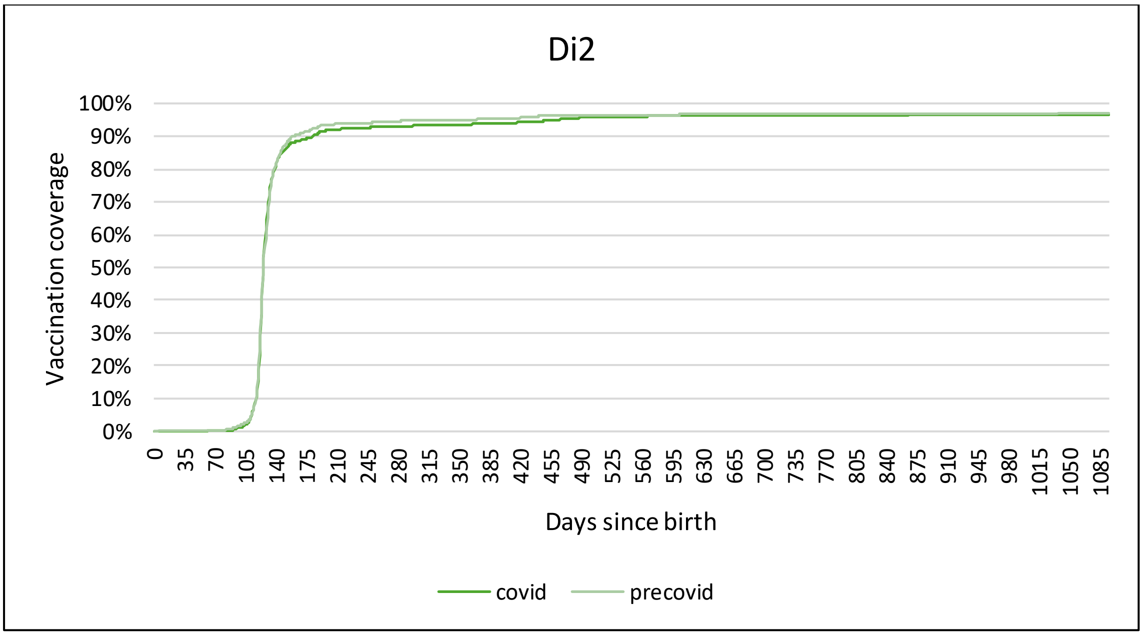
46. Brockhaus L, Urwyler P, Leutwyler U, Würfel E, Kohns Vasconcelos M, Goldenberger D, et al. Diphtheria in a Swiss Asylum Seeker Reception Centre: Outbreak Investigation and Evaluation of Testing and Vaccination Strategies. Int J Public Health. 2024 Apr;69:1606791. http://dx.doi.org/10.3389/ijph.2024.1606791.

Supplementary material

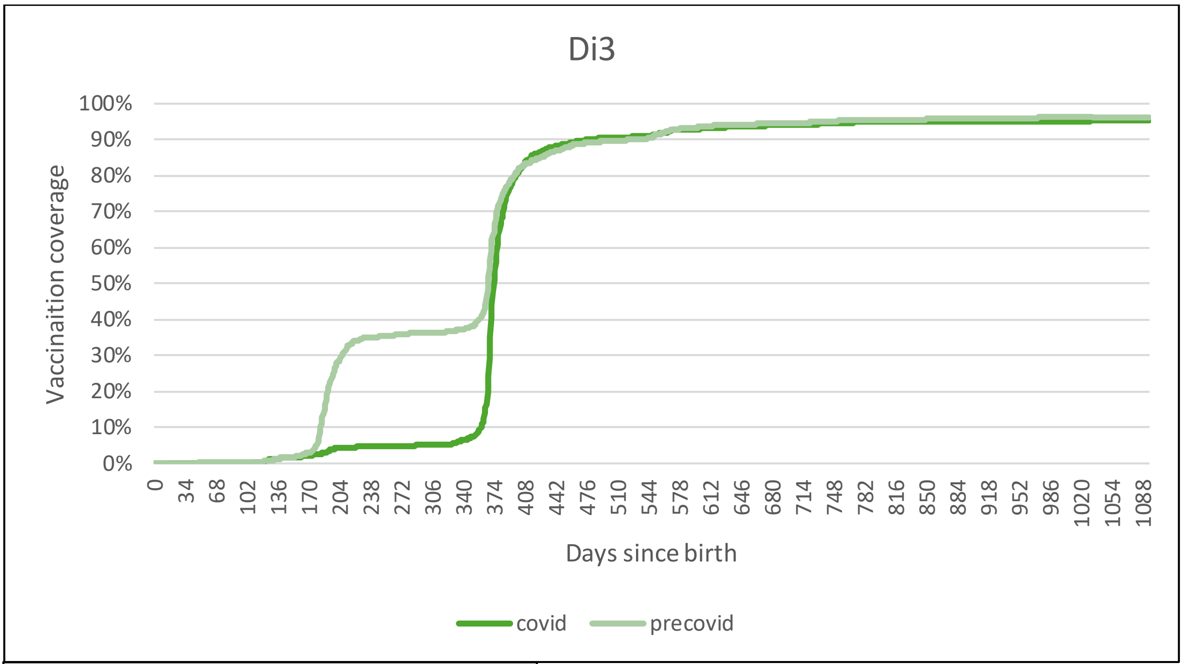
Supplementary figure S1. Vaccination Coverage for Diphtheria 1 dose (Di1)



Supplementary figure S2. Vaccination Coverage for Diphtheria 2 doses (Di2)

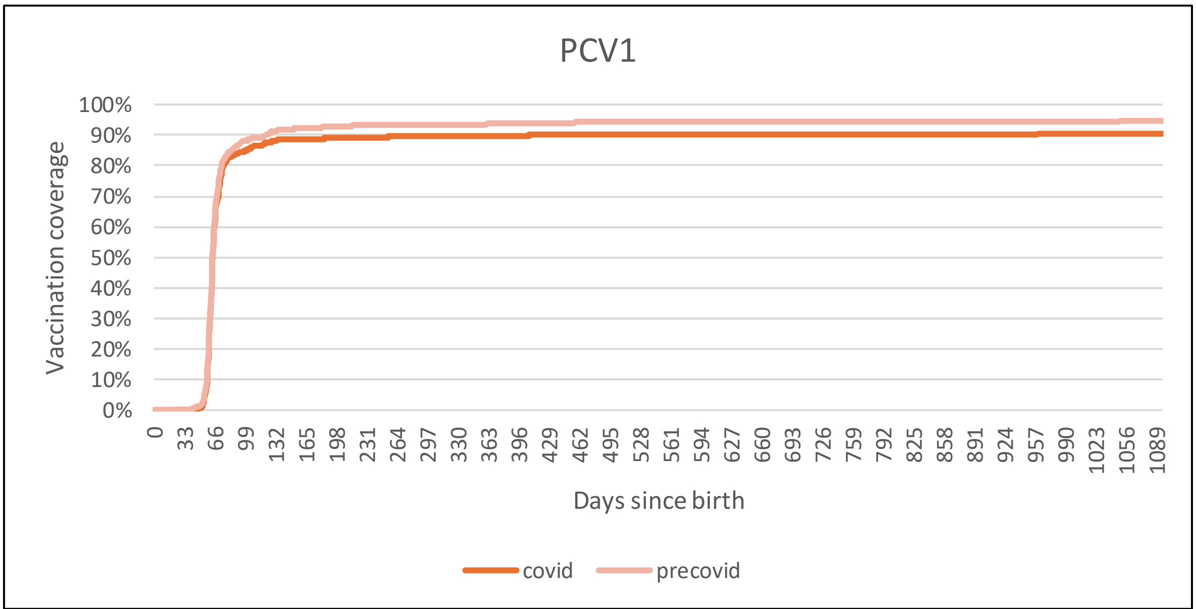


Supplementary figure S3. Vaccination Coverage for Diphtheria 3 doses (Di3)*

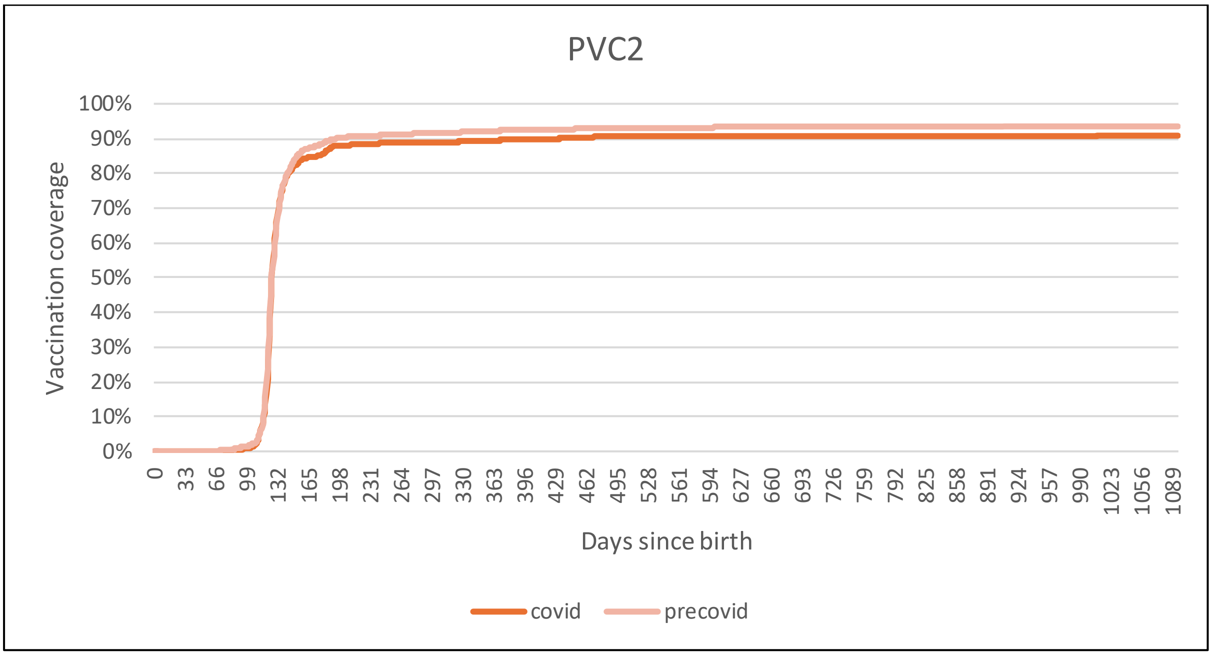


(Note*: adaptation in vaccination schedule 2019)

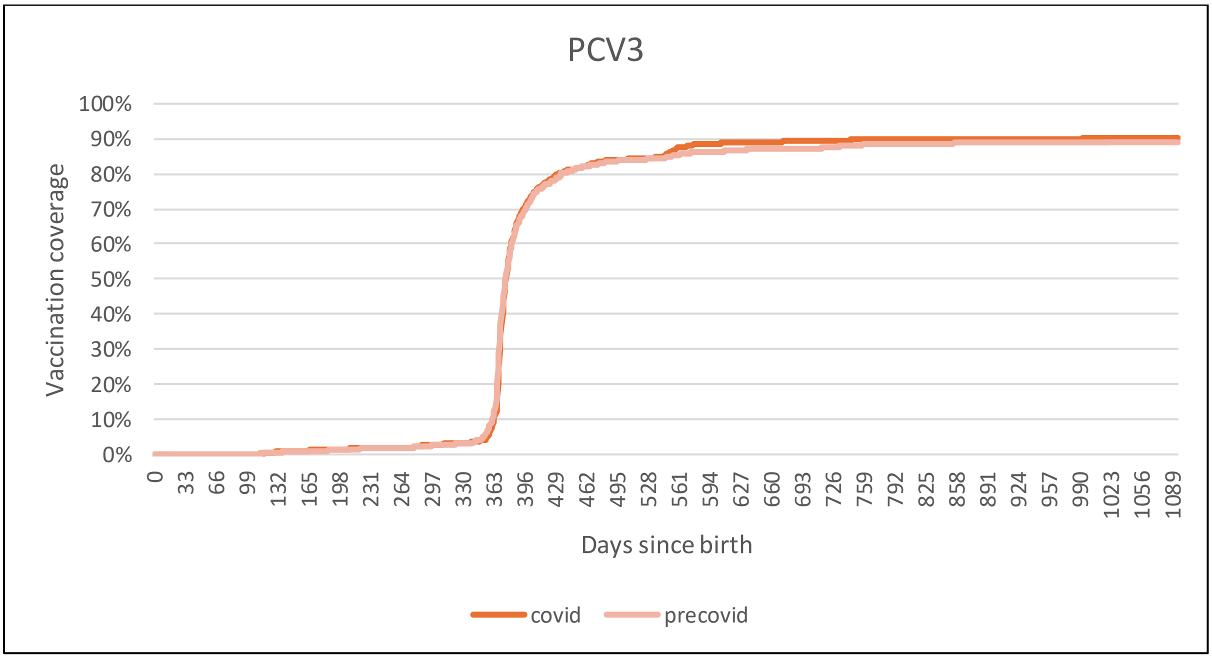
Supplementary figure S4. Vaccination Coverage for Pneumococcal Conjugate Vaccine 1 dose (PCV1)



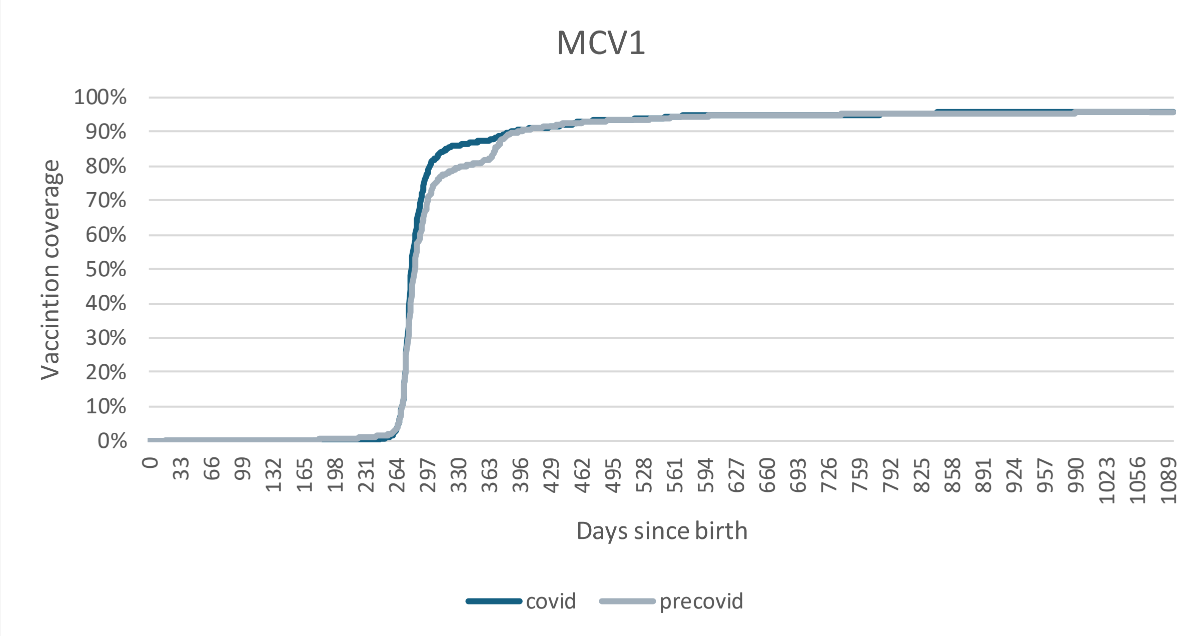
Supplementary figure S5. Vaccination Coverage for Pneumococcal Conjugate Vaccine 2 doses (PCV2)



Supplementary figure S6. Vaccination Coverage for Pneumococcal Conjugate Vaccine 3 doses (PCV3)

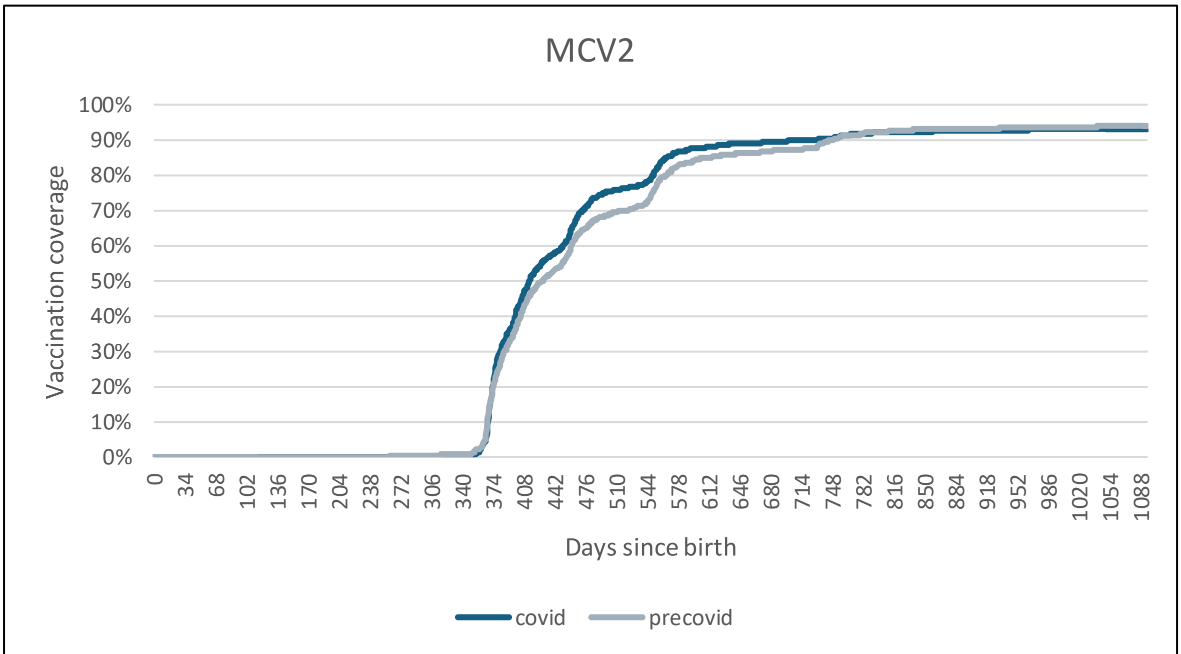


Supplementary figure S7. Vaccination Coverage for measles containing vaccine 1 dose (MCV1) *



(Note*: adaptation in vaccination schedule 2019)

Supplementary figure S8. Vaccination Coverage for measles containing vaccine 2 doses (MCV2)*



(Note*: adaptation in vaccination schedule 2019)

Table A1. Geographical major regions of Switzerland

Major regions	**Integrated Cantons**
Lake Geneva	Vaud, Valais, Geneva
Espace Mittelland	Berne, Fribourg, Solothurn, Neuchâtel, Jura
Northwest Switzerland	Basel-Stadt, Basel-Landschaft, Aargau
Zurich	Zurich
Eastern Switzerland	Glarus, Schaffhausen, Appenzell Ausserrhoden, Appenzell Innerrhoden, St. Gallen, Grisons, Thurgau
Central Switzerland	Lucerne, Uri, Schwyz, Obwalden, Nidwalden, Zug
Ticino	Ticino