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Pediatric health service utilization during the COVID-19 pandemic (PedCov)

Interim report

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Table of content

Table index

Figure index

Abbreviations

ATC	Anatomical Therapeutic Chemical *(e.g., vaccines)*
FOPH	Federal Office of Public Health
ED	Emergency department
ITS	Interrupted time-series modelling
SFSO	Swiss Federal Statistical Office
SGP	pädiatrie schweiz (Swiss Society of Pediatrics)
TBE	tick-born encephalitis
ATS	The Australasian Triage Scale
CTAS	The Canadian Triage and Acuity Scale
ARMA	autoregressive moving average

1 Introduction

The World Health Organization officially defined COVID-19 a pandemic on March 11th and in the meantime 215 253 258 cases have been confirmed in Europe, alone (1). All over the world a range of public health measures, containment, and control measures, have been implemented to curb the local epidemics. These measures, including social distancing and hygiene measures as well as restrictions in gathering and movement, have been implemented with varying stringency throughout the pandemic globally. The “lockdown”, the strongest response to the pandemic included “stay-at-home” orders, closing of schools and a shutdown of public life, was driven by the scenario of an exponential epidemic development. It is crucial to understand the impact and outcome of this pandemic and the measures taken against it on health both from a medical and public health perspective. In the early stage of the pandemic research focused on epidemiological data on confirmed cases and fatality or treatment, but increasingly the medical and public health community pointed to the impact of containment measures on the lives of citizens with a high risk of further impacting population health (2–10).

In Switzerland, in view of overburdened health facilities, the Swiss government decided restrictions for elective care and non-urgent health provision on March 13th, 2020 for all health professions and levels of care, primary to tertiary care – including pediatric health care. However, the pediatric associations and the Federal Office of Public Health (FOPH) communicated an exception for screening and vaccination visits for children up to 2 years of age.

As the pandemic continued, several additional waves occurred. Furthermore, it is likely that comparable threats emerge in the future. Hence, it becomes more and more important to investigate the secondary impact of the COVID-19 pandemic on pediatric care and health outcomes, not least to be able to derive insights for future pandemics. It is widely accepted, that pediatric care plays a pivotal role for health and development in childhood and adolescence, with long-term impact on adult health (11–15). This is true for treatment of acute or chronic disease as well as preventive encounters such as well child-visits and vaccinations.

International evidence indicates that general utilization of health services by children and adolescents has declined considerably during the lock-down, characterized by “stay-at-home” policies, closing of shops and schools and strong restrictions to public and private activities. Early warnings came from China and Italy, yielding lower numbers of emergency department visits (16,17) or outpatient healthcare visits (18), related to restrictive containment policies or fear of infection (19–23). The restricted or self-restricting behavior has led to side-effects such as delayed health care seeking (16,18,24–26), well-child visits or vaccinations (27–30) as well as postponements of well-child visits and treatment visits of children with severe disease (21,31,32), or with specific concerns and diagnoses

(18,19,33,34). In some countries, the reported drop in utilization by children and adolescents is very high. For example, in Saudi Arabia there was a 52.5% decline in daily average total number of vaccinations administered during lockdown compared to baseline (29). Emergency departments (EDs) in Italy reported a considerable decline in emergency visits of up to 73% and a doubling of hospitalizations (17,35). However, the publications vary in the effect sizes (36–40) and are not all consistent, some report stable or even increasing health care utilization for specific sub-groups (34,41). Many studies also rely on cross-sectional data. Thus, in addition to the overall effect, a more nuanced and longitudinal analysis of the COVID-19 effects on the utilization of health care by children and adolescents is needed to better understand the potential impact of pandemic measures. Longitudinal analyses also allow to differentiate whether changes in utilization were likely due to the pandemic or due to changes that already began before and continued throughout the pandemic. A decline might either indicate an actual reduction in health care needs or reduced health care seeking despite equal or increased need. On the other hand, stable consultations in mental health services despite the worsening of mental health problems and symptoms or abuse in children and adolescents (9,42–44) might be due to increased barriers in seeking help or limited resources to provide care for increasing numbers of people in need for treatment. And, some elective and preventive care, such as well-child visits and vaccinations, may only have been postponed. In fact, after an initial reduction of vaccinations early in the pandemic in the United Kingdom, a rebound was seen later in the pandemic (45), but this was not documented in all countries (30). Increasing health care seeking for respiratory symptoms during the pandemic – despite a general decline in health care utilization – may relate to a higher need of reassurance (46) and exclusion of a COVID-19 infection (18).

Studies that have addressed the impact of the COVID-19 pandemic and associated containment measures on children's and adolescents' general health, their utilization of different health services, and on the provision of health care to this age group comprehensively (i.e., concurrently for different health services) are largely missing for Switzerland. Such data are important to provide country-specific evidence and explanations for an adequate response by health authorities and policy makers.

2 Aims

Due to existing research gaps, the overall aim of the project was to estimate the impact of the pandemic on health care utilization in children and adolescents and to study factors associated with utilization.

More specifically, the project aimed to investigate…

a) …the utilization of pediatric primary and emergency care during the COVID-19 pandemic, measured in terms of the rates of consultations, compared to pre-pandemic utilization;

b) …age-specific patterns with respect to utilization, in general, and regarding diagnostic groups, elective visits or emergency visits during the COVID-19 pandemic compared to pre-pandemic health care utilization in primary or tertiary care;
c) …the association between utilization of pediatric care and confinement measure stringency and the epidemiological course of the pandemic.

Furthermore, it is intended that the results will inform policy and practice on the short and potential long-term impact of COVID-19 pandemic on child and adolescent health. The understanding of Swiss specific utilization patterns in relation to the pandemic development and measures will provide insights for future pandemic measures and communication strategies.

To address these goals, two types of data – health insurance data and pediatric ED data – were analyzed. For the sake of clarity, the methods, results and discussion of these two data types will be discussed one after another. An overall outlook is provided in a last Section.

3 Health insurance data

3.1 Methods

3.1.1 Study data

The main data for the quantitative analysis on a national level was obtained from the SASIS AG data and tariff pool (www.sasis.ch). The SASIS data include 96% of the pediatric population insured in Switzerland and provide detailed aggregated information on service providers and service recipients. Data are supplied by health insurers monthly. The SASIS data on the use of pediatric medical services was requested for the time frame between January 2018 and March 2022 and for the age group of 0-18-year-olds. Further data on pediatric health provision for the same age range and time frame was obtained from the SWICA insurance company. SWICA is one of the largest health insurance companies in Switzerland with around 1.5 million insured persons and a good representation of all language regions. The two data sets complement each other. While SASIS has the advantage of a very high coverage, it partly lacks the desirable level of detail. For example, information on the youngest patients is only available for the age group 0-5 years, even though it is desirable to assess the age group 0-2 years more fine-grained because 1) vaccination and well child-visits for this age group did not fall under the restrictions (see Introduction); and 2) children between the age of 0 to 2 years have a high consultation rate due to a high density of recommended well-child visits (47). In contrast, the SWICA is less representative compared to the SASIS data but has a more detailed breakdown in terms of age (including data on children who are between 0-12 months and 13-24 months old) and observational units (weekly rather than monthly data).

3.1.2 Population

3.1.2.1 SASIS

The average yearly permanent resident population of Switzerland (as reported by the Swiss Federal Statistical Office [SFSO]) was used to weight the SASIS data by a factor of 0.96 to describe the study population, since SASIS data represent 96% of all insured persons. The estimated number of insured subjects (0-18-year-olds) is presented in Table 1.

Table 1: Average yearly insured subjects by age, SASIS

	Estimated number of insured subjects	
Age	Number	Percent
0-5y	505623	32.1
6-10y	419825	26.7
11-15y	407171	25.9
16-18y	241738	15.4
Total	1574357	100.0

3.1.2.2 SWICA

The reported population characteristics are based on the average number of insured persons per calendar week over the entire observation period (i.e., weighted frequencies). As mentioned previously, SWICA is less representative compared to SASIS and includes a smaller population (137 520 rather than 1 574 357; see Table 2).

Table 2: Average weekly number of insured persons by age, SWICA

	Average population	
Age	Number	Percent
0-12m	8707	6.3
13-24m	8449	6.1
3-5y	24325	17.7
6-10y	38644	28.1
11-14y	29045	21.1
15-18y	28350	20.6
Total	137520	100.0

3.1.3 Variables (TARMED position and ATC-codes for vaccinations)

Tables 3 and 4 provide an overview of the variables that were built based on the requested TARMED positions and ATC-codes from SASIS and SWICA. A more detailed overview can be found in the Appendix 6.1. TARMED positions regarding mental health services were ordered from SASIS / SWICA as well. However, findings concerning these TARMED positions will only be reported in the final report and are therefore not yet included in Table 3.

Table 3: Overview of the considered TARMED Positions

Terminology used in the results	**Description**
(Developmental pediatric) consultations	
Consultations (00.0010)	Consultation, first 5 min. (basic consultation) *This code cannot be combined with the codes for well-child visits. Hence, practitioners use either code.*
Developmental pediatric consultations (03.0135)	Developmental pediatric examination of children/adolescents and adults up to 18 years of age by a specialist in pediatrics and adolescent medicine, per 5 min. *Aspects such as drinking, eating, crying, sleep patterns, autonomy development and development of social behavior are assessed in such developmental pediatric examinations.*
Well-child visits	
SASIS Well-child visits up to 5 years (03.0020-03.0090)	All well-child visits (screening and preventative interventions) according to the recommendations of the SGP'93 within the first 5 years were grouped together.
SWICA Well-child visits up to 12 months (03.0020/30/40/50/60)	All well-child visits (preventative examinations) according to the recommendations of the SGP'93 within the first year were grouped together.
Well-child visits for children over 1 to 5 years (03.0070/80/90)	All well-child visits (preventative examinations) according to the recommendations of the SGP'93 after the first up to the fifth year were grouped together.
Telephone consultations	
All telephone consultations (00.0110)	Telephone consultations by the physician, first 5 min.
Long telephone consultations (00.0120, 00.0125)	Telephone consultations by physician / specialist, every additional 5 min.
Urgent consultations/visits	
Urgent consultations/visits (00.2505/10/20/40/60/80)	Emergency inconvenience rate (e.g., for urgent consultations/visits outside regular office hours) *The urgency is not necessarily objectively present (as assessed by a physician) but might sometimes solely be perceived as such by the caregiver of the child.*

Note: SGP = "pädiatrie schweiz" (Swiss Society of Pediatrics)

Table 4: Overview of the considered vaccines

Terminology used in the results	Description / ATC-codes
Diphtheria/tetanus/pertussis (polio / haemophilus influenzae-b infection / hepatitis B)	Various polyvalent vaccines[1] were grouped together. All of them protect against diphtheria, tetanus, and pertussis, some additionally against polio, haemophilus influenzae-b infection, and/or hepatitis B. The following ATC-codes were grouped together: J07AJ52, J07CA02, J07CA06, J07CA09
Pneumococcus	J07AL02 which protects against Streptococcus pneumoniae serotypes 1, 3, 4, 5, 6A, 6B, 7F, 9V, 14, 18C, 19A, 19F, and 23F (Pneumococcal 13-valent conjugate vaccine)
Measles/mumps/rubella/(varicella)	Two ATC-codes were grouped together, J07BD52 and J07BD54. Both are aimed to prevent measles, mumps, and rubella. J07BD54 additionally protects against varicella.
Meningococcus	Two ATC-codes were grouped together: J07AH08 which protects against meningococcus ACWY and J07AH07 which protects against meningococcus type C.
TBE (tick-borne encephalitis)	J07BA01

Note: [1] A polyvalent vaccines immunizes against several pathogens or subtypes of a pathogen.

The reasoning for grouping certain ATC-codes together and to focus on specific age groups in the reporting is also based on the vaccination schedule of the Federal Office of Public Health (FOPH). According to this schedule (48–52), *basic vaccinations* are recommended because they are essential for the health of individuals and because they provide important protection for the health of the population. Furthermore, the FOPH lists *complementary vaccinations* that are recommended because they provide optimal individual protection. However, they do not belong to the basic vaccinations because they are not a public health priority. Lastly, some vaccinations are recommended for *particular risk groups*. Table 5 provides a simplified overview of the vaccination schedules (48–52) of the FOPH that were in use during our analytical time frame between 2018-2022.

Only the vaccinations that are relevant for the current project are listed. Regarding basic vaccinations, the initial vaccination should often be concluded by the 12th month. Initial shots in the 2nd, 4th, and 12th months are, for instance, recommended to prevent diphtheria, tetanus, pertussis, polio, haemophilus influenzae type B, and hepatitis B. Polyvalent vaccines (including a hexavalent combination vaccine) are generally used to prevent the above-mentioned disease. Therefore, the different vaccines that are used to prevent diphtheria, tetanus, pertussis, polio, haemophilus influenzae type B, and hepatitis B were grouped together for the analyses (see Table 3). For diphtheria, tetanus and pertussis, booster vaccinations are also recommended between 4-7 years and 11-14/15 years.

Vaccinations to prevent pneumococcus are also planned for the 2nd, 4th, and 12th month. Vaccinations against measles/mumps/rubella (a trivalent or quadrivalent (also including varicella) vaccine is used) are recommended at the age of 9 and 12 month. Regarding the observation period of the current project (2018-2022), the vaccination to prevent varicella was only recommended later (11-14/15 years) for those people who did not have this disease up to this point. However, vaccination against varicella can also be included as part of a polyvalent vaccine that also prevents measles, mumps, and rubella. Therefore, measles/mumps/rubella and varicella were grouped together for the analyses. Even though vaccinations against HPV also belong to the basic vaccinations, they are not mentioned in Table 5 because they are not recorded via ATC codes, but rather billed as part of the cantonal vaccination programs. Therefore, data on HPV-vaccinations are not available in the health insurance data.

The complementary vaccination against meningococcus is recommended at age 24 month and 11-14/15 years. The initial vaccination against tick-born encephalitis (TBE; recommended for people who are living in high-risk regions, which includes almost all parts of Switzerland, expect for the Canton of Geneva and of Ticino) are recommended from the 6 years onwards. In sum, the initial doses of the listed basic vaccinations are mostly concluded by the age of 12 months, whereas the complementary vaccinations or the vaccinations for risk-groups are scheduled for a (slightly) later point in time.

Table 5: Vaccination schedule 2019, adapted from the FOPH schedule

	Type of vaccination										
	Basic									Comple-mentary	For risk-groups
Age	Diphtheria	Tetanus	Pertussis	Polio	Haemophilus influenzae type B	Hepatitis B	Pneumococcus	Measles/mumps/rubella	Varicella	Meningococcus	Tick-born encephalitis
2 mo.	x	x	x	x	x	x	x				
4 mo.	x	x	x	x	x	x	x				
9 mo.								x			
12 mo.	x	x	x	x	x	x	x	x			
24 mo.										x	
4-7 yrs.	x[1]	x[1]	x[1]								x[3]
11-14/15 yrs.	x[1]	x[1]	x[1]						x[2]	x	x[3]

Note: Adapted from the vaccination schedules valid during the time period under investigation, 2018 - 2022 (48–52). HPV not listed, because HPV are not captured by insurance data. Catch-up vaccination (i.e., vaccination against a pathogen in the case of missing, incomplete, or unclear primary immunization), which might take place delayed (i.e., after the recommended point in time according to the schedule), are not listed in the table. Adults are not listed in the table, since the current project focuses on younger people (0-18 years of age).

[1] booster vaccinations (i.e., revaccination against a pathogen after complete primary vaccination, which took place some time ago). [2] Vaccination against varicella is recommended for individuals who did not have the disease up to this point. [3] Recommended for people living in endemic areas.

3.1.4 Statistical analyses – Interrupted Possion time-series model

The statistical analyses were based on monthly SASIS insurance data and weekly SWICA data (main outcome: TARMED positions and ATC-codes), respectively. Both data sets span the time frame between January 2018 and March 2022 (SWICA: first calendar week of 2018 – 9th calendar week of 2022). To determine potential effects of the pandemic, an interrupted Poisson time-series model (ITS) allowing for overdispersion and adjusting for seasonality by including two Fourier terms has been employed (see excurse on ITS below for more details).

The models include the following elements:

- "time": Time describes changes in utilization rates during the pre-pandemic period. An estimate that is lower than 1.0 and significant indicates that the rates decreased in the pre-pandemic period. In contrast, a significant estimate above 1.0 specifies that the utilization increased over the pre-pandemic period. An estimate of 1.0 indicates that the utilization did not change in the pre-pandemic phase.
- "pandemic": The average utilization rates of the pandemic period are compared with the average utilization rates in the pre-pandemic period (i.e., the two levels are compared). The date when the Swiss Federal Council announced the first lockdown has been chosen as the indicator discriminating between pre-pandemic and pandemic periods (this point in time can be interpreted as the "intervention" in the ITS models). If a significant estimate is below 1.0, it indicates that the average utilization rate was lower in the pandemic compared to the pre-pandemic period. If a significant estimate is above 1.0, it indicates that the average rates were higher in the pandemic vs. pre-pandemic period. An estimate of 1.0 indicates that the average rates did not differ between the pandemic and pre-pandemic period.
- "time x pandemic": The interaction term refers to the pandemic period. If it is significant, it indicates that the trend in the pandemic period differs from the one in the pre-pandemic phase. A significant estimate above 1.0 indicates that utilization rates increased again in the pandemic period. A significant estimate below 1.0 indicates a decrease in the utilization rates in the pandemic period. A non-significant interaction indicates that the utilization remained similar in the pandemic period.

Findings can be interpreted as being robust when they are based on utilization rates of about 10-20 per 1000 or more. The reporting of the results is guided by this statistical rule of thumb.

Graphical representations of ITS analyses show the predicted trend over the observation period (green line), a deseasonalised trend (blue line; i.e., the seasonal pattern from the observations (blue dots) was extracted from the data) – allowing for a better assessment of pandemic effects –, and a counterfactual trend, i.e., the trajectory if the pre-pandemic trend would have continued over the entire observation period (red line). Statistical significance has been established at $p<0.05$. All analyses have been conducted using Stata 17.0 (53).

Excurse on interrupted Poisson time-series

Time series is a series of values of a particular variable obtained at successive times. The interval between the data points is typically equal. An example of a time series is temperature that is measured repeatedly. In the analyses that are based on health insurance data, the time series consists of weekly or monthly measured utilization of health services (i.e., TARMED positions or ATC-positions).

Seasonality is an important aspect of time series. Variables that have a seasonal pattern include weather (e.g., warmer in summer / during the day compared to winter / night) or sales data (e.g., increases in sales before Christmas). But also some aspects of the population's health might follow a seasonal pattern (e.g., higher rates of flu infections in winter), which might also impact the utilization of particular health services. This methodological issue (seasonality) is addressed in our models.

Fourier terms are used to improve the fit of the model. They are used to control for seasonality in our estimated models.

Overdispersion: The Poisson distribution assumes that the variance is equal to the expected count. This assumption is often not met in real data, i.e., the variance is often greater than the expected count. This is called overdispersion. In our estimated models, we account for overdispersion.

ITS models are used to analyze whether changes in an outcome (e.g., health care utilization) are associated with a particular intervention (e.g., the implementation of a lock-down). The term "interruption" refers to the point in time when the intervention (in our analyses: the first lockdown) occurred. In other words, ITS tests the following hypothesis: "The outcome variable (health care utilization) did not change despite the intervention (the lockdown).". Our ITS models addressed all the methodological issues (i.e., seasonality and overdispersion) to improve the robustness of the analysis.

3.2 Results

Even though all TARMED positions and ATC-codes that are listed in Table 3 have been analyzed, we will mainly focus on the discussion of those results that can be assumed to be robust (i.e., rates of approximately 10-20 per 1000). As mentioned in the Methods, this threshold is based on statistical experiences and is aimed to limit over-interpretation of few data points.
Subsequently, the results are structured according to the TARMED positions or ACT-codes. For each TARMED position or ACT-code, the results that are based on SASIS are presented first, followed by the results of the SWICA data. As detailed in the Methods, the advantage

of the SASIS is its high coverage (representativeness), while the SWICA data has the advantage of using more nuanced age categories for the youngest children (rather than 0-5-year-olds, the SWICA uses the age categories 0-12 months, 13-24 months, and 3-5 years).

3.2.1 Basic consultations

3.2.1.1 SASIS

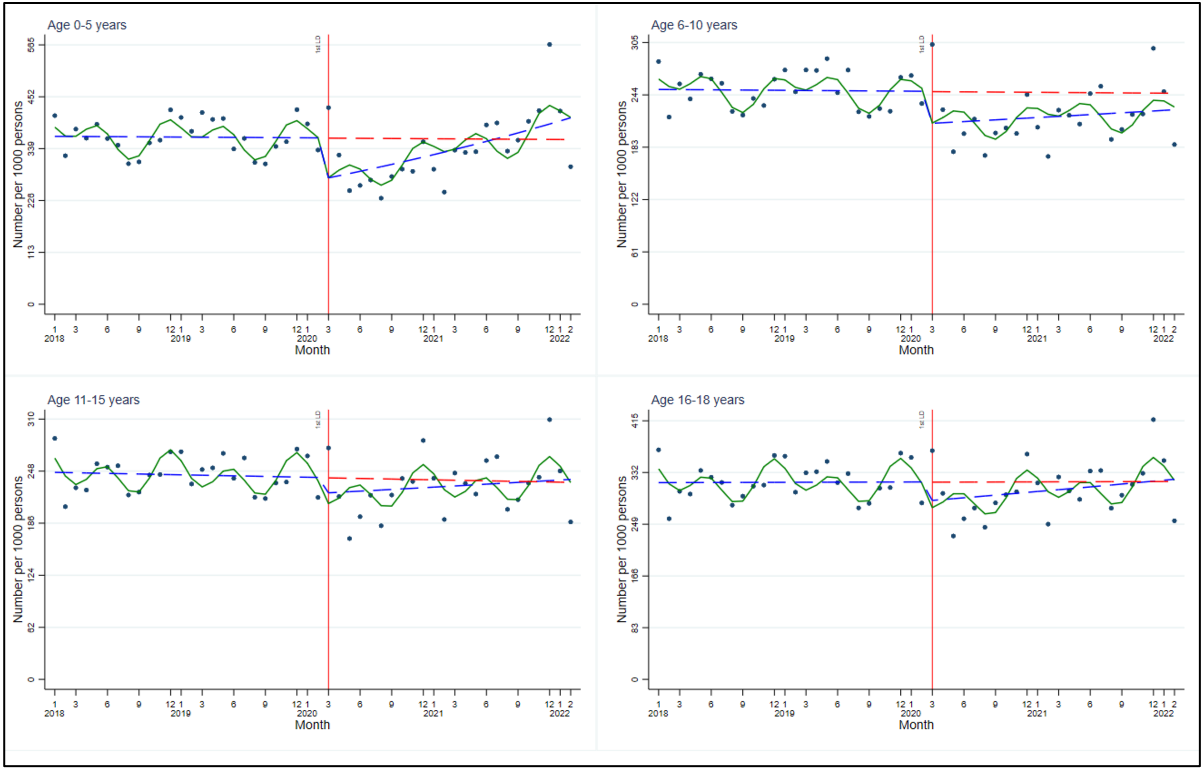
As shown in Table 6, the utilization rates for basic consultations (TARMED position 00.0010) did not change significantly in any age group during the pre-pandemic phase (as indicated by non-significant estimates for *time*). However, the average utilization rates for basic consultations were significantly lower in the pandemic compared to the pre-pandemic period in the two youngest age groups as indicated by significant estimates below 1 regarding the *pandemic effect* (0-5y: 0.760 [0.644-0.896], p < 0.01); 6-10y: 0.850 [0.742-0.974], p < 0.05). In the age group 0-5y, the utilization rates increase again during the pandemic phase, as indicated by a significant interaction term *time x pandemic* above 1 (1.017 [1.007-1.028], p<0.01). In other words: After an initial drop in the utilization immediately after the lockdown, utilization rates seemed to normalize to some extend and pre-pandemic levels of utilization were approximately reached during the observed pandemic period. In contrast, utilization rates remained low in the age group 6-10y in the pandemic phase (non-significant interaction term; 1.003 [0.994-1.013]). For the older age groups, (11-15y, 16-18y), no significant pandemic effects were observed, indicating that average utilization rates did not differ between pandemic and pre-pandemic phase. Furthermore, the interactions *time x pandemic* were not significant for these older age groups, indicating that utilization also did not change during the pandemic phase. The described patterns are also illustrated in Figure 1.

Table 6: Model estimates for consultations (00.0010), SASIS

	0-5y	6-10y	11-15y	16-18y
Time	1.000	1.000	0.999	1.000
	[0.993,1.007]	[0.994,1.006]	[0.993,1.005]	[0.995,1.006]
Pandemic	0.760**	0.850*	0.925	0.906
	[0.644,0.896]	[0.742,0.974]	[0.815,1.049]	[0.802,1.024]
Time x Pandemic	1.017**	1.003	1.004	1.005
	[1.007,1.028]	[0.994,1.013]	[0.996,1.012]	[0.997,1.013]

Note: Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality.
Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets.
* p < 0.05, ** p < 0.01, *** p < 0.001

Figure 1: Consultations (00.0010), SASIS



Caption: ● Observed —— Predicted – – – – Predicted deseasonlised trend – – – – Counterfactual

3.2.1.2 SWICA

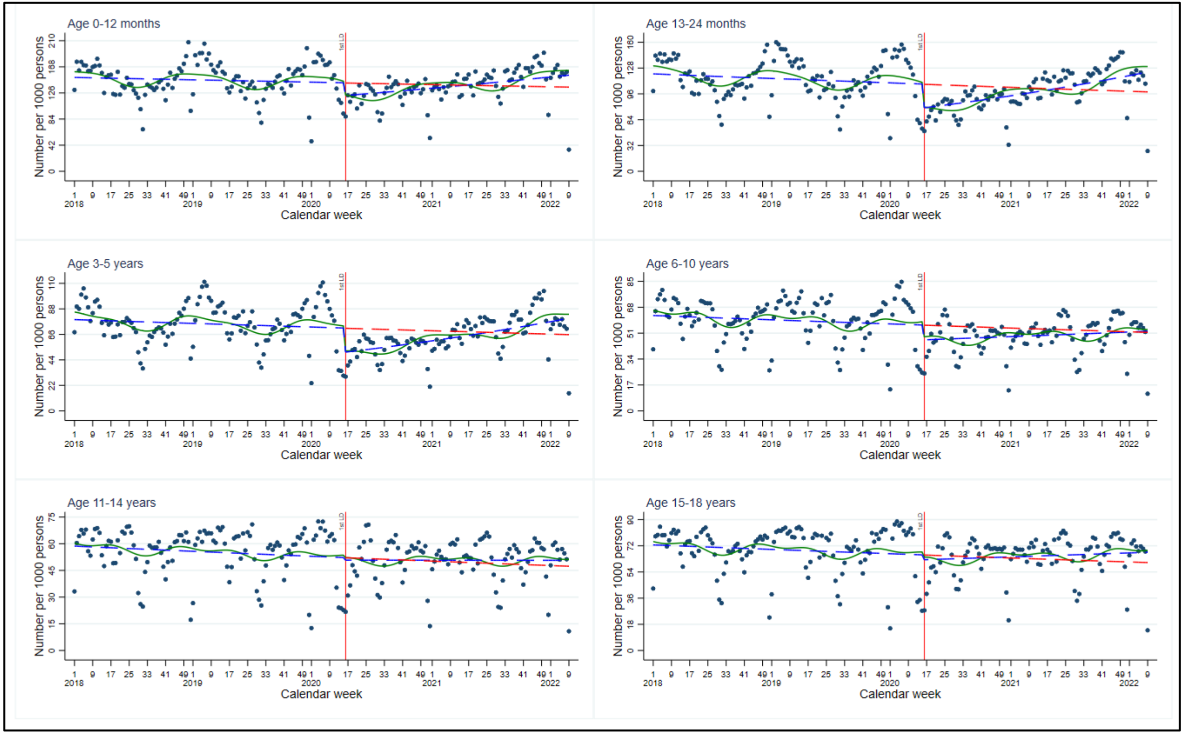
The SWICA-results largely correspond to the findings that have been described for SASIS. More specifically, no significant changes in utilization of basic consultations have been found in the pre-pandemic phase in the SWICA data (no significant effect of *time*; see Table 7), which confirms the findings from SASIS. Furthermore, the lower average utilization in the pandemic compared to the pre-pandemic phase that has been identified for 0-5- and 6-10-year-olds in the SASIS-data also emerged in the SWICA data: Significant pandemic effects were found for the age categories 0-12m (0.856 [0.778-0.943], p < 0.01), 13-24m (0.728 [0.650-0.816], p < 0.001), 3-5y (0.709 [0.626-0.804], p < 0.001), and 6-10y (0.828 [0.727-0.943], p < 0.01). That no significant pandemic effect emerged for the older age groups (11-14y, 15-18y) also corresponds to the SASIS-results described in the previous section. The normalization of utilization in the pandemic phase (an increase after an initial drop as indicated by a significant interaction term), that has been yielded for 0-5-year-olds in SASIS also emerged in SWICA (0-12m: 1.003 [1.001-1.004], p < 0.001; 13-14m: 1.005 [1.004-1.007], p < 0.001; 3-5y: 1.005 [1.004-1.007], p < 0.001). However, in contrast to SASIS where the decreased utilization remained low in 6-10-year-olds in the pandemic phase, a normalization was also observed for 6-10-year-olds in the SWICA data (1.002 [1.000-1.004], p < 0.05). The findings of no significant pandemic effects or interaction terms for the two oldest age groups (11-14y, 15-18y), however, are again in line with the SASIS-results (also see Figure 2).

Table 7: Model estimates for consultations (00.0010), SWICA

	0-12m	13-24m	3-5y	6-10y	11-14y	15-18y
Time	1.000	0.999	0.999	0.999	0.999	0.999
	[0.999,1.000]	[0.998,1.000]	[0.998,1.000]	[0.998,1.000]	[0.998,1.000]	[0.998,1.000]
Pandemic	0.856**	0.728***	0.709***	0.828**	0.973	0.950
	[0.778,0.943]	[0.650,0.816]	[0.626,0.804]	[0.727,0.943]	[0.849,1.115]	[0.840,1.075]
Time x Pandemic	1.003***	1.005***	1.005***	1.002*	1.001	1.002
	[1.001,1.004]	[1.004,1.007]	[1.004,1.007]	[1.000,1.004]	[0.999,1.003]	[1.000,1.004]

Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality.
Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets.
* p < 0.05, ** p < 0.01, *** p < 0.001

Figure 2: Consultations (00.0010), SWICA



Caption: ● Observed — Predicted – – – Predicted deseasonlised trend – – – Counterfactual

3.2.2 Developmental pediatric consultations

3.2.2.1 SASIS

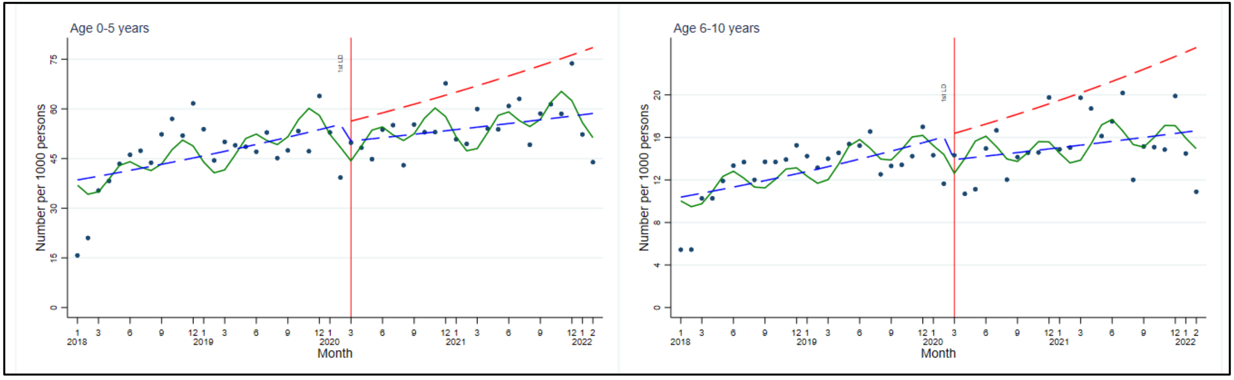
The TARMED position 03.0135 was mostly used for young children, possibly since developmental pediatric examinations focus on topics that are particularly important in infancy/early childhood (e.g., crying and sleeping patterns). Hence, only results for 0-5- and 6-10-year-olds are reported, whereby the rates for the later just lie above the threshold (10 per 1000) needed for robust findings (for older age groups, the rates were even lower). Table 8 indicates that the rates for this TARMED position increased in the pre-pandemic phase in 0-5-year- (1.015 [1.006-1.023], p < 0.01) and 6-10-year-olds (1.018 [1.008-1.028], p < 0.001). Even though Figure 3 seems to indicate that the utilization rates decreased slightly at the time of the lock-down in both age groups, the pandemic effect was not significant. Furthermore, no significant interactions (*time x pandemic*) were found, indicating that utilization did not change during the pandemic phase.

Table 8: Model estimates developmental pediatric consultations (03.0135), SASIS

	0-5y	6-10y
Time	1.015**	1.018***
	[1.006,1.023]	[1.008,1.028]
Pandemic	0.896	0.852
	[0.747,1.076]	[0.693,1.047]
Time x Pandemic	0.992	0.990
	[0.980,1.004]	[0.977,1.004]

Note: Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality.
Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets.
* p < 0.05, ** p < 0.01, *** p < 0.001

Figure 3: Developmental pediatric consultations (03.0135), SASIS



Caption: ● Observed —— Predicted – – – Predicted deseasonlised trend – – – Counterfactual

3.2.2.2 SWICA

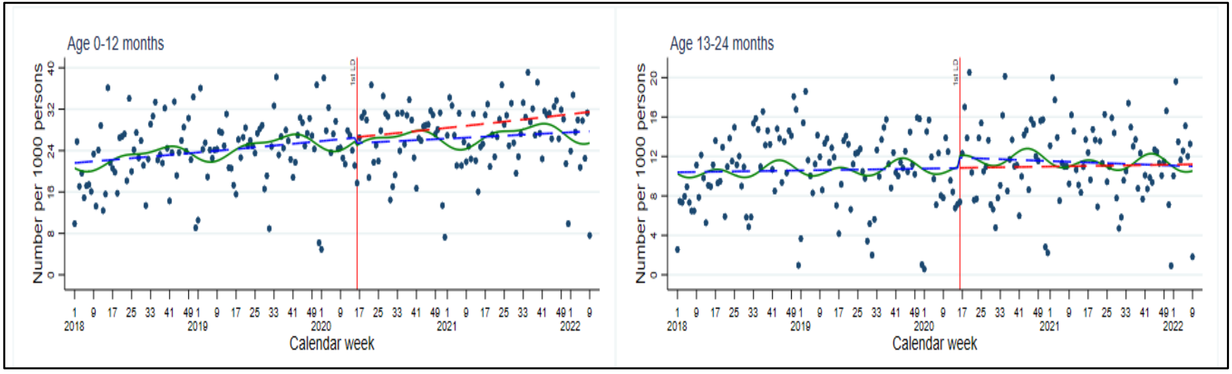
Regarding the TARMED position on developmental pediatric consultations, only the results for the youngest age groups (0-12m; 13-24m) are reported due to their robustness (see Table 9; the rates are too low for the older age groups). The significant increase in the utilization in the pre-pandemic phase (i.e., significant time effect) that has been described for 0-5-year-olds in the previous section (SASIS) also emerged for the 0-12-month-olds (1.002 [1.000-1.003], p < 0.005), but not for 13-24-months-olds in the SWICA-dataset (1.000 [0.998-1.002], not significant). In line with the SASIS-results, no pandemic effect or significant interaction was observed for this TARMED position in the SWICA-data. Overall, the pandemic did not seem to have impacted the utilization of developmental pediatric consultations (also see Figure 4).

Table 9: Model estimates developmental pediatric consultations (03.0135), SWICA

	0-12m	13-24m
Time	1.002*	1.000
	[1.000,1.003]	[0.998,1.002]
Pandemic	0.960	1.098
	[0.837,1.101]	[0.905,1.332]
Time x Pandemic	0.999	0.999
	[0.997,1.001]	[0.996,1.002]

Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality.
Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets.
* p < 0.05, ** p < 0.01, *** p < 0.001

Figure 4: Developmental pediatric consultations (03.0135), SWICA



Caption: ● Observed —— Predicted – – – Predicted deseasonlised trend – – – Counterfactual

3.2.3 Well-child visits

3.2.3.1 SASIS

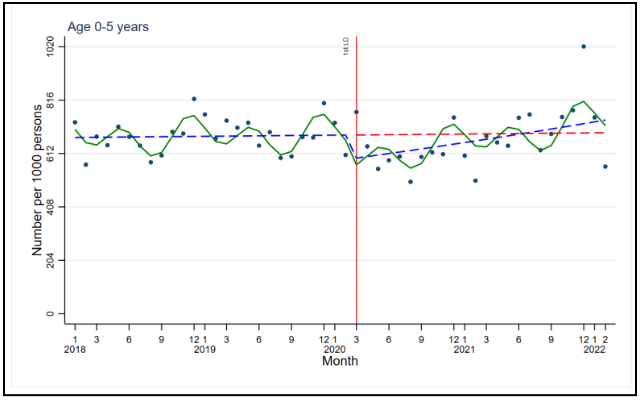
As listed in Table 10, all well-child visits that are recommended by the SGP refer to the first five years. The different TARMED positions that were grouped together refer to different well-child visits within this first five years. No significant changes in utilization were found for the pre-pandemic phase (non-significant results for *time*). However, on average, the utilization rates were lower in the pandemic compared to the pre-pandemic period (0.871 [0.765-0.992]; p < 0.05). This effect seemed to have occurred due to an initial drop in utilization after the lockdown (see Figure 5), since the utilization rates increased again subsequently (as indicated by a significant interaction term: 1.009 [1.000-1.018]; p < 0.05).

Table 10: Model estimates well-child visits up to 5 years (03.0020-90), SASIS

	0-5y
Time	1.001
	[0.995,1.006]
Pandemic	0.871*
	[0.765,0.992]
Time x Pandemic	1.009*
	[1.000,1.018]

Note: Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality. Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets.
* p < 0.05, ** p < 0.01, *** p < 0.001

Figure 5: Well-child visits up to 5 years (03.0020-90), SASIS



Caption: ● Observed —— Predicted – – – – Predicted deseasonlised trend – – – – Counterfactual

3.2.3.2 SWICA

For SWICA, the rates for the well-child visits within the first 12 months (differentiated for 1st, 2nd, 4th, 6th, and 9-12th months) and from 15 month up to 5 years (differentiated for 15-18th, 24th, and 5th year) are too low to be reported.

3.2.4 Telephone consultations

3.2.4.1 SASIS

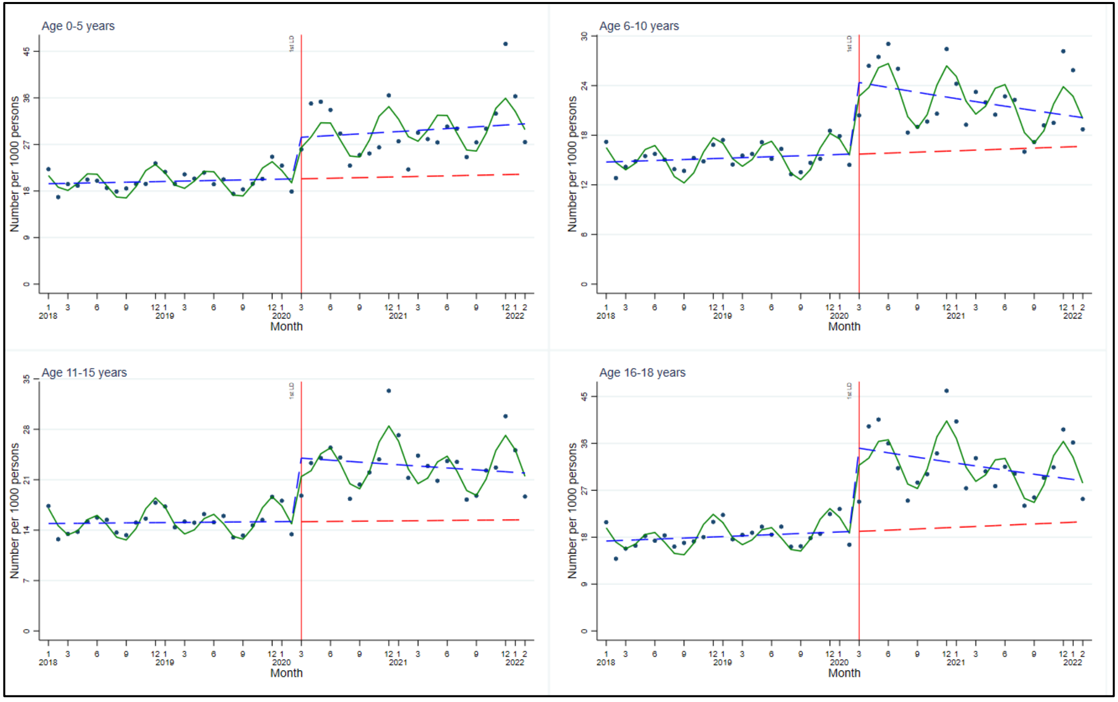
Incidence rates regarding telephone consultations were lower as for other health services (e.g., consultations or well-child visits), but are above the threshold of 10 per 1000 and therefore can be assumed to be robust. No changes in the utilization of telephone consultations were found for the pre-pandemic phase (non-significant estimates for *time*; see Table 11 and Figure 6). However, in all age groups, the average utilization of telephone consultations was significantly higher in the pandemic compared to the pre-pandemic period. This is indicated by significant estimates for *pandemic* for 0-5y (1.394 [1.218-1.594], p < 0.001), 6-10y (1.547 [1.387-1.726], p < 0.001), 11-15y (1.578 [1.430-1.741], p < 0.001), and 16-18y (1.831 [1.614-2.076], p < 0.001). While this heightened level of utilization remained on a similar level throughout the pandemic phase in some age groups (no significant interaction term for 0-5y and 11-15y), it significantly decreased again in others (significant interaction term for 6-10y: 0.989 [0.982-0.996], p < 0.01; 16-18y: 0.988 [0.979-0.996], p < 0.01).

Table 11: Model estimates all telephone consultations (00.0110), SASIS

	0-5y	6-10y	11-15y	16-18y
Time	1.002	1.003	1.001	1.004
	[0.995,1.008]	[0.997,1.008]	[0.996,1.006]	[0.998,1.010]
Pandemic	1.394***	1.547***	1.578***	1.831***
	[1.218,1.594]	[1.387,1.726]	[1.430,1.741]	[1.614,2.076]
Time x Pandemic	1.002	0.989**	0.995	0.988**
	[0.993,1.011]	[0.982,0.996]	[0.989,1.002]	[0.979,0.996]

Note: Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality.
Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets.
* p < 0.05, ** p < 0.01, *** p < 0.001

Figure 6: All telephone consultations (00.0110), SASIS



Caption: ● Observed —— Predicted – – – Predicted deseasonlised trend – – – Counterfactual

The results for long telephone consultations are not presented in detail, as the rates were very low (<10 per 1000). However, the effect of the pandemic seemed to be identical for long telephone consultations as for all telephone consultations: the average utilization rates were higher in the pandemic compared to the pre-pandemic phase in all age groups. Although these findings must be interpreted with caution, this increase seemed to have remained high in the youngest age group (0-5y) but decreased again in all other age groups (6-10y; 11-15y; 16-18y).

3.2.4.2 SWICA

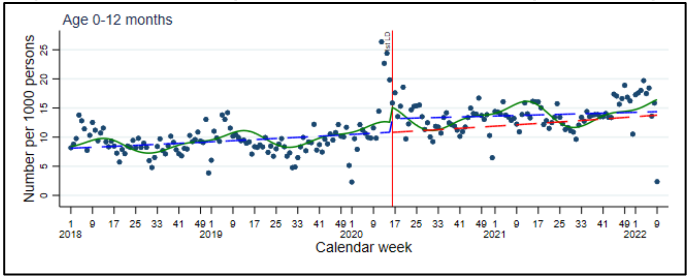
The rates for all telephone consultations are mostly too low for meaningful interpretations. Only data regarding 0-12-month-olds are just around the threshold of 10/1000 needed for robust findings. In this age group, utilization already increased during the pre-pandemic time (1.002 [1.001-1.004], p < 0.001; see Table 12 and Figure 7). Furthermore, the average utilization was higher in the pandemic compared to the pre-pandemic phase (1.213 [1.066-1.381], p < 0.01), confirming the findings from the SASIS-data. Lastly, the interaction term was not significant, indicating that utilization remained high during the observed pandemic phase.

Table 12: Model estimates all telephone consultations (00.0110), SWICA

	0-12m
Time	1.002***
	[1.001,1.004]
Pandemic	1.213**
	[1.066,1.381]
Time x Pandemic	0.998
	[0.996,1.000]

Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality.
Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 7: All telephone consultations (00.0110), SWICA



Caption: ● Observed — Predicted – – – Predicted deseasonlised trend – – – Counterfactual

The rates for long telephone consultations are not reported since they are too low.

3.2.5 Urgent consultations/visits

3.2.5.1 SASIS

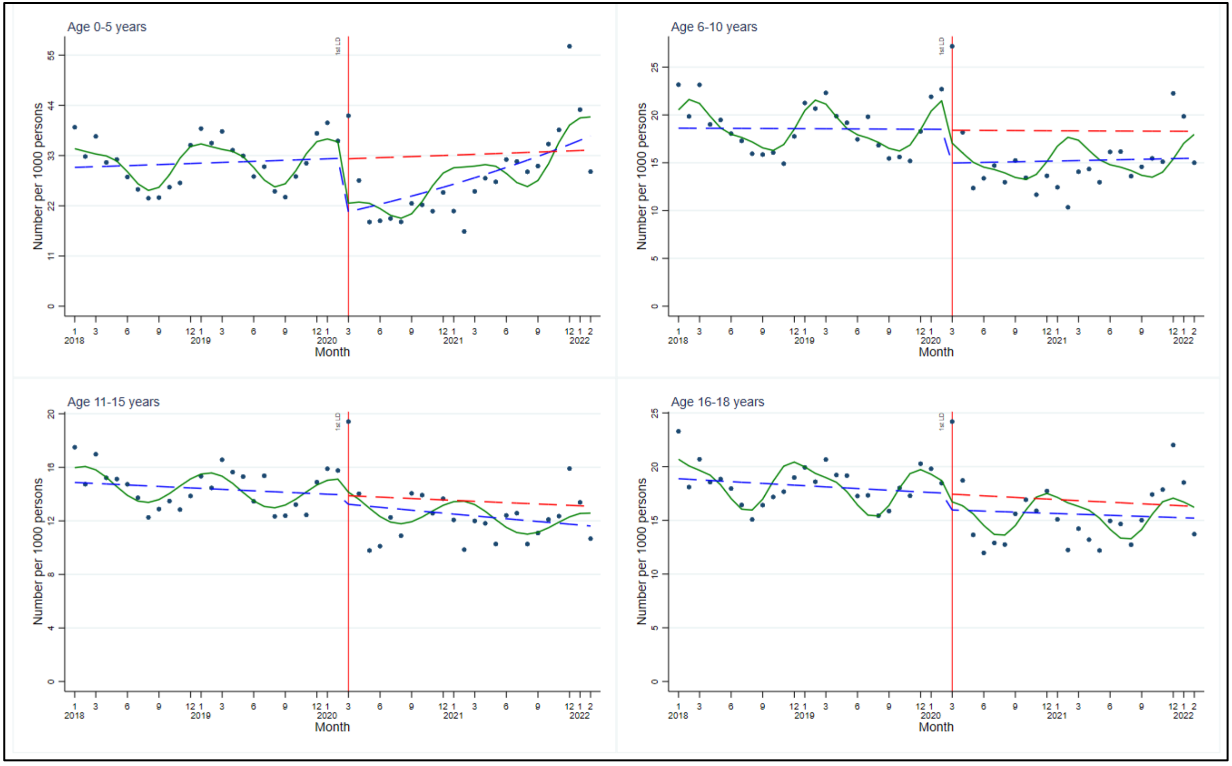
As detailed in Table 3, urgent consultations/visits are services for urgent health problems. The health problems might be perceived as being urgent by a physician and/or the caregiver of the child. No changes were observed in the pre-pandemic phase (no significant results for *time*; see Table 13). However, the average rates of such urgent consultations/visits were significantly lower during the pandemic compared to the pre-pandemic time in 0-5- (0.638 [0.500-0.813]; p < 0.001) and 6-10-year-olds (0.810 [0.665-0.985]; p < 0.05). While utilization of such services remained on a low level in 6-10-year-olds in the pandemic phase (1.002 [0.989-1.015]; not significant), it increased again in 0-5-years-old after the initial drop (1.023 [1.008-1.040]; p < 0.01; also see Figure 8). No significant pandemic effects or interaction terms were found for the older age groups (11-15y; 16-18y).

Table 13: Model estimates urgent consultations/visits (00.2505/10/20/40/60/80), SASIS

	0-5y	6-10y	11-15y	16-18y
Time	1.002	1.000	0.997	0.997
	[0.992,1.013]	[0.991,1.008]	[0.991,1.004]	[0.991,1.004]
Pandemic	0.638^{***}	0.810^{*}	0.951	0.913
	[0.500,0.813]	[0.665,0.985]	[0.819,1.103]	[0.783,1.064]
Time x Pandemic	1.023^{**}	1.002	0.997	1.001
	[1.008,1.040]	[0.989,1.015]	[0.987,1.007]	[0.991,1.011]

Note: Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality.
Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets.
* p < 0.05, ** p < 0.01, *** p < 0.001

Figure 8: Urgent consultations/visits (00.2505/10/20/40/60/80), SASIS



Caption: ● Observed —— Predicted – – – Predicted deseasonlised trend – – – Counterfactual

3.2.5.2 SWICA

The SWICA-rates were only around the threshold of 10/1000 for 0-12-month- and 13-24-month-olds at the beginning of the observational period (for the older age groups, even smaller rates were observed). Even though the data needs to be interpreted with caution, the pattern that has been described for SASIS seems to be confirmed by the SWICA data: As reported for 0-5-year-olds (SASIS), the average utilization was significantly lower in 0-12-month- and 13-25-month-olds in the pandemic compared to the pre-pandemic period (SWICA). Furthermore, and in line with the SASIS-results, a normalization was observed during the pandemic phase in the mentioned age groups (SWICA). Hence, the utilization significantly increased again during the pandemic period, indicating a certain normalization.

3.2.6 Vaccinations

The rates for some vaccinations were very low (below the threshold of 10 per 1000) for some age groups. These low rates are also due to the fact that certain vaccinations are scheduled for a particular age group according to the vaccination schedule of the FOPH (see Section 3.1.3). The subsequent reporting will be based on the robustness of the results and referring to the vaccination schedule.

3.2.6.1.1 Measles/mumps/rubella/(varicella)

SASIS

According to the vaccination schedule (48–52), two shots against measles/mumps/rubella are planned in the first 12 months of a child's life. Vaccination against varicella were – for the time frame of the current study (2018-2022) recommended between the ages 11-14/15 years, but only for those people who did not have this disease hitherto. However, since 2020 a polyvalent vaccination including measles, mumps, and rubella and varicella was remunerated by insurance companies, thus varicella vaccination might have occurred within the first 12 months.

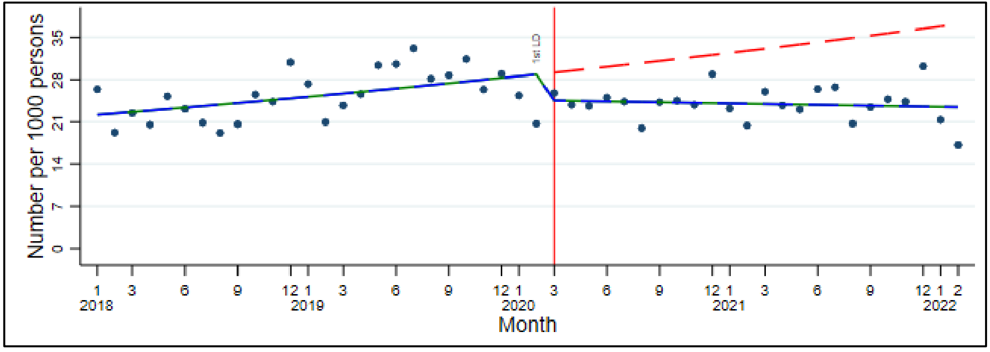
Given the recommended age span for measles/mumps/rubella we focused on 0-5-year-olds. Also, only, in this age category the vaccination rates for measles/mumps/rubella/(varicella) were above the threshold for robust results (≥10 per 1000). The rates for this vaccination increased significantly in the pre-pandemic phase (see Table 14; 1.011 [1.004-1.017], $p < 0.01$). However, the average vaccination rates were lower during the pandemic vs. pre-pandemic phase (0.841 [0.729-0.971], $p < 0.05$). Furthermore, the vaccination rates further decreased during the pandemic period (0.988 [0.977-0.998], $p < 0.05$). The results are also illustrated in Figure 9.

Table 14: Model estimates vaccination against measles/mumps/rubella/(varicella), SASIS

	0-5y
Time	1.011**
	[1.004,1.017]
Pandemic	0.841*
	[0.729,0.971]
Time x Pandemic	0.988*
	[0.977,0.998]

Note: Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality. Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.00$

Figure 9: Vaccination against measles/mumps/rubella/(varicella), 0-5-year-olds, SASIS



Caption: • Observed — Predicted – – – Predicted deseasonlised trend – – – Counterfactual

SWICA

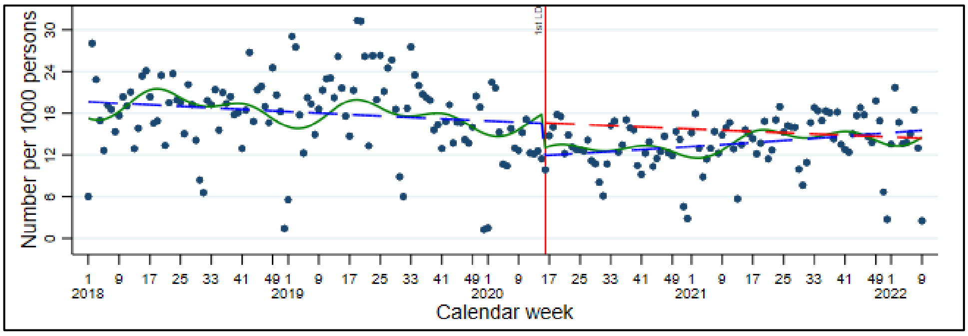
In the SWICA data, the rates were only robust for the 13-24-months-olds. As indicated in Table 15 and in contrast to the SASIS-data, the vaccination rates did not increase in the pre-pandemic period (non-significant estimate for *time*). However, confirming the SASIS-findings, the average rates were significantly lower in the pandemic vs. pre-pandemic period (0.721 [0.607-0.856], $p < 0.001$). Rather than further decreasing in the pandemic phase (as found based on SASIS), the vaccination rates seemed to normalize in the pandemic phase (as indicated by a significant interaction term: 1.004 [1.001-1.007], $p < 0.05$). These results are also illustrated in Figure 10.

Table 15: Model estimates vaccination against measles/mumps/rubella/(varicella), SWICA

	13-24 months
Time	0.999
	[0.997,1.000]
Pandemic	0.721***
	[0.607,0.856]
Time x Pandemic	1.004**
	[1.001,1.007]

Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality. Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets. * p < 0.05, ** p < 0.01, *** p < 0.001

Figure 10: Vaccination against measles/mumps/rubella/(varicella), 13-14-months-olds, SWICA



Caption: ● Observed —— Predicted – – – Predicted deseasonlised trend – – – Counterfactual

3.2.6.1.2 Diphtheria / tetanus / pertussis (polio / haemophilus influenzae-b infection / hepatitis

SASIS

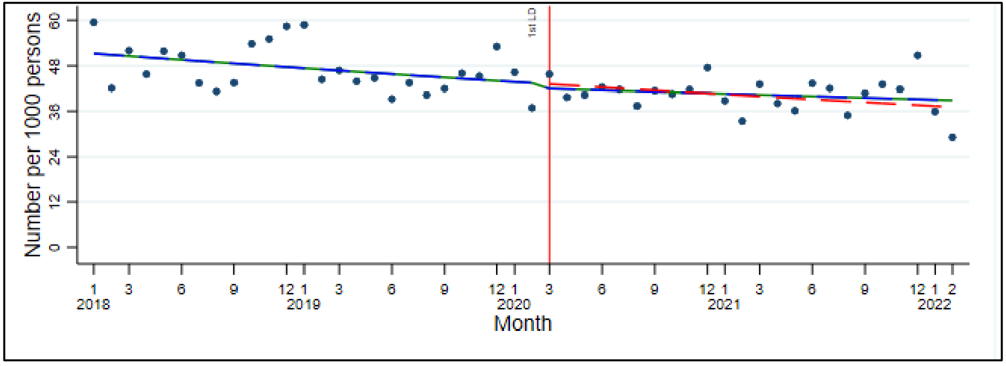
As detailed in Table 5, the vaccination schedule (48–52) plans three shots up to 12 months against diphtheria / tetanus / pertussis (polio / haemophilus influenzae-b infection / hepatitis). For diphtheria / tetanus / pertussis, further vaccinations between the ages of 4-7 and 11-14/15 years are planned. However, since the rates were below 10 / 1000 for the 11-15 years, only the results for the 0-5- and 6-10-year-olds are reported subsequently (see Table 16). Vaccination rates significantly decreased in the pre-pandemic phase in the youngest age group (0-5 years: 0.993 [0.987-0.999], p < 0.05), but not among 6-10-year-olds. For both age groups, no significant pandemic effects emerged. Hence, the average vaccinations rates did not differ between the pandemic vs. pre-pandemic phases. Furthermore, the interaction terms were not significant, indicating that the rates did not change in the pandemic phase (also see Figure 11 and 12).

Table 16: Model estimates vaccination against diphtheria / tetanus / pertussis (polio / haemophilus influenzae-b infection / hepatitis), SASIS

	0-5y	6-10y
Time	0.993* [0.987,0.999]	1.002 [0.994,1.009]
Pandemic	0.972 [0.848,1.112]	0.992 [0.842,1.167]
Time x Pandemic	1.003 [0.994,1.013]	0.995 [0.983,1.006]

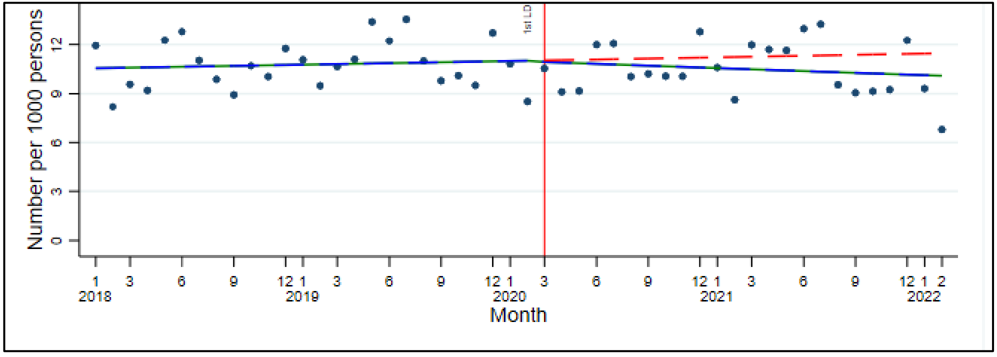
Note: Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality.
Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets.
* p < 0.05, ** p < 0.01, *** p < 0.001

Figure 11: Vaccination against (polio / haemophilus influenzae-b infection / hepatitis), 0-5-year-olds, SASIS



Caption: • Observed — Predicted - - - - Predicted deseasonlised trend - - - - Counterfactual

Figure 12: Vaccination against (polio / haemophilus influenzae-b infection / hepatitis), 6-10-year-olds, SASIS



Caption: • Observed — Predicted - - - - Predicted deseasonlised trend - - - - Counterfactual

SWICA

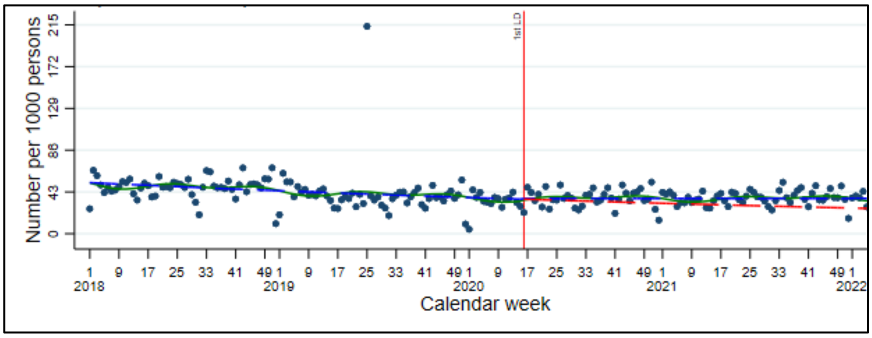
The SWICA data only provide robust estimates for the two youngest age groups, i.e., 0-12- and 13-14-month-olds (see Table 17 and Figures 13 and 14). The patterns identified for these age groups are not identical. During the pre-pandemic phase, vaccination rates decreased for 0-12-month-olds (0.997 [0.995-0.999], p < 0.001), but increased for 13-24-months-olds (1.003 [1.001,1.004], p < 0.01). Furthermore, while no significant level effect was found for 0-12-month-olds, average vaccination rates were significantly lower in the pandemic compared to the pre-pandemic phase among 13-24-month-olds (0.710 [0.592-0.852], p < 0.001). Lastly, the vaccination rates increased in the pandemic period among 0-12-month-olds (1.003 [1.000-1.007], p < 0.05) but decreased among 13-24-months-olds (0.996 [0.993-0.999], p < 0.01). The pattern concerning 0-12-month-olds seems to be more similar to the one reported for 0-5-year-olds on the basis of SASIS-data: for both, a decrease of the vaccination rates in the pre-pandemic phase was found, but no significant level effects. Since the vaccination rates are much higher in 0-12-month-olds compared to the 13-24-month-olds in the SWICA-data, it is possible that the findings reported for SASIS were mainly driven by 0-12-month-olds.

Table 17: Model estimates vaccination against diphtheria / tetanus / pertussis (polio / haemophilus influenzae-b infection / hepatitis), SWICA

	0-12m	13-24m
Time	0.997^{***} [0.995,0.999]	1.003^{**} [1.001,1.004]
Pandemic	1.022 [0.829,1.260]	0.710^{***} [0.592,0.852]
Time x pandemic	1.003^{*} [1.000,1.007]	0.996^{**} [0.993,0.999]

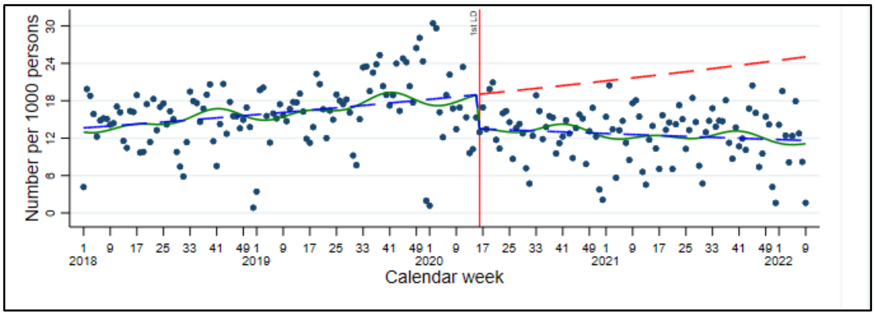
Note: Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality.
Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets.
* p < 0.05, ** p < 0.01, *** p < 0.001

Figure 13: Vaccination against (polio / haemophilus influenzae-b infection / hepatitis), 0-12-month-olds, SWICA



Caption:

Figure 14: Vaccination against (polio / haemophilus influenzae-b infection / hepatitis), 13-24-month-olds, SWICA



Caption:

3.2.6.1.3 Pneumococcus

SASIS

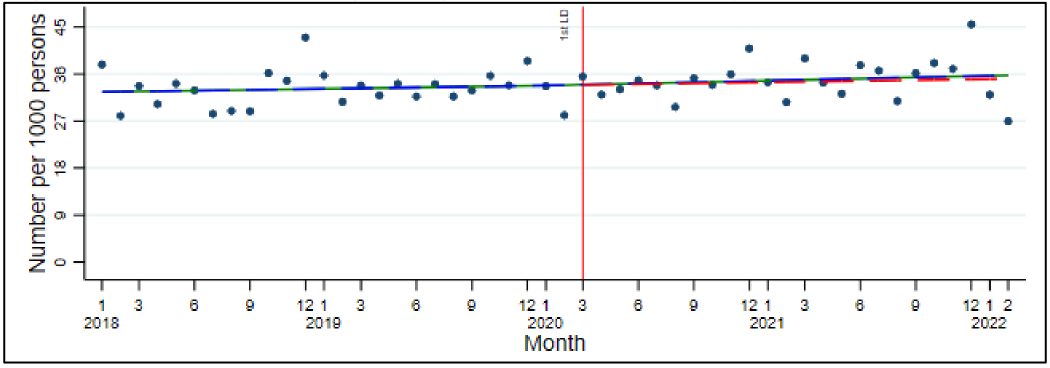
The vaccination schedules (48–52) indicate that vaccinations against pneumococcus should be concluded by 12 months. This corresponds to the highest vaccination rates in the youngest age group (0-5y), that are followed by very low rates that would not be robust to report. No significant time or level effects or interaction term were found for this vaccination in 0-5-year-olds (see Table 18 and Figure 15).

Table 18: Model estimates vaccination against pneumococcus, SASIS

	0-5y
Time	1.002
	[0.996,1.007]
Pandemic	1.002
	[0.887,1.132]
Time x Pandemic	1.001
	[0.992,1.009]

Note: Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality.
Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets.
* p < 0.05, ** p < 0.01, *** p < 0.001

Figure 15: Vaccination against pneumococcus, 0-5-year-olds, SASIS



Caption:

SWICA

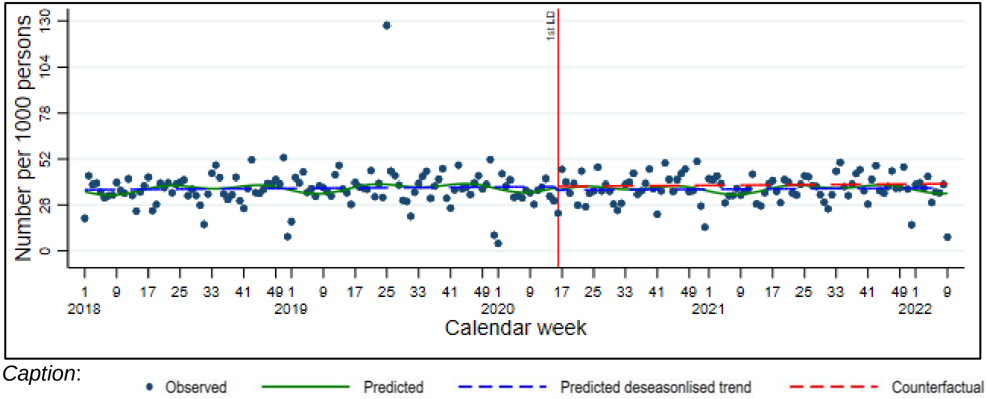
For SWICA, robust results are available for 0-12- and 13-24-month-olds. Confirming the findings for 0-5-year-olds (SASIS), no significant time, pandemic or time x pandemic effect was yielded (see Table 18 and Figure 16).

Table 19: Model estimates vaccination against pneumococcus, SWICA

	0-12m	13-24m
Time	1.000	1.000
	[0.999,1.002]	[0.998,1.002]
Pandemic	0.945	1.058
	[0.806,1.108]	[0.867,1.292]
Time x pandemic	1.000	0.999
	[0.997,1.002]	[0.996,1.002]

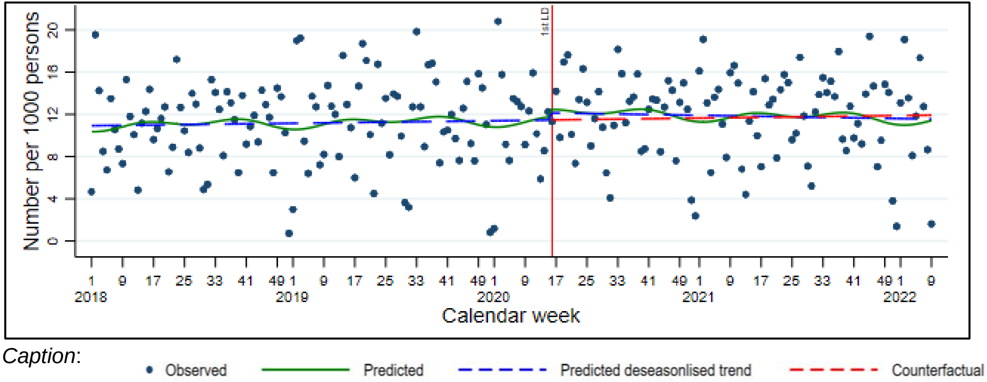
Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality.
Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets.
* p < 0.05, ** p < 0.01, *** p < 0.001

Figure 16: Vaccination against pneumococcus, 0-12-month-olds, SWICA



Caption:

Figure 17: Vaccination against pneumococcus, 13-24-month-olds, SWICA



Caption:

3.2.6.1.4 Meningococcus

SASIS

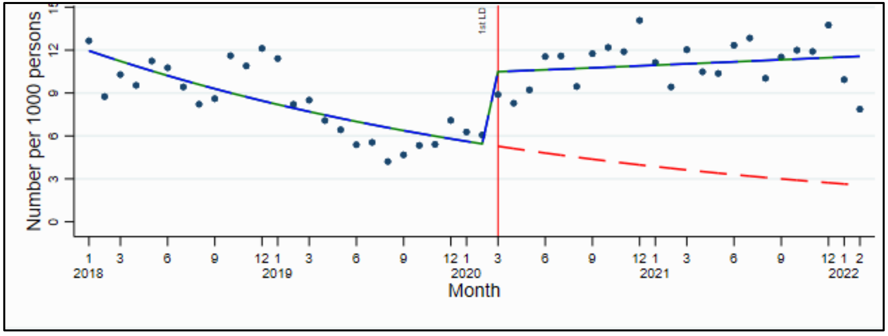
According to the vaccination schedules (48–52), vaccinations against meningococcus should take place at 24 months and 11-14/15 years. However, the rates for this vaccination were generally rather low (around or below the threshold of 10 per 1000 that are needed for robust findings) and only partly acceptable for 0-5-year-olds. As indicated in Table 20 and Figure 18, vaccination rates decreased in the pre-pandemic period in 0-5-year-olds (0.969 [0.960-0.979], p < 0.001). Furthermore, the average vaccination rate was higher in the pandemic compared to the pre-pandemic period (1.986 [1.611-2.449], p < 0.001). Lastly, an increase in vaccination rates in 0-5-year-olds during the pandemic period was found (1.036 [1.022-1.051], p < 0.001).

Table 20: Model estimates vaccination against meningococcus, SASIS

	0-5y
Time	0.969^{***}
	[0.960,0.979]
Pandemic	1.986^{***}
	[1.611,2.449]
Time x Pandemic	1.036^{***}
	[1.022,1.051]

Note: Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality. Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets.
* p < 0.05, ** p < 0.01, *** p < 0.001

Figure 18: Vaccination against meningococcus, 0-5-year-olds, SASIS



Caption:

SWICA

The vaccination rates for meningococcus were too low in the SWICA data set and will therefore not be reported.

3.2.6.1.5 Tick-born encephalitis

SASIS

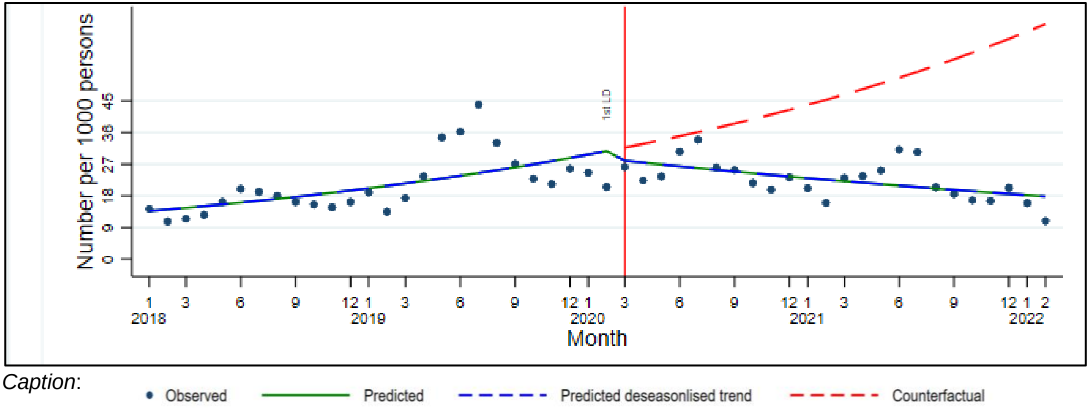
Vaccinations against TBE are recommended for risk-groups (those living in endemic areas) from the age of 6 years on (48–52). Even though almost all regions of Switzerland are endemic areas, the rates for this vaccination are rather low. The threshold of 10 per 1000 for robust data was only reached in the age group 6-10 years. Therefore, results are only reported for this age group (see Table 21 and Figure 19). Vaccination against TBE increased in the pre-pandemic phase (1.033 [1.019-1.047], p < 0.001; see Table 21) but decreased in the pandemic phase (0.949 [0.930-0.969], p < 0.001). No significant pandemic effect was found.

Table 21: Model estimates vaccination against TBE, SASIS

	6-10
Time	1.033***
	[1.019,1.047]
Pandemic	0.883
	[0.674,1.155]
Time x Pandemic	0.949***
	[0.930,0.969]

Note: Interrupted time-series Poisson regression allowing for overdispersion, adjusted for seasonality. Coefficients are Incident Rate Ratios (IRR). 95% confidence interval in brackets.
* p < 0.05, ** p < 0.01, *** p < 0.00

Figure 19: Vaccination against meningococcus, 6-10-year-olds, SASIS



Caption:

SWICA

The rates for TBE-vaccines were too low and are therefore not reported.

3.3 Summary

The analyses indicated that utilization of pediatric services was impacted by the pandemic. However, this impact was not uniform. For some health services, the average utilization rates were lower during the pandemic vs. the pre-pandemic period. This pandemic difference was always due to an initial marked drop in the utilization. The development after the lock-down phase differed. Sometimes the utilization increased again after the lockdown. Such a normalization after an initial drop was found in 0-5-year-olds for consultations, well-child visits, and urgent visits/consultations. For other services, the decreased utilization after the lockdown remained on a relatively low level or decreased even more during the observed pandemic period. This pattern was found for vaccinations against measles/mumps/rubella/(varicella) in 0-5-year-olds. A higher average utilization during the pandemic vs. pre-pandemic phase was observed for telephone consultations. For some age groups, this was due to an initial increase in utilization after the lockdown and subsequent normalization (e.g., decrease). For other age groups, the utilization rates remained high during the pandemic phase. Lastly, some services and age groups were not affected by the pandemic. For instance, a decreased utilization in the pandemic vs. pre-pandemic phase for consultations and urgent visits/consultations was only found for 0-5- and 6-10-year-olds, but not for older age groups. Furthermore, non-significant pandemic effects were found for various vaccines, including vaccines against diphtheria/tetanus/pertussis (polio / haemophilus influenzae-b infection / hepatitis B), pneumococcus, or TBE (SASIS).

In sum, the utilization of some pediatric health services in Switzerland was significantly affected throughout the pandemic, with the strongest impact directly after the lockdown. However, the pandemic did not have a uniform effect on the utilization. There are differences by service, age groups, direction of effect and in the recovery patterns across the pandemic phase. Table 22 provides a summary of the main results (SASIS).

Table 22: Overview of the pandemic effects (health insurance data SASIS)

TARMED positions / ATC	**Age group**	**Pandemic effect**
Consultations (00.0010)	0-5y	↓
	6-10y	↓
	11-15y	n.s.
	16-18y	n.s.
Developmental pediatric consultations (03.0135)	0-5y	n.s.
	6-10y	n.s.
	11-15y	-
	16-18y	-
Well-child visits (03.0020/30/40/50/60/70/80/90)	0-5y	↓
	6-10y	-
	11-15y	-
	16-18y	-
All telephone consultations (00.0110)	0-5y	↑
	6-10y	↑
	11-15y	↑
	16-18y	↑
Urgent visits/consultations (00.2505/10/20/40/60/80)	0-5y	↓
	6-10y	↓
	11-15y	n.s.
	15-18y	n.s.
Measles/mumps/rubella/(varicella)	0-5y	↓
	6-10y	-
	11-15y	-
	16-18y	-
Diphtheria/tetanus/pertussis (polio / haemophilus influenzae-b infection / hepatitis B)	0-5y	n.s.
	6-10y	n.s

TARMED positions / ATC	Age group	Pandemic effect
	11-15y	-
	16-18y	-
Pneumococcus	0-5y	n.s
	6-10y	-
	11-15y	-
	16-18y	-
Meningococcus	0-5y	↑
	6-10y	-
	11-15y	-
	16-18y	-
TBE	0-5y	-
	6-10y	n.s.
	11-15y	-
	16-18y	-

Note: ↑ significant increase; ↓ significant decrease; n.s.: non-significant; - : not reported since the rates are too low.

3.4 Discussion

The data present a clear impact on utilization by the pandemic, especially immediately after the lock-down. However, when interpreting the findings, it must be considered that utilization rates do not necessarily correspond to the actual care needs of children and adolescents. A higher level of utilization of a particular service during the pandemic compared to the pre-pandemic phase may, for instance, indicate an actual increase of the need or demand for this service. However, it is also possible that an increase in utilization occurred because a particular service served as a substitute for another during the pandemic. Increased rates of telephone consultations during the pandemic, for instance, might have occurred because this health service substituted in-person consultations. Hence, a parent who would typically have visited the pediatrician with his/her child for certain health issues prior to the pandemic may have decided to contact the pediatrician by phone during the pandemic. This change in the utilization pattern (telephone rather than in-person consultations) might also have been encouraged by pediatricians. This example highlights the importance of interpreting utilization rates of various health services together.

Further, non-significant pandemic effects (no significant differences in the average utilization between the pandemic vs. the pre-pandemic periods) might reflect a constant utilization of a specific service or correspond to a reduced utilization should the need or demand have been higher in the post-pandemic period as compared to the pre-pandemic period. This was presumably not the case for those vaccinations for which no pandemic effect or a small effect, was found. In the case of vaccines against pneumococcus, however, the vaccination was only recommended as base immunization in 2019 and an increase in vaccination rate would have been expected in 2020. It might have been the case for other services such as consultations and urgent visits for children older than 10 years. We cannot rule out one or the other but estimated the expected utilization development based on pre-pandemic data to provide some idea of a potential under-utilization albeit stable utilization rates.

Lastly, a decreased utilization may be due to an actual decrease in demand or need or a change in utilization. It would be particularly problematic if the need for such a service remained the same or even increased during the pandemic. Assuming an increase in demand or need after the lock-down would imply an underestimation of the observed drop in utilization. Which scenario underlies, for instance, the significant decrease in consultations or the urgent visits/consultations among 0-5-year-olds cannot be answered solely based on the health insurance data. A decreased utilization immediately after the lockdown was also found for 0-5-year-olds regarding well-child visits, even though parents of children up to the age of two were explicitly encouraged to attend these well-child visits, as they are important from a prevention, screening, and immunization point of view. Even though utilization of well-child visits increased again after an initial drop in the pandemic phase, it remains unclear, whether all children who missed a well-child visit have made up for this later, or if some forgone this recommended service.

In sum, health insurance data provide valuable data on the services utilized but are limited with regard to assessing the adequacy of the services utilized. To interpret the described findings more comprehensively, PedCov also investigates data from three large pediatric clinics. Further, it would be useful to take existing data on the actual need of young people during the pandemic (e.g., epidemiological data or experiences of pediatricians) into account. Such data is very scarce, especially for Switzerland.

To conclude this section, we would like to point out two methodological aspects that need to be considered. Firstly, health insurance data only provides utilization rates for TARMED positions and ACT-codes and the data cannot be assigned to individuals. An increase in the utilization of a service, might, for instance, also have been driven by an increased and repeated utilization of some individuals. There is, however, no reason to believe that the average frequency of consultations per insured child should differ by pre-pandemic and pandemic phase. Secondly, it needs to be considered that different physicians might use TARMED positions differently, as pointed out by the primary pediatricians of the PedCov consortium. For instance, some physicians might prefer to use a particular TARMED position, while others use a different TARMED position for a similar service or consultation. The use of ATC codes was, however, not affected. Again, we may safely assume that the way physicians usually code health services has not been affected by the pandemic and remained relatively stable over time. One exception is the use of the TARMED position “telephone consultations”, which was officially approved to also be used for digital communications (E-mails or online communication tools) during the pandemic phase, and which indeed increased significantly. Also, this potential limitation, does not impact the results on consultations or well-child visits, if added up, the consultations plus the well-child visits provide a full number of consultations.

4 Pediatric emergency department data

4.1 Methods

4.1.1 Study data

The tertiary pediatric hospitals provided detailed data of daily ED consultation visits. The data on ED visits were obtained from the IT departments of three children’s hospitals located in Zurich, Geneva, and Ticino. All of these EDs work interdisciplinary and treat children and adolescents with a range of conditions, including infections, trauma, and surgical conditions. Zurich’s pediatric ED is the largest ED in Switzerland, treating approximately 50’000 patients annually. Meanwhile, Geneva’s ED is the largest in French-speaking Switzerland, and Bellinzona’s ED is the largest in the Italian-speaking region. Anonymous daily data were obtained for all ED patients from March 2018 to February 2022, including age (in years), sex, triage category, hospital admission, nationality, and postal code. Non-coded diagnosis data were exclusively available for the ED in Zurich.

The hospital dataset is especially valuable because it covers three different language regions that experienced different epidemiological waves and case rates (www.bag.admin.ch), assuming different patterns of utilization of primary and tertiary care.

4.1.2 Variables

Age groups

The anonymized dataset obtained the patient’s age in years, which was then grouped into three categories: 0-4-year-olds, 5-12-year-olds, and 13-18-year-olds.

Triage categories

Upon entering the EDs of Zurich, Geneva, or Ticino, every patient is assessed by a trained nurse to prioritize patient care according to the patient’s clinical urgency. The Australasian Triage Scale (ATS) was used in the children’s hospitals in Zurich and Ticino with five categories defined as follows: 1= Immediately life-threatening, 2= Imminently life-threatening (doctor contact within 10 minutes), 3= Potentially life-threatening (doctor contact within 30 min), 4= Potentially serious (doctor contact within 60 min), 5= Less urgent (doctor contact within 120 min). Meanwhile, the Canadian Triage and Acuity Scale (CTAS) was used in Geneva, consisting of the same five categories as the ATS, but with a difference in the time until doctor contact for triage scale 2, which was 15 minutes. For analysis purposes, triage scores 1-3 were considered as an urgent medical condition, while scores 4-5 were considered non-urgent.

Diagnostic groups

Non-coded diagnoses from the ED reports were categorized into main groups. The most common diagnostic groups (italic) with examples were:

- Respiratory disorders
  - *Upper airway infection*: running nose, conjunctivitis, sore throat, tonsillitis, ear infection, parotitis
  - *Lower airway infection*: bronchiolitis, laryngotracheitis, obstructive bronchitis, pneumonia
  - *Upper and lower airway disease*: aspiration, asthma, pneumopathy, obstructive sleeping syndrome
  - *Others*: epistaxis, swollen lymph nodes
- Gastrointestinal disorders
  - *Gastroenteritis*: vomiting, diarrhea
  - *Constipation*
  - *Unspecific abdominal pain*: meteorism
  - *Appendicitis*
  - *Others*: Reflux, hypertrophic pyloric stenosis, invagination, swallowed foreign body
- Trauma
  - *Fracture*
  - *Contusion arm/leg*
  - *Contusion face*: nose, ear, mouth, teeth, eye injury
  - *Traumatic brain injury*
  - *Laceration*
  - *Burn*
  - *Motor vehicle accident*
  - *Others*: drowning

- Neurological disorders
  - *Headache, vertigo*: including syncope, migraine
  - *Seizures*
  - *Others*: cerebrovascular disease, complications due to ventrico-peritoneal shunt
- Urological, nephrological, gynecological disorders
  - *Testicular pain*: testicular torsion, epididymitis, orchitis, torsion of a testicular appendage, idiopathic scrotal edema
  - *Urinary tract infection*
  - *Gynecological disorder*: vulvitis, vulvovaginitis, hymenal atresia, mastitis, ovary pathology
  - *Others urological*: balanitis, paraphimosis, complications after surgery, kidney stones
  - *Others nephrological*: glomerulonephritis, nephrotic syndrome, hemolytic-uremic syndrome, renal insufficiency

Skin disorders

Unspecific rash
Urticaria: including vasculitis
Hand Foot Mouth disease
Chicken pox
Scarlet fever
Others: insect bites, atopic dermatitis, impetigo

A limitation must be mentioned regarding the group of respiratory disorders. Our aim was to categorize the diagnoses as either infectious or non-infectious. However, in German, the terms "asthma" and "obstructive bronchitis" are not strictly differentiated from each other. "Asthma" is more commonly used in older children with chronic inflammation of the airways, whereas "obstructive bronchitis" generally describes bronchospasm in young children as part of a viral respiratory infection. As a result, obstructive bronchitis was added to infections of the lower airways, while asthma exacerbation was included in airway diseases, as it is primarily caused by allergies.

4.1.3 Statistical analyses

Interrupted time series (ITS) modelling was used to assess the COVID-19 related impact and compare pre-pandemic and pandemic health service consultations. The weekly number of ED visits in each cantonal hospital was calculated using the ISO 8601 standard to define weeks in the year. The first and last weeks of data (ISO week 9 in 2018 and 2022) were excluded as they only had partial counts, and week 53 of 2020 was also removed to ensure 52 weeks per year. The changepoint was set to week 12 of 2020 in all cantons, corresponding to the onset of the first lockdown on 16.03.2020. The pre-pandemic period was defined as the period preceding the changepoint, while the pandemic period was defined as the period following the changepoint. A transition period of ± 3 weeks around the changepoint (from week 9 to week 15 of 2020) was assumed, and data from this period were not used to fit the model. This transition period was adopted because, depending on the stratification considered, the effect of the pandemic on the number of visits in EDs did not start at the same time in all 3 cantons. For example, the number of visits in the ED in Ticino already dropped drastically in the two weeks preceding the onset of the lockdown.

The ITS model was constructed using two negative binomial regressions (i.e., Poisson regression allowing for overdispersion), each fitted separately to each period. The expected counts were modelled on the logarithmic scale. Each regression included an intercept term and a linear trend (on log scale) for the time (in weeks) since the start of the observation period (i.e., week 10 of 2018), with time=0 referring to the changepoint in week 12 of 2020. Within each period, seasonality was modelled using Fourier series with two harmonics. Additionally, residual autocorrelation was modelled using an autoregressive moving average (ARMA) process while assuming independence between data from the two periods. A suitable ARMA structure was selected by minimizing the corrected Akaike Information Criterion (54).

The effects of interest (adjusted for seasonality) in the ITS model are as follows:

- Time: quantifies the pre-pandemic trend. The corresponding coefficient estimates the ratio of the expected number of visits (adjusted for seasonality) for two weeks separated by one year during the pre-pandemic period. A value of 1 indicates a stable condition (no change over time). A value above 1 suggests that the expected number of visits increased during the pre-pandemic period, while a value below 1 suggests that this number decreased.
- Pandemic: quantifies the magnitude of the drop in the number of visits at the onset of the first lockdown. The corresponding coefficient estimates the ratio in the expected number of visits (adjusted for seasonality) on week 12 of 2020 according to the pandemic and pre-pandemic models. A value of 1 indicates a stable condition (no change). A value above 1 suggests that the expected number of visits increased at the onset of the lockdown, while a value below 1 suggests that this number decreased. Note that the percentage drop in the number of visits is quantifies by one minus the pandemic coefficient.
- Time x Pandemic: quantifies the difference between the pandemic and pre-pandemic trends (i.e., the interaction term in a regular ITS model). The corresponding coefficient estimates the ratio between the pandemic and pre-pandemic trends. A value of 1 indicates a stable condition (no change in trend between the pre-pandemic and pandemic periods). A value above 1 suggests that the pandemic trend increased compared to the pre-pandemic trend, while a value below 1 suggests that the pandemic trend decreased compared to the pre-pandemic trend.

Statistical analyses were conducted using R version 4.2.2 (55) and the gcmr package (56) was used to fit negative binomial regressions with autocorrelated errors. Categorical data were summarized by frequencies and percentages.

4.2 Results

4.2.1 Demographics

Over the study period from March 2018 to February 2022, a total of 304’438 ED visits were recorded, with 160’318 in Zurich, 110’735 in Geneva, and 33’385 in Ticino. The median age of patients visiting the EDs was 4 years (inter-quartile range: 1-9 years), with 54.7% children up to four years old, 35.1% aged 5-12 years, and 10.2% aged 13-18 years. Table 23 provides demographic information for the three EDs.

Table 23: Number of visits (%) in EDs from March 1st 2018 to February 28th 2022

	Overall	Zurich	Geneva	Ticino
Number visits in ED	304'438	160'318	110'735	33'385
Age				
0-4 years	166'578 (54.7)	91'976 (57.4)	60'823 (54.9)	13'779 (41.3)
5-12 years	106'773 (35.1)	54'676 (34.1)	37'316 (33.7)	14'781 (44.3)
13-18 years	31'087 (10.2)	13'666 (8.5)	12'596 (11.4)	4'825 (14.5)
Females	136'974 (45.0)	72'336 (45.1)	50'005 (45.2)	14'633 (43.8)
Triage category urgent	117'588 (38.6)	52'083 (32.5)	55'588 (50.2)	9'917 (29.7)
Accidents	81'236 (26.7)	40'917 (25.5)	26'687 (24.1)	13'632 (40.8)
Hospitalizations	30'757 (10.1)	18'690 (11.7)	9'350 (8.4)	2'717 (8.1)

4.2.2 Weekly number of ED visits and trends

This section summarizes findings from ITS modelling. Detailed results of the ITS models are provided in section 6.2 (Appendix).

Pre-pandemic trends

Regarding weekly ED visits and trends, ITS modelling revealed that after accounting for seasonality, the expected weekly number of visits in EDs during the pre-pandemic period remained relatively stable in Zurich, while numbers increased by approximately 6% every year in Geneva and Ticino. Taken together, these increases were not statistically significant (see Figure 20, Table 26). However, when focusing on urgent visits, significant pre-pandemic trends were observed in Geneva (+10.1% per year, 95% CI [1.2; 19.8]) and Ticino (+38.7% per year, 95% CI [22.3; 57.3]) (see Figure 28, Table 34). In these cantons, positive pre-pandemic trends were also observed in the number of hospitalizations (+5.1% per year in Geneva, 95% CI [0.5; 9.9], and + 21.6% per year in Ticino, 95% CI [8.5; 36.3]) (see Figure 24, Table 30). In contrast, the number of visits in EDs of accidental causes were decreasing during the pre-pandemic phase in Zurich (-6.8% per year, 95% CI [-9.4; -4.0]) and to a lesser extent in Ticino (-3.8% per year, 95% CI [-15.0; +9.0]) (see Figure 27, Table 33).

Effect of the pandemic

The ITS models revealed a decrease of nearly 50% in the number of ED visits at the onset of the lockdown, followed by a gradual recovery until the second half of 2021 when the number of ED visits reached pre-pandemic levels (see Figure 20, Table 26). These trends were consistent across all three regions and mainly affected the youngest age group, with a drop exceeding 50% (see Figure 21, Table 27). However, the results varied depending on the stratification used for the analysis. For instance, unlike Geneva and Zurich, the number of hospitalizations in Ticino did not decrease at the onset of the lockdown (-1.1%, 95% CI [-19.0; 17.8]) (see Figure 24, Table 30), while the number of visits due to accidents did not show significant changes in Zurich and Ticino, but a drop of 25.1% (95% CI [8.9; 38.5]) was estimated in Geneva (see Figure 27, Table 33). On the other hand, visits related to non-accidental causes decreased drastically by more than 50% in all three hospitals, with an estimated drop in Ticino reaching 61.7% (95% CI [54.2; 67.9]) (see Figure 26, Table 32). Furthermore, the observed number of non-urgent visits (triage category > 3) already dropped drastically in the two weeks preceding the onset of the national lockdown, as seen in Figure 29.

Interaction effect pandemic x time

A gradual normalization in the number of visits was observed during the pandemic period following the lockdown for most outcomes, but some notable exceptions were identified by the ITS models. First, in contrast to what happened in Geneva and Zurich, the increase in the number of urgent visits in Ticino was not different from that observed during the pre-pandemic period (see Figure 28). Secondly, hospitalizations in Ticino even gradually decreased after the lockdown, as illustrated in Figure 24. At last, no marked change in trend was observed in the number of visits related to accidents between the pre-pandemic and pandemic periods in all three cantons, as suggested by the non-statistically significant coefficients for Time x Pandemic (see Table 33).

4.2.3 Diagnoses

Grouped diagnoses were evaluated to determine changes in the prevalence of specific medial conditions during the months of March and April from 2018-2021 (see Table 23). A detailed analysis of diagnostic groups revealed a significant decrease in visits for respiratory and gastrointestinal infections in 2020 compared to 2019. Communicable diseases such as upper and lower airway infections and gastroenteritis were found to have decreased by over 50% in 2020 when compared to the same period in 2019. In contrast, only a marginal reduction was observed in the total number of visits for trauma cases during the same period.

Table 24: Diagnoses and frequency of pediatric emergency visits in Zurich from 2018-2021

	March 18 N= 4155	**April 18** N= 3798	**March 19** N= 4024	**April 19** N= 3681	**March 20** N= 2721	**April 20** N= 2055	**March 21** N= 3142	**April 21** N= 3523
Respiratory disorders	**1499 (36.1%)**	**1258 (33.1%)**	**1366 (33.9%)**	**1182 (32.1%)**	**989 (36.3%)**	**255 (12.4%)**	**803 (25.6%)**	**1031 (29.2%)**
Upper airway infection	15.9%	15.2%	14.7%	14.6%	12.3%	4.8%	10.3%	11.6%
Lower airway infection	8.4%	9.0%	7.5%	7.3%	8.9%	2.4%	5.1%	6.8%
Upper and lower airway disease	11.2%	8.1%	10.8%	9.3%	13.6%	4.1%	8.2%	9.1%
Others	0.6%	0.8%	1.0%	0.8%	1.6%	1.1%	1.9%	1.7%
Gastrointestinal disorders	**742 (17.9%)**	**586 (15.4%)**	**739 (18.4%)**	**652 (17.7%)**	**362 (13.3%)**	**236 (11.5%)**	**423 (13.5%)**	**446 (12.7%)**
Gastroenteritis	12.4%	9.2%	12.7%	12.3%	6.9%	4.4%	6.4%	5.9%
Constipation	1.8%	1.8%	1.7%	1.9%	1.5%	1.6%	2.1%	1.6%
Unspecific abdominal pain	2.0%	2.2%	2.2%	1.8%	2.7%	2.4%	2.5%	2.8%
Appendicitis	0.6%	0.5%	0.4%	0.4%	0.5%	0.9%	0.4%	0.3%
Others	1.1%	1.7%	1.3%	1.2%	1.6%	2.2%	2.1%	2.0%
Trauma	**1014 (24.4%)**	**1097 (28.9%)**	**1047 (26.7%)**	**965 (26.2%)**	**736 (27.0%)**	**947 (46.1%)**	**1080 (34.4%)**	**983 (27.9%)**
Fracture	5.7%	7.5%	5.9%	5.5%	6.1%	10.3%	7.3%	7.7%
Contusion arm/leg	7.5%	8.1%	8.6%	7.2%	6.3%	11.0%	10.3%	9.7%
Contusion face	1.5%	1.9%	1.8%	2.0%	1.5%	3.2%	2.2%	2.1%
Traumatic brain injury	4.2%	4.3%	4.4%	4.9%	5.4%	8.4%	6.5%	6.6%
Laceration	4.3%	5.2%	4.9%	5.5%	5.5%	11%	6.6%	6.1%
Burn	1.0%	1.6%	0.7%	0.8%	1.8%	1.8%	1.1%	1.3%
Motor vehicle accident	0.1%	0.3%	0.2%	0.2%	0.2%	0.2%	0.4%	0.1%
Others	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Neurological disorders	**140 (3.4%)**	**86 (2.3%)**	**126 (3.1%)**	**94 (2.6%)**	**84 (3.1%)**	**74 (3.6%)**	**95 (3.0%)**	**102 (2.9%)**
Headache, vertigo	0.9%	0.7%	1.2%	0.7%	1.2%	1.0%	1.5%	1.1%
Seizures	1.9%	1.0%	1.7%	1.3%	1.1%	1.3%	1.1%	1.4%
Others	0.6%	0.5%	0.2%	0.5%	0.8%	1.3%	0.5%	0.4%
Urological, nephrological, gynecological disorders	**120 (2.9%)**	**110 (2.9%)**	**128 (3.2%)**	**124 (3.4%)**	**120 (4.4%)**	**100 (4.9%)**	**140 (4.5%)**	**124 (3.5%)**
Testicular pain	0.7%	0.5%	0.5%	0.6%	0.8%	1.2%	0.8%	0.7%
Urinary tract infection	1.1%	1.1%	1.4%	1.7%	2.5%	2.2%	1.9%	1.8%
Gynecological disorders	0.6%	0.7%	0.4%	0.4%	0.5%	0.2%	0.7%	0.3%
Others urological	0.3%	0.4%	0.5%	0.3%	0.4%	0.9%	0.6%	0.4%
Others nephrological	0.2%	0.2%	0.3%	0.3%	0.3%	0.3%	0.4%	0.3%

Skin disorders	**174 (4.2%)**	**165 (4.4%)**	**133 (3.3%)**	**177 (4.8%)**	**83 (3.1%)**	**92 (4.5%)**	**100 (3.2%)**	**118 (3.3%)**
Unspecific rash	1.9%	1.9%	1.4%	2.4%	1.9%	2.6%	1.9%	2.0%
Urticaria	0.7%	0.3%	0.7%	0.9%	0.4%	0.7%	0.6%	0.7%
Hand Foot Mouth disease	0.3%	0.2%	0.1%	0.1%	0.0%	0.0%	0.2%	0.1%
Chicken pox	0.7%	0.5%	0.5%	0.7%	0.3%	0.2%	0.3%	0.3%
Scarlet fever	0.3%	0.3%	0.2%	0.2%	0.2%	0.2%	0.0%	0.0%
Others	0.3%	1.0%	0.4%	0.6%	0.2%	0.7%	0.2%	0.3%

Note: Number of patients and percentage of patients with a certain diagnosis per month

4.3 Summary

The aim of this study was to investigate the impact of the COVID-19 pandemic on pediatric ED utilization in different regions of Switzerland. At the onset of the lockdown, a drop of nearly 50% in the number of ED visits was observed, followed by a gradual normalization until the second half of 2021 when the number of ED visits reached pre-pandemic levels. This pattern mostly affected the youngest age group (0-4 years old) and was similar for patients with non-urgent and urgent medical conditions in all three regions. However, the decrease in urgent visits appeared more pronounced in Zurich and Geneva than in Ticino. Accordingly, hospitalization rates in Ticino did not decrease significantly at the onset of the lockdown, in contrast to the findings in Zurich and Geneva. In-depth analyses of diagnostic groups revealed a significant decrease in viral infections (respiratory and gastrointestinal) in 2020 compared with 2019, whereas the reduction in trauma patients was only marginal.

4.4 Discussion

The COVID-19 lockdown resulted in a nearly 50% decrease in ED visits in Swiss pediatric EDs, which is consistent with findings in international literature reporting reductions ranging from 30 to 89% (57). Our ITS modeling indicated that the drop in pediatric ED visits began even before the lockdown, when first positive COVID-19 cases in Switzerland were observed. This effect was most pronounced in Ticino, the Swiss region initially most affected by the pandemic. The time needed until pediatric ED visits reached pre-pandemic levels took over a year in our study. The reasons for this may include parents’ fear of contracting COVID-19 in EDs and fewer communicable diseases, such as respiratory and gastrointestinal infections, due to containment measures such as wearing face masks in public gatherings.

The reduction in pediatric ED visits was primarily observed in the youngest age group, which typically represents the largest proportion of patients in pediatric EDs. The lower rate of communicable diseases in this age group may be attributed to reduced contact with other children and less parent or siblings to child transition due to the implementation of hygiene measures.

Urgent and non-urgent cases decreased at the onset of the lockdown. However, in Ticino, the decrease in urgent cases was not as evident as in the rest of the country. Also, in Ticino, the rate of hospitalization did not decrease at the onset of the lockdown compared to Zurich and Geneva. The incidence of Covid-19 positive cases was significantly higher in Ticino compared to the north of Switzerland at the beginning of the pandemic. This might have contributed to a higher rate of children with respiratory infections needing hospital care. A detailed analysis of COVID-19 diagnosis for Ticino was not possible because the diagnoses were not part of the dataset. Therefore, this question cannot be answered definitely.

Respiratory, gastrointestinal diseases and trauma cases decreased in Switzerland during the lockdown. The drop of infections was over 50%, whereas trauma cases showed only a minor reduction. The stay-at-home policy might have resulted in fewer accidents due to cancelled sporting events and closed playgrounds. However, home accidents may have increased due to less supervision of young children as parents were occupied with home office.

Despite official recommendations, pediatric ED visits halved after the lockdown in all three language regions, affecting mostly infants and toddlers. Whether the observed decrease in ED visits among this age group represents a genuine decline is uncertain, as it is possible that care was shifted to alternative settings. The insurance data, however, also show a reduction of consultations while telephone consultations actually increased. Partly, parents may also have decided against visits in non-urgent cases and instead managed the illness themselves. Parents might have opted to avoid visiting EDs with their children too young to wear face masks, and instead chose to visit their pediatrician or use telemedicine.

4.5 Outlook

This interim report provides first insights into the main findings of the study. The focus of the report lies on the health insurance data (differentiated by age categories) and trends in pediatric ED visits before and after the start of the pandemic. For the final report, additional and more detailed analyses will be reported based on the same data. Regarding health insurance data, it is, for instance, planned to also report gender and regional differences regarding utilization. Furthermore, it will be assessed whether the utilization of mental health services – i.e., health services that have not yet been included in the interim report – changed during the pandemic. Lastly, it will be assessed how the utilization curves relate to the stringency of the measures.

Regarding pediatric ED data, in a next step, we plan to conduct in-depth analysis of the data to further explore a possible association between ED visits, confinement measure stringency, and the epidemiological course of the pandemic. Additionally, we plan to investigate whether certain regions (urban versus rural) were disproportionately impacted by the stay-at-home policy and subsequently reduced their use of pediatric EDs. Lastly, we aim at analyzing shifts of the regional distributions of utilization over time. These analyses of geographic data will provide valuable insights into how the pandemic and associated policies may have affected access to pediatric EDs.

Once these additional results are available, it is planned to integrate and compare the different data (health insurance and ED data) to get a more comprehensive picture about the effects of the pandemic on utilization. Furthermore, it is then planned to submit and discuss the findings in more detail with practitioners during regular consortium meetings, at conferences (it is planned to present first results at the Swiss Public Health Conference, the European Public Health Conference, the Swiss Pediatrics Annual Meeting (Abstract has been accepted) and the Congress for Children and Adolescents' Medicine), and with selected experts (e.g., in the field of mental health for the utilization of mental health services). This exchange will allow us to gain a deeper understanding of the data and to discuss possible implications of the results. Publishing first results in peer-reviewed journals will also enable an in-depth examination of the material and a comparison with the international literature.

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6 Appendix

6.1 Detailed description of the TARMED positions / ATC-codes that were grouped together for the analyses (health insurance data)

Table 25: Overview of the considered TARMED positions / ATC-codes

	Description and *further information*[1]	**Analyses[2]**
TARMED positions		
(Developmental pediatric) consultations		
00.0010	Consultation, first 5 min. (basic consultation) *This code cannot be combined with the codes for well-child visits. Hence, practitioners use either code.*	Consultations (00.0010)
03.0135	Developmental pediatric examination of children/adolescents and adults up to 18 years of age by a specialist in pediatrics and adolescent medicine, per 5 min. *Aspects such as drinking, eating, crying, sleep patterns, autonomy development and development of social behavior are assessed in such developmental pediatric examinations.*	Developmental pediatric consultations (03.0135)
Well-child visits		
	Well-child visits (preventative examinations) according to recommendations SGP'93, in the…	SASIS: Since the youngest age group in this data set is 0-5y, all well-child visits were grouped together for the analyses and summarized under the term “well-child visits up to 5 years (03.0020-03.0090)”. SWICA: Since the age groups in this data set are more nuanced, the well-child visits were analyzed more detailed, i.e., “well-child visits up to 12 months (03.0020-60)” and “well-child visits for children over 1 to 5 years of age (03.007-90)”
03.0020	…1st month	
03.0030	…2nd month	
03.0040	…4th month	
03.0050	…6th month	
03.0060	…9th – 12th month	
03.0070	…15th – 18th month	
03.0080	…24th month	
03.0090	…5th year	
Telephone consultations		
	Telephone consultation by the…	
00.0110	…physician, first 5 min.	All telephone consultations
00.0120	…physician for persons over 6 years … of age, each additional 5 min.	Long telephone consultations
00.0125	…specialist for children under 6 years of age …, every additional 5 min.	

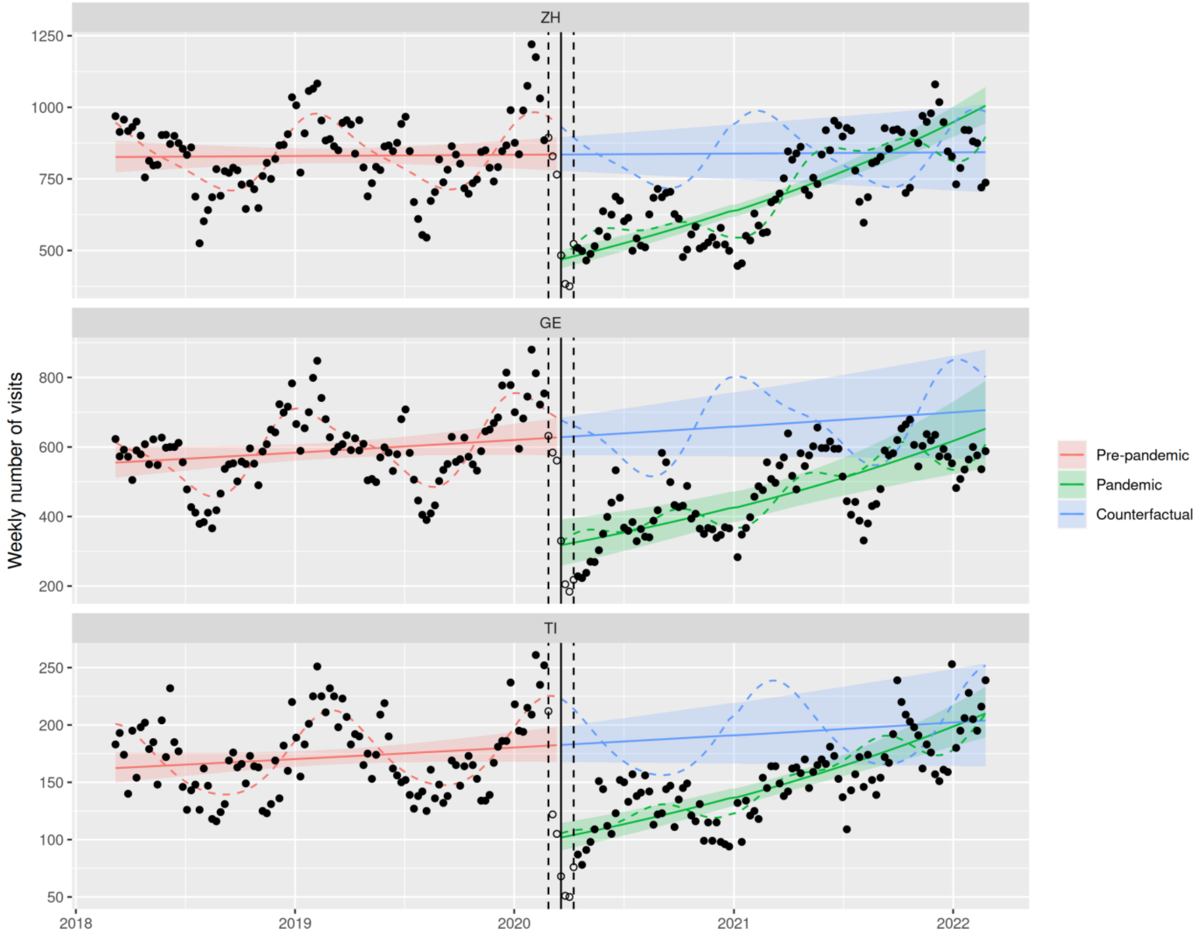
	Description and *further information*[1]	**Analyses[2]**
Urgent consultations/visits		
	Emergency inconvenience rate…	Consultations/visits for urgent health problems (00.2505/10/20/40/60/80) *"Urgent health problems" refer to health issues that are perceived as being urgent by a physician and/or the caregiver of the child*
00.2505	…F for urgent consultations/visits outside regular office hours, as well as Mon-Fri 19-22, Sat 7-19, and Sun 7-19	
00.2510	…A, Mon-Fri 7-19, Sat 7-12	
00.2520	…B, Mon-Sun 19-22, Sat 12-19, Sun 7-1	
00.2540	…C, Mon-Sun 22-7	
00.2560	…D for telephone consultation, Mon-Sun 19-22, Sat 12-19, Sun 7-19	
00.2580	…E for telephone consultation, Mon-Sun 22-7	
ATC-codes		
J07AJ52	Vaccinum diphtheria adsorbatum	Diphtheria/tetanus/pertussis (polio / haemophilus influenzae-b infection / hepatitis B)
J07CA02	Vaccinum diphtheria adsorbatum	
J07CA06	Vaccinum diphtheria adsorbatum	
J07CA09	Vaccinum diphtheria adsorbatum	
J07AL02	Vaccinum pneumococcale polysaccharidicum	Pneumococcos
J07BD52	Measles-mumps-rubella	Measles/mumps/rubella/(varicella)
J07BD54	Measles-mumps-rubella -varicella	
J07AH08	Meningococcus ACWY	Meningococcus
J07AH07	Meningococcus Type C	
J07BA01	TBE (tick-borne encephalitis)	TBE (tick-borne encephalitis)

Note: [1] Further information was, for instance, provided by the practitioners who were involved in the project. This information is of importance to interpret the data (e.g., to comprehend the relation between different TARMED positions). [2] This column indicates, which TARMED positions or ATC-codes were grouped together for the analyses. Furthermore, it indicates what terminology was used to describe the service (including vaccines) in the results. SGP = "pädiatrie schweiz" (Swiss Society of Pediatrics)

6.2 Pediatric Emergency Department data: detailed results of the ITS models

6.2.1 Weekly number of ED visits (total)

Figure 20: Observed total number of visits in ED per week, by canton (ZH, GE, TI)



Note: Dashed curves refer to the expected number of visits (including seasonal effects) while log-linear regression lines depict the trend in the expected number of visits (adjusted for seasonality) during the pre-pandemic and pandemic periods. Colored areas refer to a 95% confidence interval for the regression lines. The two vertical dashed lines delimit the transition period (week 9 to 15 of 2020, data not used to fit the model) while the solid vertical line refers to the assumed change point (week 12 of 2020: onset of the lockdown).

Table 26: Model estimates for the weekly total number of visits in ED, by canton (ZH, GE, TI)

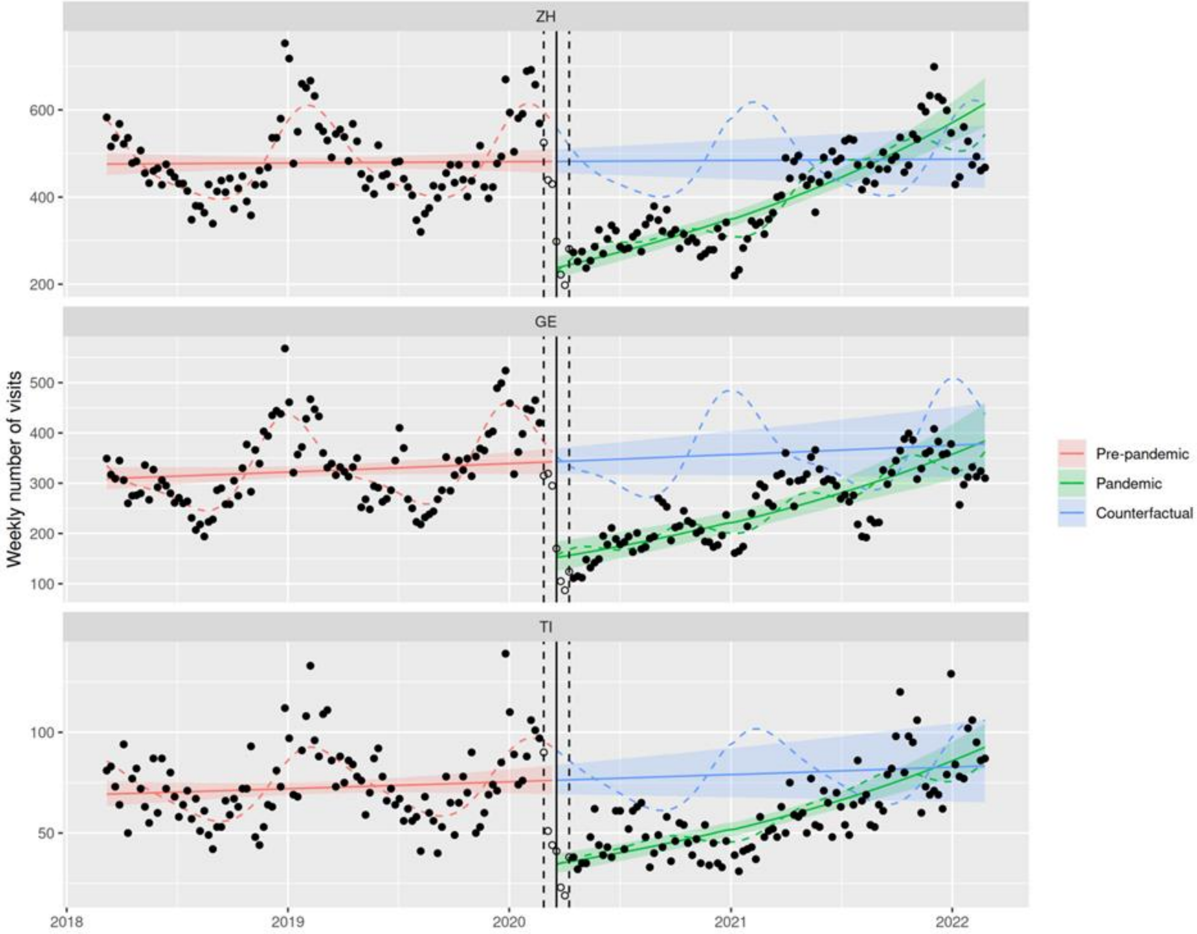
Canton	Time	Pandemic	Time x Pandemic
ZH	1.005 [0.947; 1.067]	0.561*** [0.509; 0.619]	1.480*** [1.359; 1.612]
GE	1.062 [0.988; 1.143]	0.506*** [0.404; 0.633]	1.369** [1.125; 1.665]
TI	1.059 [0.985; 1.139]	0.558*** [0.483; 0.645]	1.376*** [1.214; 1.560]

Note: Interrupted time-series negative binomial regression, adjusted for seasonality and autocorrelation. Coefficients refer to the ratio of weekly number of visits (after one year for trends). 95% confidence interval in brackets. *p < 0.05, **p < 0.01, ***p < 0.001

6.2.2 ED visits in different age groups

Age group 0-4 years old

Figure 21: Observed number of visits in ED for young children (age ≤4 years) per week, by canton (ZH, GE, TI)



Note: Dashed curves refer to the expected number of visits (including seasonal effects) while log-linear regression lines depict the trend in the expected number of visits (adjusted for seasonality) during the pre-pandemic and pandemic periods. Colored areas refer to a 95% confidence interval for the regression lines. The two vertical dashed lines delimit the transition period (week 9 to 15 of 2020, data not used to fit the model) while the solid vertical line refer to the assumed change point (week 12 of 2020: onset of the lockdown).

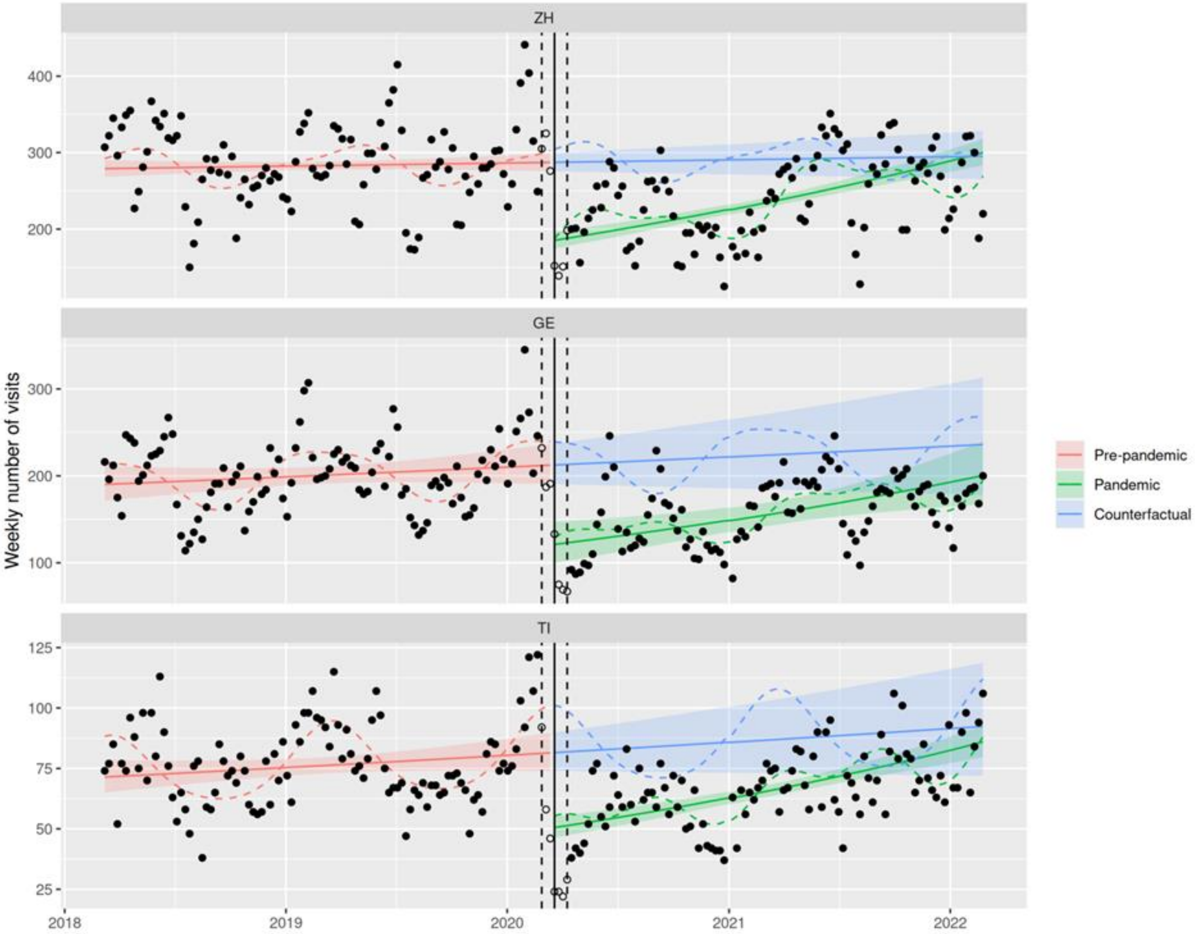
Table 27: Model estimates for ED number of visits in the age group 0-4 years old, by canton (ZH, GE, TI)

Canton	Time	Pandemic	Time x Pandemic
ZH	1.006 [0.959; 1.056]	0.493*** [0.439; 0.554]	1.628*** [1.472; 1.802]
GE	1.052 [0.987; 1.122]	0.444*** [0.361; 0.545]	1.539*** [1.284; 1.844]
TI	1.048 [0.966; 1.136]	0.456*** [0.385; 0.539]	1.590*** [1.376; 1.837]

Note: Interrupted time-series negative binomial regression, adjusted for seasonality and autocorrelation. Coefficients refer to the ratio of weekly number of visits (after one year for trends). 95% confidence interval in brackets. *p < 0.05, **p < 0.01, ***p < 0.001

Age group 5-12 years old

Figure 22: Observed number of visits in ED for children aged 5-12 years per week, by canton (ZH, GE, TI)



Note: Dashed curves refer to the expected number of visits (including seasonal effects) while log-linear regression lines depict the trend in the expected number of visits (adjusted for seasonality) during the pre-pandemic and pandemic periods. Colored areas refer to a 95% confidence interval for the regression lines. The two vertical dashed lines delimit the transition period (week 9 to 15 of 2020, data not used to fit the model) while the solid vertical line refer to the assumed change point (week 12 of 2020: onset of the lockdown).

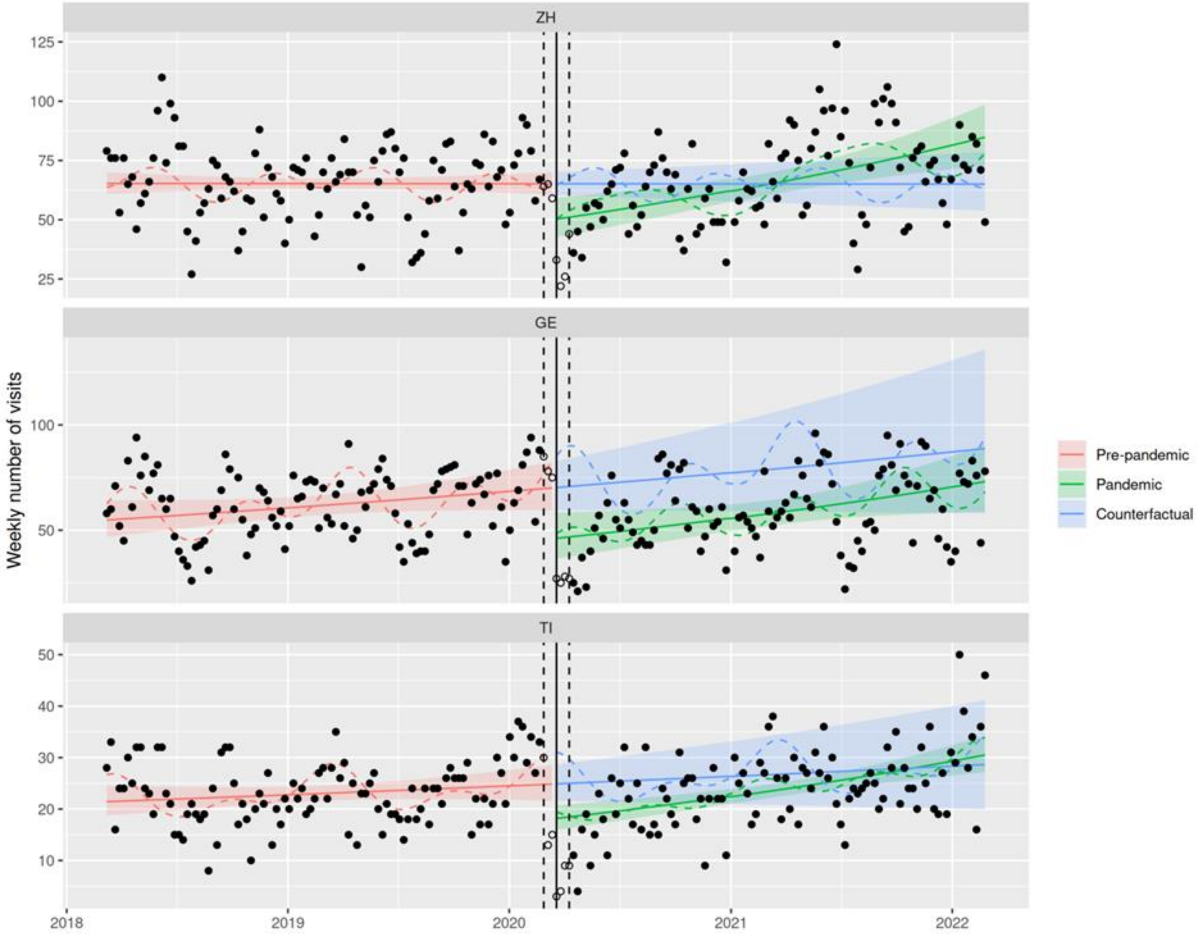
Table 28: Model estimates for ED number of visits in the age group 5-12 years old, by canton (ZH, GE, TI)

Canton	Time	Pandemic	Time x Pandemic
ZH	1.014 [0.979; 1.051]	0.645*** [0.600; 0.693]	1.267*** [1.188; 1.350]
GE	1.056 [0.962; 1.159]	0.570*** [0.456; 0.713]	1.230* [1.011; 1.496]
TI	1.067 [0.982; 1.160]	0.619*** [0.544; 0.705]	1.235*** [1.105; 1.381]

Note: Interrupted time-series negative binomial regression, adjusted for seasonality and autocorrelation. Coefficients refer to the ratio of weekly number of visits (after one year for trends). 95% confidence interval in brackets. *p < 0.05, **p < 0.01, ***p < 0.001

Age group 13-18 years old

Figure 23: Observed number of visits in ED for adolescents (13-18 years) over time, by canton (ZH, GE, TI)



Note: Dashed curves refer to the expected number of visits (including seasonal effects) while log-linear regression lines depict the trend in the expected number of visits (adjusted for seasonality) during the pre-pandemic and pandemic periods. Colored areas refer to a 95% confidence interval for the regression lines. The two vertical dashed lines delimit the transition period (week 9 to 15 of 2020, data not used to fit the model) while the solid vertical line refer to the assumed change point (week 12 of 2020: onset of the lockdown).

Table 29: Model estimates for ED number of visits in the age group 13-18 years old, by canton (ZH, GE, TI)

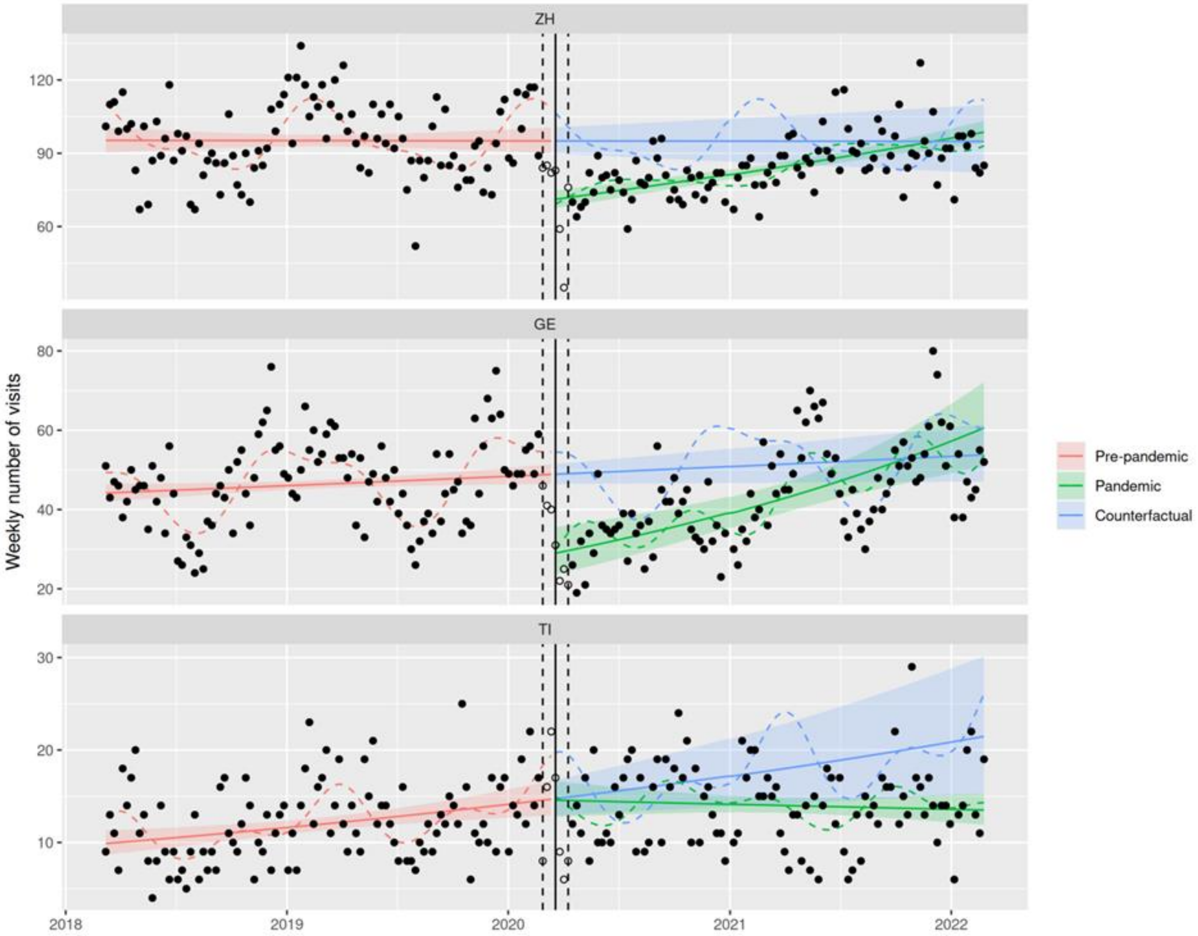
Canton	Time	Pandemic	Time x Pandemic
ZH	0.999 [0.938; 1.063]	0.771** [0.644; 0.923]	1.314*** [1.121; 1.539]
GE	1.129 [0.981; 1.300]	0.657** [0.493; 0.876]	1.125 [0.874; 1.446]
TI	1.076 [0.954; 1.214]	0.731** [0.603; 0.885]	1.216* [1.031; 1.435]

Note: Interrupted time-series negative binomial regression, adjusted for seasonality and autocorrelation. Coefficients refer to the ratio of weekly number of visits (after one year for trends). 95% confidence interval in brackets. *p < 0.05, **p < 0.01, ***p < 0.001

6.2.3 Inpatient or outpatient management

Weekly number of ED visits requiring hospitalization

Figure 24: Observed number of hospitalization in ED per week, by canton (ZH, GE, TI)



Note: Dashed curves refer to the expected number of visits (including seasonal effects) while log-linear regression lines refer to the expected number of visits adjusted for seasonality. Colored areas refer to a 95% confidence interval for the regression line. The two vertical dashed lines delimit the transition period (week 9 to 15 of 2020, data not used to fit the model) while the solid vertical line refer to the assumed change point (week 12 of 2020: onset of the lockdown).

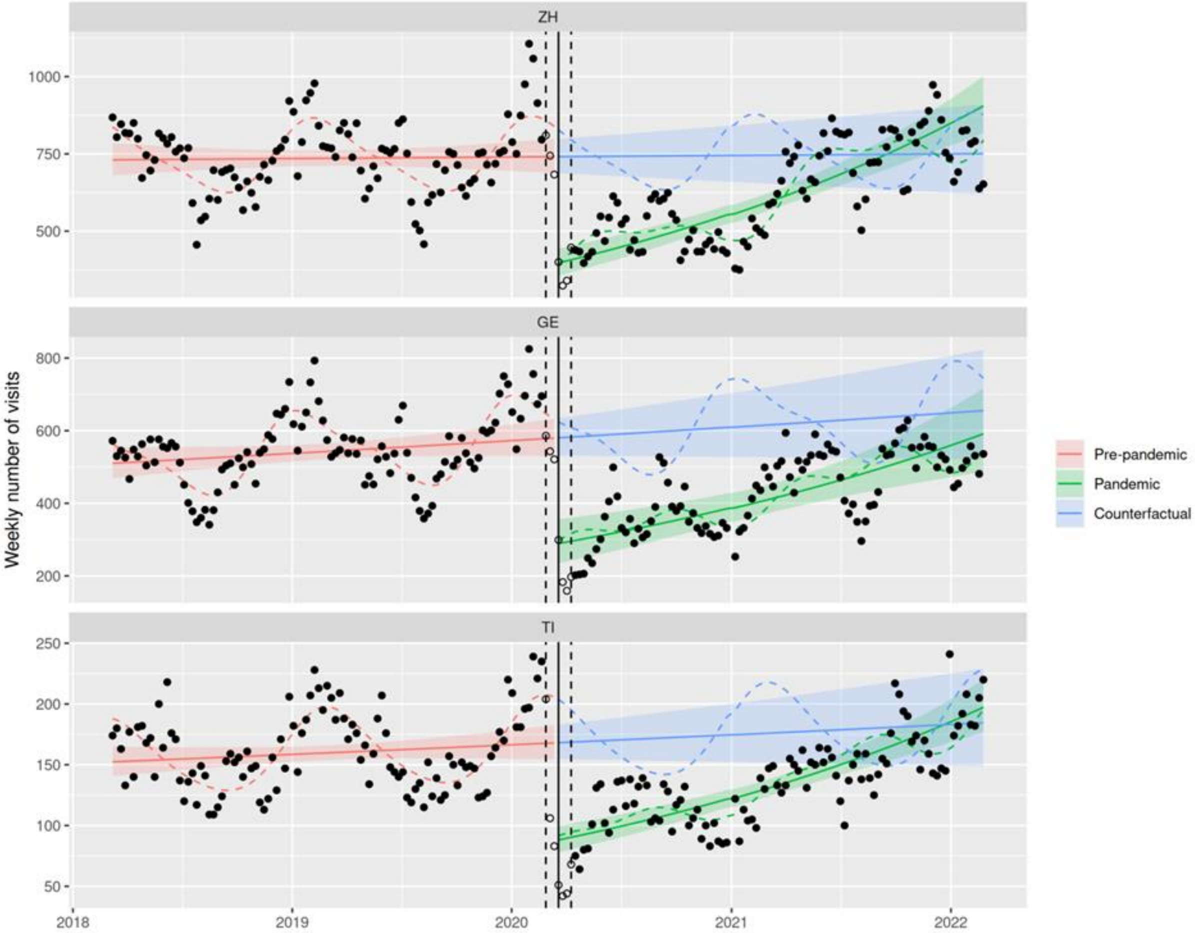
Table 30: Model estimates for the weekly number of hospitalizations, by canton (ZH, GE, TI)

Canton	Time	Pandemic	Time x Pandemic
ZH	0.999 [0.952; 1.048]	0.749*** [0.693; 0.808]	1.186*** [1.111; 1.267]
GE	1.051* [1.005; 1.099]	0.593*** [0.481; 0.732]	1.396*** [1.166; 1.670]
TI	1.216*** [1.085; 1.363]	0.989 [0.822; 1.190]	0.790** [0.671; 0.932]

Note: Interrupted time-series negative binomial regression, adjusted for seasonality and autocorrelation. Coefficients refer to the ratio of weekly number of visits (after one year for trends). 95% confidence interval in brackets. *p < 0.05, **p < 0.01, ***p < 0.001

Weekly number of ED visits with ambulatory care

Figure 25: Observed number of visits in ambulatory care per week, by canton (ZH, GE, TI)



Note: Dashed curves refer to the expected number of visits (including seasonal effects) while log-linear regression lines depict the trend in the expected number of visits (adjusted for seasonality) during the pre-pandemic and pandemic periods. Colored areas refer to a 95% confidence interval for the regression lines. The two vertical dashed lines delimit the transition period (week 9 to 15 of 2020, data not used to fit the model) while the solid vertical line refer to the assumed change point (week 12 of 2020: onset of the lockdown)

Table 31: Model estimates for ED number of visits in ambulatory care, by canton (ZH, GE, TI)

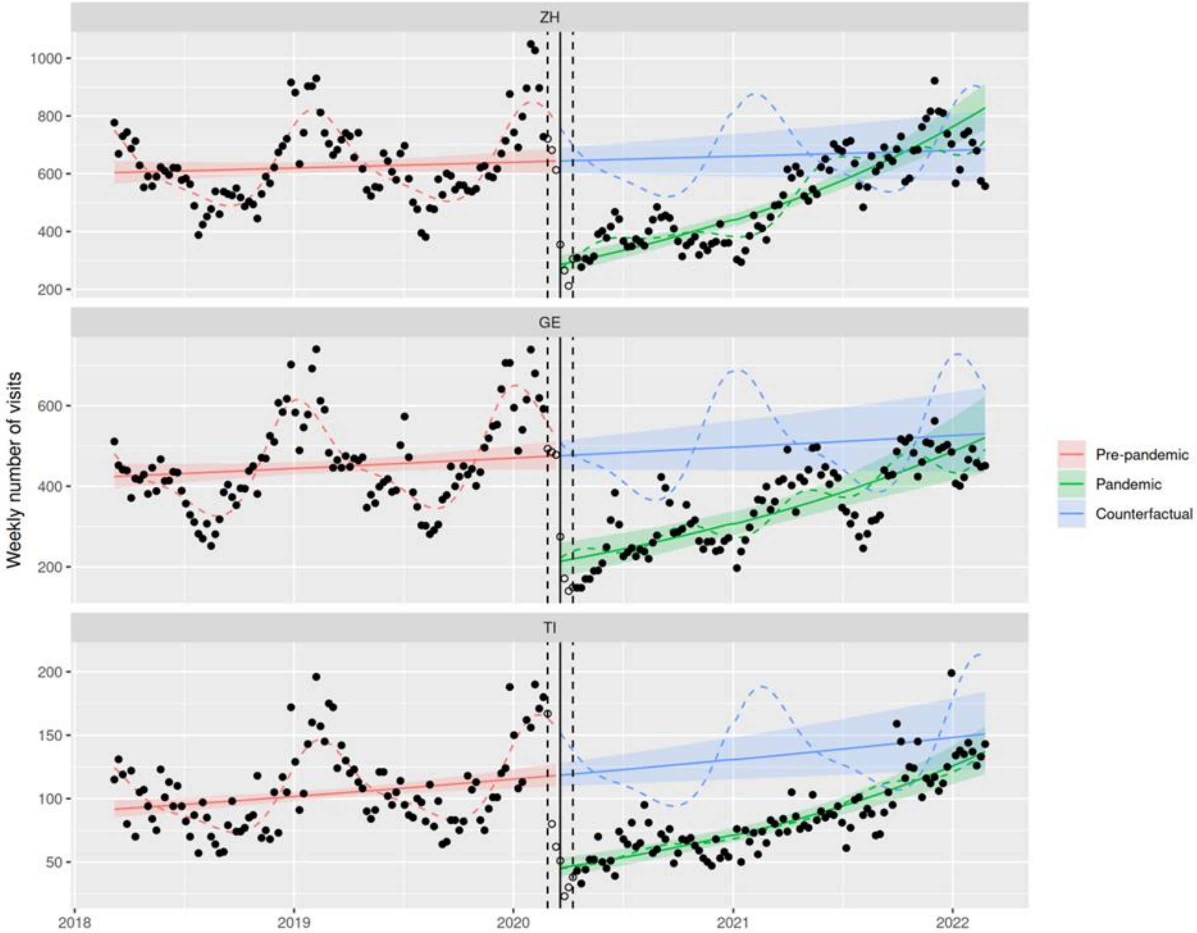
Canton	Time	Pandemic	Time x Pandemic
ZH	1.007 [0.945; 1.073]	0.536*** [0.470; 0.613]	1.524*** [1.356; 1.712]
GE	1.065 [0.988; 1.149]	0.498*** [0.398; 0.625]	1.362** [1.117; 1.660]
TI	1.049 [0.977; 1.128]	0.524*** [0.452; 0.608]	1.449*** [1.274; 1.648]

Note: Interrupted time-series negative binomial regression, adjusted for seasonality and autocorrelation. Coefficients refer to the ratio of weekly number of visits (after one year for trends). 95% confidence interval in brackets. *p < 0.05, **p < 0.01, ***p < 0.001

6.2.4 ED visits due to non-accidental and accidental causes

ED visits related to non-accidents (e.g. diseases)

Figure 26: Observed number of visits in ED related to non-accidental causes per week, by canton (ZH, GE, TI)



Note: Dashed curves refer to the expected number of visits (including seasonal effects) while log-linear regression lines depict the trend in the expected number of visits (adjusted for seasonality) during the pre-pandemic and pandemic periods. Colored areas refer to a 95% confidence interval for the regression lines. The two vertical dashed lines delimit the transition period (week 9 to 15 of 2020, data not used to fit the model) while the solid vertical line refer to the assumed change point (week 12 of 2020: onset of the lockdown).

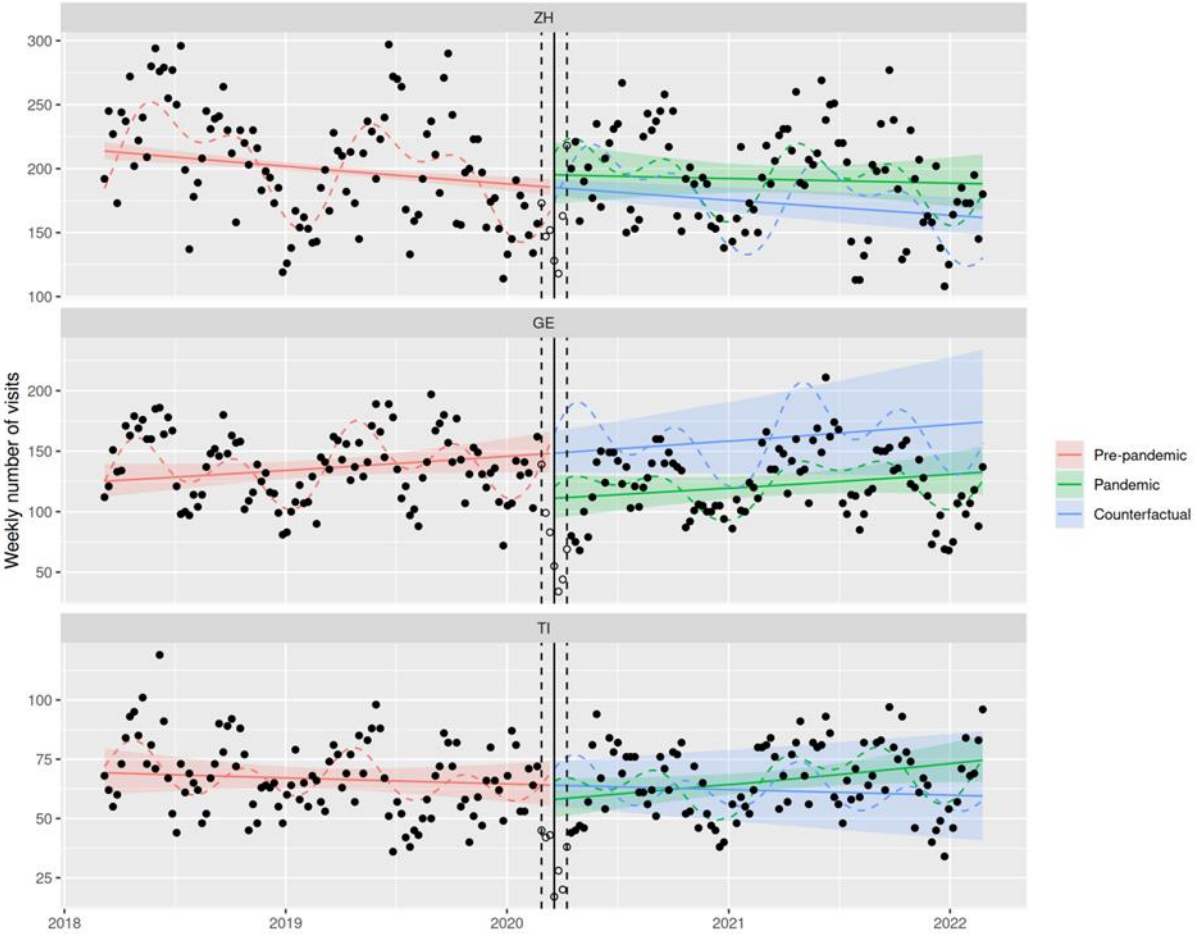
Table 32: Model estimates for ED number of visits due to other reasons than accidents, by canton (ZH, GE, TI)

Canton	Time	Pandemic	Time x Pandemic
ZH	1.032 [0.974; 1.094]	0.443*** [0.391; 0.503]	1.686*** [1.509; 1.883]
GE	1.058 [0.992; 1.128]	0.449*** [0.364; 0.555]	1.502*** [1.247; 1.809]
TI	1.134*** [1.062; 1.212]	0.383*** [0.321; 0.458]	1.565*** [1.343; 1.823]

Note: Interrupted time-series negative binomial regression, adjusted for seasonality and autocorrelation. Coefficients refer to the ratio of weekly number of visits (after one year for trends). 95% confidence interval in brackets. *p < 0.05, **p < 0.01, ***p < 0.001

ED visits related to accidents

Figure 27: Model estimates for ED number of visits due to accidents, by canton (ZH, GE, TI)



Note: Dashed curves refer to the expected number of visits (including seasonal effects) while log-linear regression lines depict the trend in the expected number of visits (adjusted for seasonality) during the pre-pandemic and pandemic periods. Colored areas refer to a 95% confidence interval for the regression lines. The two vertical dashed lines delimit the transition period (week 9 to 15 of 2020, data not used to fit the model) while the solid vertical line refer to the assumed change point (week 12 of 2020: onset of the lockdown).

Table 33: Model estimates for ED number of visits due to accidents, by canton (ZH, GE, TI)

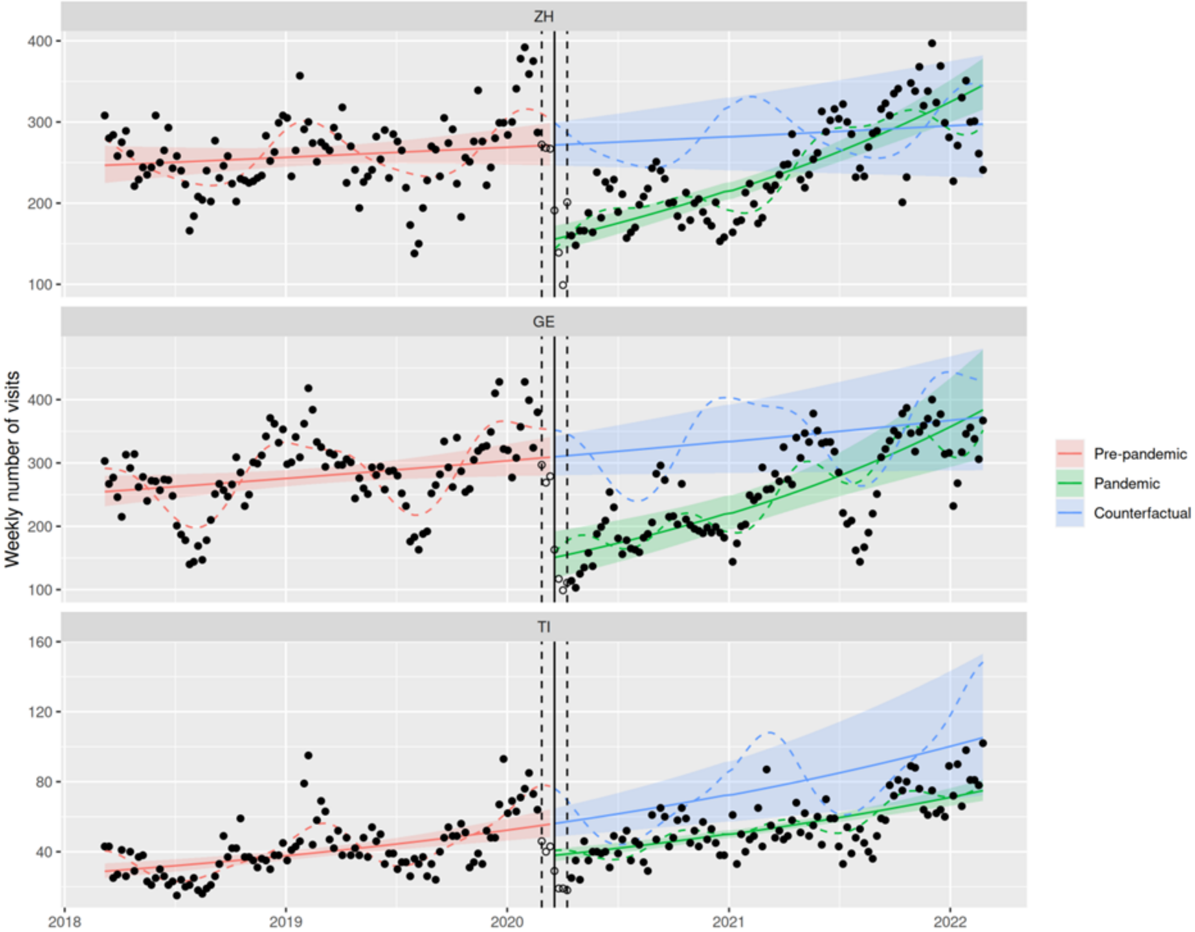
Canton	Time	Pandemic	Time x Pandemic
ZH	0.932*** [0.906; 0.960]	1.053 [0.927; 1.197]	1.053 [0.939; 1.180]
GE	1.087 [0.986; 1.198]	0.749** [0.615; 0.911]	1.009 [0.849; 1.198]
TI	0.962 [0.850; 1.090]	0.909 [0.744; 1.110]	1.181 [0.993; 1.405]

Note: Interrupted time-series negative binomial regression, adjusted for seasonality and autocorrelation. Coefficients refer to the ratio of weekly number of visits (after one year for trends). 95% confidence interval in brackets. *p < 0.05, **p < 0.01, ***p < 0.001

6.2.5 Urgency of ED visits (triage categories)

Urgent ED visits (triage category ≤3)

Figure 28: Observed number of urgent visits in ED per week, by canton (ZH, GE, TI)



Note: Dashed curves refer to the expected number of visits (including seasonal effects) while log-linear regression lines refer to the expected number of visits adjusted for seasonality. Colored areas refer to a 95% confidence interval for the regression line. The two vertical dashed lines delimit the transition period (week 9 to 15 of 2020, data not used to fit the model) while the solid vertical line refer to the assumed change point (week 12 of 2020: onset of the lockdown)

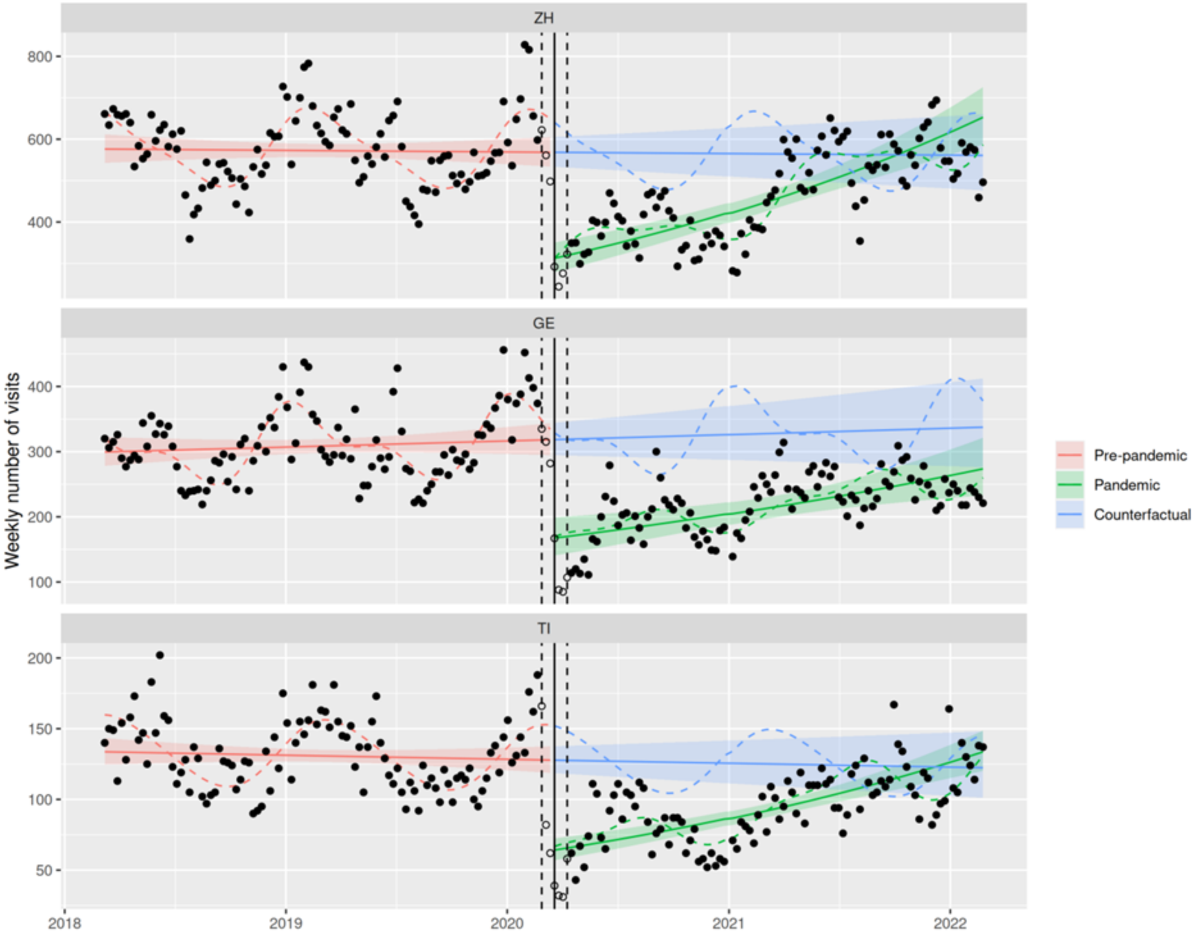
Table 34: Model estimates for the weekly number of ED visits in triage category ≤3 (urgent), by canton (ZH, GE, TI)

Canton	Time	Pandemic	Time x Pandemic
ZH	1.048 [0.965; 1.139]	0.573*** [0.498; 0.659]	1.444*** [1.279; 1.631]
GE	1.101* [1.012; 1.198]	0.487*** [0.375; 0.632]	1.476*** [1.176; 1.854]
TI	1.387*** [1.223; 1.573]	0.676*** [0.570; 0.802]	1.027 [0.885; 1.193]

Note: Interrupted time-series negative binomial regression, adjusted for seasonality and autocorrelation. Coefficients refer to the ratio of weekly number of visits (after one year for trends). 95% confidence interval in brackets. *p < 0.05, **p < 0.01, ***p < 0.001

Non-urgent ED visits (triage category >3)

Figure 29: Observed number of non-urgent visits in ED per week, by canton (ZH, GE, TI)



Note: Dashed curves refer to the expected number of visits (including seasonal effects) while log-linear regression lines refer to the expected number of visits adjusted for seasonality. Colored areas refer to a 95% confidence interval for the regression line. The two vertical dashed lines delimit the transition period (week 9 to 15 of 2020, data not used to fit the model) while the solid vertical line refer to the assumed change point (week 12 of 2020: onset of the lockdown).

Table 35: Model estimates for the weekly number of ED visits in triage category >3 (non-urgent), by canton (ZH, GE, TI)

Canton	Time	Pandemic	Time x Pandemic
ZH	0.993 [0.941; 1.048]	0.550*** [0.482; 0.627]	1.477*** [1.316; 1.657]
GE	1.031 [0.965; 1.101]	0.526*** [0.435; 0.636]	1.253** [1.059; 1.482]
TI	0.978 [0.918; 1.042]	0.502*** [0.436; 0.578]	1.497*** [1.325; 1.692]

Note: Interrupted time-series negative binomial regression, adjusted for seasonality and autocorrelation. Coefficients refer to the ratio of weekly number of visits (after one year for trends). 95% confidence interval in brackets. *p < 0.05, **p < 0.01, ***p < 0.001