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

Final report

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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

Executive Summary

Background: COVID-19 – officially declared a pandemic by the World Health Organization on March 11th, 2020 – negatively impacted societies around the world. COVID-19-related mortality and morbidity were heightened in people with certain pre-existing conditions and in the elderly. Although the direct impact of COVID-19 on the mortality and morbidity of children and adolescents was much less severe, it is still conceivable that indirect effects of the pandemic and the introduced measures affected their health negatively. In Switzerland, the government introduced various measures to reduce the likelihood of virus transmission, including a lockdown and restrictions of elective and non-urgent medical care in the early phase of the pandemic. Children up to two years of age were partly exempt from these exceptions and pediatric associations and the Federal Office of Public Health communicated early that 0-2-year-olds should adhere to the regularly scheduled well-child visits and vaccinations. However, before carrying out the present study, it was largely unclear whether caregivers adhered to these recommendations and how pediatric utilization changed as an effect of the pandemic more generally in Switzerland.

Aims: The current study aimed to investigate the impact of the pandemic on primary and tertiary health care utilization in children and adolescents and to study factors associated with utilization. The resulting insights were intended to inform policy and practice and to be a sound basis for the formulation of recommendations to address potential current issues regarding the health of young people and to be better prepared for potential future health crises.

Methods: Interrupted time series were used to analyze Swiss national health insurance data (primary care: data from SASIS and SWICA were analyzed) and pediatric emergency department data (tertiary care: data from three hospitals were analyzed) from January 2018 – June 2022 in 0-18-year-olds. The first lockdown was used to differentiate between pre-pandemic and pandemic periods. Incident rate ratios and 95% confidence intervals (square brackets) are reported.

Results: Lower average utilization rates during the pandemic vs. the pre-pandemic period were identified for various health services and this decrease was mostly observed for the youngest age groups. In primary care, this pattern emerged for regular (0-5y: 0.760 [0.644-0.896]; 6-10y: 0.850 [0.742-0.974]), well-child (0-5y: 0.871 [0.765-0.992]), and urgent visits (0-5y: 0.638 [0.500-0.813]; 6-10y: 0.810 [0.665-0.985]), and for the vaccination against measles/mumps/rubella (MMR; 0-5y: 0.841 [0.729-0.971]). Similarly, in tertiary care, ED visits decreased nearly 50% in all three regions at the onset of the lockdown (Zurich: 0.561 [0.509-0.619]; Geneva: 0.506 [0.404-0.633]; Ticino: 0.558 [0.483-0.645]), and it took over a year until pediatric ED visits reached pre-pandemic levels. This reduction was primarily observed in the youngest age group (0-4y): Zurich: 0.493 [0.439-0.554]; Geneva: 0.444 [0.361-0.545]; Ticino: 0.456 [0.385-0.539]. Both non-urgent and urgent visits decreased at the onset of the lockdown: non-urgent visits (Zurich: 0.55 [0.482-0.627]; Geneva: 0.526 [0.435-0.636]; Ticino: 0.502 [0.436-0.578]) and urgent visits (Zurich: 0.573 [0.498-0.659]; Geneva: 0.487 [0.375-0.632]; Ticino: 0.676 [0.57-0.802]). The utilization rates of most services dropped markedly after the lockdown – i.e., when the most stringent measures were put in place – and recovered to some extent over the pandemic phase. However, no recovery was found for regular and urgent visits in 0-6-year-olds and for the MMR-vaccination in 0-5-year-olds. In primary care, higher average utilization rates during the pandemic were identified for telemedical consultations in general (0-5y: 1.394 [1.218-1.594]; 6-10y: 1.547 [1.387-1.726]; 11-15y: 1.578 [1.430-1.741]; 16-18y: 1.831 [1.614-2.076]), and for telemedical consultations through a psychiatrist in older age groups (11-15y: 1.813 [1.553,2.118], $p<0.001$; 16-18y: 1.973 [1.649,2.362], $p<0.001$). In some age groups, the utilization of telemedicine increased significantly

after the lockdown and remained elevated over the pandemic phase, whereas it decreased again in other age groups. Utilization of other psychiatric health services besides telemedical consultations through a psychiatrist did not differ significantly between pre- and pandemic periods. However, utilization rates for psychiatric crisis interventions increased over the pandemic period in 16-18-year-olds (16-18y: 1.015, [1.004,1.027], $p<0.01$). In primary care, the impact of the pandemic mostly did not vary by gender or region. However, low utilization rates have made it impossible to draw conclusions in this regard for some TARMED positions. In tertiary care, however, regional differences were noted. The number of urgent ED visits and hospitalization in Ticino at the beginning of the lockdown differed compared to Zurich and Geneva. In Ticino, the decrease in urgent visits 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, unlike in Zurich and Geneva (Zurich: 0.749 [0.693-0.808]; Geneva: 0.593 [0.481-0.732]; Ticino: 0.989 [0.822-1.190]). Our geographical analyses, using postal codes from ED patients, showed a decrease in the number of ED visits during the pandemic. However, there was no change in the pattern, suggesting that rural regions were not disadvantaged compared to urban regions and that patients from these areas were also able to visit the EDs.

Conclusions: Utilization of pediatric health services in Switzerland was significantly affected by the pandemic, with the strongest impact directly after the lockdown. However, the pandemic did not have a uniform effect on utilization. There were differences by service, age groups, direction of effect and in the recovery patterns across the pandemic phase. Some services may have been substituted by others (e.g., in-person visits by telemedicine), while others might have been missed or postponed (e.g., well-child visits, some vaccinations). Furthermore, a decrease in the demand for pediatric services might have caused changes in utilization (e.g., reduced demand for urgent/regular consultations due to a reduction of the incidence of some infectious diseases). Although the analyzed data provide important insights, a comprehensive, timely and adaptive monitoring as well as timely qualitative data would have allowed a more nuanced answer to the question on how the pandemic affected the health and health care utilization of young people.

Based on the results we recommend to:

1. **Promote catch-up well-child visits and MMR-vaccinations** with appropriate (communication) strategies.
2. **Be prepared and better equipped** for **short-term changes** in pediatric health service demands e.g., during potential future crises, such as for adolescent mental health services.
3. **Develop a** national **pediatric monitoring system** for primary and tertiary care to continuously assess health AND health care utilization of children and adolescences.
4. **Improve and further develop telemedicine** and prepare steps to upscale such services if needed for primary and tertiary care.
5. For potential future crisis it would be important to **take regional differences into account, involve local representatives, and to make differentiated recommendations**, where appropriate (e.g., where and to whom stay home policies apply).

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 lockdown, 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).

A recent study from Switzerland studied the impact of the COVID-19 pandemic on the utilization of inpatient and outpatient mental healthcare in Switzerland using nationwide hospital data and claims data from a large Swiss health insurer (Helsana) (47). However, the analyses do not allow detailed conclusions on the utilization of children and adolescents, since only the age group "< 20 years" was considered. A finer graded view for children and adolescents is particularly warranted, since the results indicate a distinct pattern for the youngest age group, most strikingly, an increase in inpatient and outpatient mental healthcare utilization among young females after the first shutdown rather than a decrease or maintenance of the utilization of such services. Besides the mentioned publication, 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 and beyond mental 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 (including lessons learned) of these two data types will be discussed one after another. An overall discussion 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 value of using two data sets

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 (48). 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 7.2.1.

Table 3: Overview of the considered TARMED Positions

Terminology used in the results (TARMED number)	**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.*

Terminology used in the results (TARMED number)	**Description**
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) 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 within the first year were grouped together. 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.
Telemedicine	
All telemedical consultations (00.0110)	Telemedical consultations by the physician, first 5 min.
Long telemedical consultations (00.0120, 00.0125)	Telemedical 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.*
Psychiatric health services	
Psychiatric diagnostic/therapy first session (02.0010)	Psychiatric diagnostics and therapy, individual therapy, first session, per 5 min.
Psychiatric diagnostic/therapy subsequent session (02.0020)	Psychiatric diagnostics/therapy, individual therapy, subsequent session
Psychiatric diagnostic/therapy family (02.0040)	Psychiatric diagnostics and therapy, family therapy, per 5 min.
Psychiatric diagnostic/therapy group (02.0050)	Psychiatric diagnostics and therapy, group therapy, per 5 min.
Psychiatric crisis intervention (02.0080)	Psychiatric crisis intervention, per 5 min.
Telemedical consultations psychiatrist (02.0060/65/66)	Telemedical consultations by a psychiatrist per 5 min.
Psychiatrics and psychological testing (02.0090)	Psychological and psychiatric test assessment by the specialist, per 5 min., as the sole psychiatric service

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 (49–53), *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 (49–53) 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 (49–53). 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

3.1.4.1 Interrupted Poisson 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. The main analyses were stratified by age. Secondary analyses were carried out regarding gender and regional differences. In terms of regional differences, language regions were considered in SASIS (German-speaking, French-speaking, and Ticino as Italian-speaking canton). Bilingual cantons were assigned to a language region according to the most frequently spoken language. Berne, for instance, was assigned to the German-speaking language region. The German-speaking language region was used as reference. SWICA data did not allow the same classification into language regions. However, SWICA provides a different indictor for regions, which differentiates between urban (used as reference), intermediate, and rural.

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 (54).

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 lockdown). 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.

3.1.4.2 Stringency analyses

The KOF Stringency Indices were considered for additional analyses to assess if utilization rates of pediatric care varied with the stringency of measures that were in place at a certain point in time. Details on the KOF Stringency Indices can be found elsewhere (KOF Stringency Indices – KOF Swiss Economic Institute | ETH Zurich and (55)). In short, the KOF Stringency Indices represent the level of lockdown policies over time and between cantons and vary between 0 (= no measures) and 100 (= full lockdown). Daily data for these Indices is available from January 2020 onwards. However, since SASIS only provides monthly data, monthly averages for the Stringency Indices were used. Furthermore, average data for Switzerland rather than single cantons were used. These monthly national indices as well as the utilization data were incorporated into a single figure. To reduce the number of figures, only those TARMED positions and age groups were considered for which the ITS revealed a significant pandemic effect. Separate figures were created for females and males.

3.2 Results

3.2.1 Pre-pandemic trends, pandemic trends, and interactions, differentiated by age categories

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. Hence, **no details are provided regarding the following TARMED positions / ATC** subsequently (the rates of these services were too low across all considered age groups):

- Long telemedical consultations (00.0120, 00.0125),
- Psychiatric diagnostic/therapy group (02.0050), and
- Vaccination against meningococcus.

The subsequent paragraphs summarize findings from ITS modelling. More details (including estimates of the models) are provided in Appendix 7.2.2.

Table 6 summarizes pre-pandemic trends, the effects of the pandemic, and interaction effects (pandemic x time). Results are shown for the different TARMED positions / ATC and age groups, both for SASIS and SWICA. As detailed in the Methods, the advantage of SASIS is its high coverage (representativeness). Therefore, the results of SASIS are shown in bold. When results from SASIS and SWICA are contradicting, findings from SASIS should be weighted more. 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).

<u>**Pre-pandemic trends**</u>

For some TARMED positions / ACT, a change in utilization already occurred over the pre-pandemic phase in particular age groups. An ***increase in utilization***, for instance, was yielded for…

- **developmental pediatric consultations**
  - SASIS:
    - 0-5y: 1.015 [1.006,1.023], $p<0.01$
    - 6-10y: 1.018 [1.008,1.028], $p<0.001$
  - SWICA:
    - 0-12m: 1.002 [1.000,1.003], $p<0.05$
- **telemedical consultations**
  - SWICA:
    - 0-12m: 1.002 [1.001,1.004], $p<0.001$
- **vaccination against measles/mumps/rubella/(varicella)**
  - SASIS:
    - 0-5y: 1.011 [1.004,1.017]; $p<0.01$
- **psychiatric diagnostic/therapy family**
  - SASIS:
    - 6-10y: 1.006 [1.000,1.013], $p<0.05$
    - 16-18y: 1.008 [1.003,1.014], $p<0.01$

In contrast, a decrease was observed for the vaccination against diphtheria/tetanus/polio in some age groups (SASIS: 0-5y: 0.993 [0.987,0.999], p<0.01; SWICA: 0-12m: 0.997 [0.995-0.999], p < 0.001), but an increase in another (SWICA: 13-24m: 1.003 [1.001,1.004], p < 0.01).

Effect of the pandemic

For most of the studied TARMED positions, ***no pandemic effect*** emerged (neither in SASIS nor in SWICA). Such non-significant effects were identified for **developmental pediatric consultations, vaccination against pneumococcus, TBE** and **almost all psychiatric health services**, except for telemedical consultations by a psychiatrist (see below).

However, for several services ***lower average utilization rates*** were yielded in the pandemic vs. the pre-pandemic phase, particularly in the youngest age groups. Specifically, a lower utilization during the pandemic was identified for…

- **regular consultations**
  - SASIS:
    - 0-5y: 0.760 [0.644-0.896], p < 0.01
    - 6-10y: 0.850 [0.742-0.974], p < 0.05
  - SWICA:
    - 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
    - 6-10y: 0.828 [0.727-0.943], p < 0.01
- **well-child visits**
  - SASIS:
    - 0-5y: 0.871 [0.765-0.992]; p < 0.05
- **urgent health problems**
  - SASIS:
    - 0-5y: 0.638 [0.500-0.813], p < 0.001
    - 6-10y: 0.810 [0.665-0.985], p < 0.05
- **vaccination against measles/mumps/rubella/varicella**
  - SASIS:
    - 0-5y: 0.841 [0.729-0.971], p < 0.05
  - SWICA:
    - 13-24m: 0.721 [0.607-0.856], p < 0.001
- **vaccination against diphtheria/tetanus/polio**
  - SWICA:
    - effect only found in the SWICA data, 13-24m: 0.710 [0.592-0.852], p < 0.001

Less commonly, ***higher average utilization rates*** were identified during the pandemic vs. the pre-pandemic phase. Such a pattern was consistently observed across all age groups and both in SASIS and SWICA for

- **telemedical consultations overall**
  - SASIS:
    - 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
    - 16-18y: 1.831 [1.614-2.076], p < 0.001
  - SWICA:
    - 0-12m: 1.213 [1.066-1.381], p < 0.01.
- **telemedical consultations by a psychiatrist**
  - SASIS:
    - 11-15y: 1.813 [1.553,2.118], p<0.001
    - 16-18y: 1.973 [1.649,2.362], p<0.001

<u>Interaction effect pandemic x time</u>

The pandemic effect described above sometimes emerged due to an initial marked down- or upward change in the utilization rates immediately after the lockdown. As indicated by significant interaction terms, utilization of some services *normalized after this initial decrease or increase* in utilization, respectively. An ***upward normalization*** (i.e., increase in utilization) after an initial drop was found in 0-5-year-olds for…

- **regular consultations**
  - SASIS:
    - 0-5y: 1.017 [1.007-1.028], p<0.01
  - SWICA:
    - 0-12m: 1.003 [1.001-1.004], p < 0.001
    - 13-24m: 1.005 [1.004-1.007], p < 0.001
    - 3-5y: 1.005 [1.004-1.007], p < 0.001
    - 6-10y: 1.002, [1.000,1.004], p < 0.05
- **well-child visits**
  - SASIS:
    - 0-5y: 1.009 [1.000-1.018], p < 0.05
- **urgent visits/consultations**
  - SASIS:
    - 0-5y: 1.023 [1.008-1.040], p < 0.01

In contrast, ***no upward normalization*** occurred for 6-10-year-olds for **regular consultations** (SASIS: 6-10y: 1.003 [0.994-1.013]) and **urgent visits/consultations** (SASIS: 6-10: 1.002 [0.989-1.015]) in the SASIS-data as indicated by non-significant interaction terms. Since SASIS-data is more representative, it can therefore be assumed that utilization remained low over the pandemic phase in 6-10-year-olds for the mentioned TARMED positions, even though the interaction term was significant for regular consultations in SWICA (0-6y: 1.002, [1.000,1.004], p < 0.05).
For other services, utilization was on average lower during the pandemic vs. pre-pandemic period and ***decreased even more over the pandemic phase***. This was found for some age groups for **vaccinations against measles/mumps/rubella/(varicella)** (SASIS: 0-5y: 0.988 [0.977-0.998], p

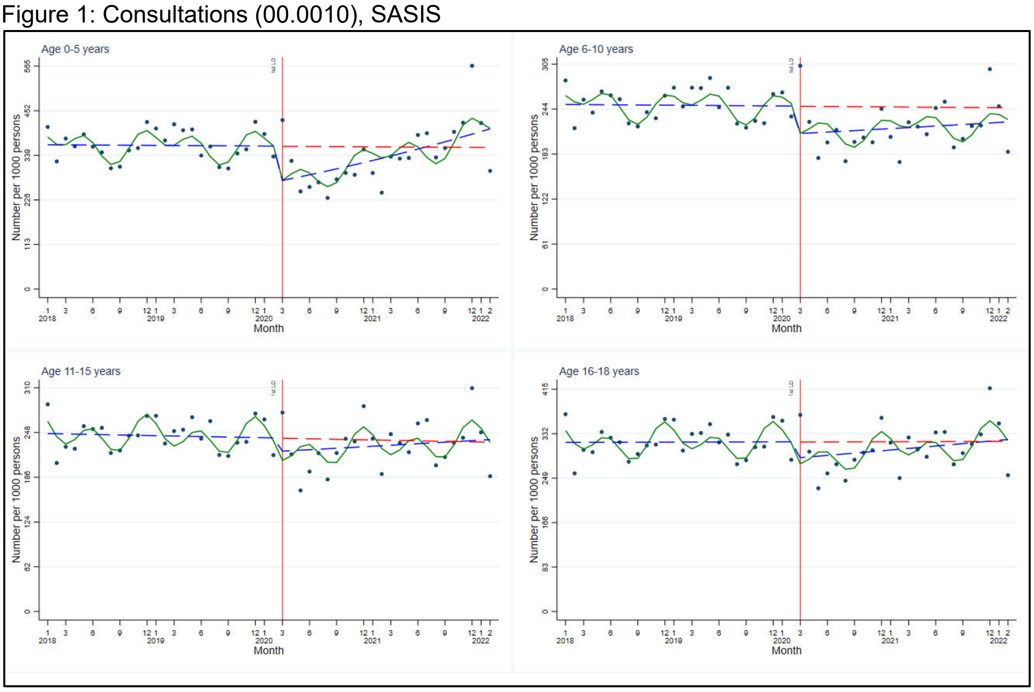
< 0.05) and **diphtheria/tetanus/polio** (SWICA: 13-24m: 0.996, [0.993,0.999], p<0.01). However, the finding regarding measles/mumps/rubella/(varicella) was not confirmed with the SWICA data, where an upward normalization was yielded for 13-24-months-olds (SWICA: 13-24m: 1.004 [1.001-1.007], p < 0.05). However, we again prioritize the results of the SASIS data, as these are more representative.

Furthermore, no pandemic effect regarding the vaccination against diphtheria/tetanus/polio was yielded for 0-12-months-olds in the SWICA data, but a significant increase in the vaccination rates over the pandemic phase (SWICA: 0-12m: 1.003 [1.000,1.007], p<0.05).

A ***downward normalization*** was sometimes observed for services with an increased utilization immediately after the lockdown. Such a pattern was, for instance, yielded for **telemedical consultation by a psychiatrist** (SASIS: 11-15y: 0.974, [0.964,0.985], p<0.001; 16-18y: 0.983 [0.971,0.995]) and for **telemedical consultations more generally** (i.e., not through a psychiatrist; TARMED position: 00.0110) for 6-10- and 16-18-year-olds, respectively (SASIS: 6-10y: 0.983 [0.971,0.995], p<0.01; 16-18y: 0.988 [0.979,0.996], p<0.01). However, for other age groups, this **heightened level of utilization remained** on a similar level over the pandemic phase, as indicated by non-significant interaction terms (SASIS: 0-5y: 1.002 [0.993,1.011]; 11-15y: 0.995 [0.989,1.002]; SWICA: 0-12m: 0.998 [0.996,1.000]). Lastly, some **interaction terms were significant, even though no pandemic effect emerged**. Utilization rates for **psychiatric crisis interventions**, for instance, increased over the pandemic period in 16-18-year-olds (SASIS: 16-18y: 1.015, [1.004,1.027], p<0.01).

Figure 1 illustrate some of the patterns that have been described above. Regular consultations are presented as example, as they are of particular importance in the pediatric setting. As described above, average utilization rates of this TARMED position were significantly lower among 0-5- and 6-10-year-olds in the pandemic vs. the pre-pandemic period, whereas no pandemic effect was identified for the older age groups. Furthermore, the Figure illustrates the upward normalization in 0-5-year-olds and no significant normalization for 6-10-year-olds over the pandemic period.

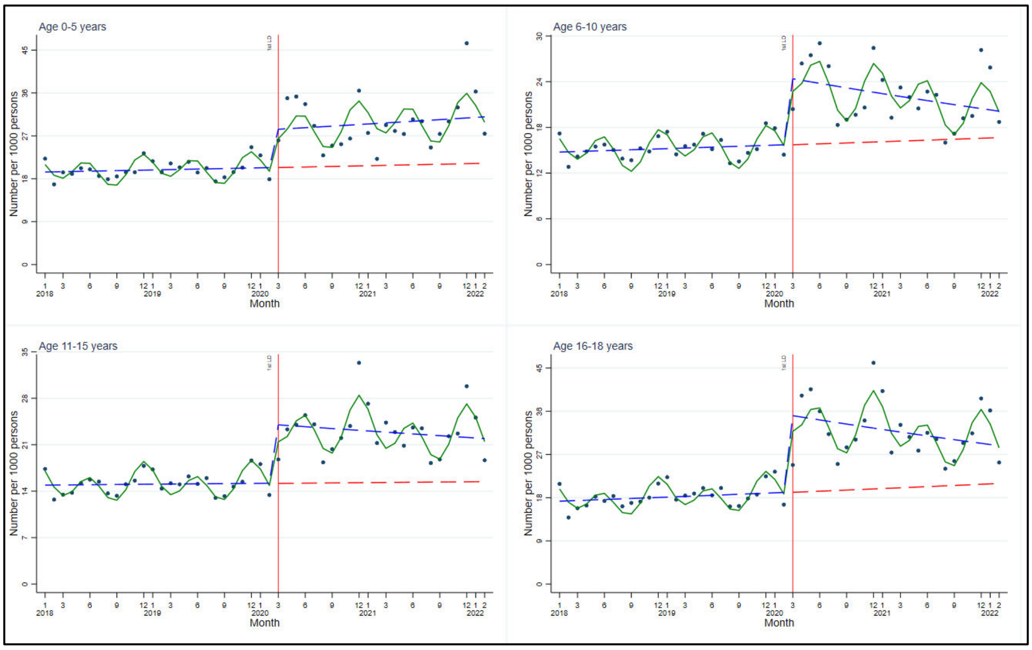
Figure 1: Consultations (00.0010), SASIS



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

Furthermore, Figure 2 illustrates that average utilization rates of telemedical consultations were significantly higher during the pandemic vs. the pre-pandemic period in all age groups, with a downward normalization in some age groups (6-10y; 16-18y), but not in others (0-5y; 11-15y).

Figure 2: All telemedical consultations (00.0110), SASIS



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

Table 6: Summary of pre-pandemic trends (time), pandemic effects, and interactions pandemic x time by age categories, SASIS and SWICA data

TARMED positions / ATC	**Age group**	**Time**		**Pandemic (level effect)**		**Interaction time x pandemic**	
		SASIS	SWICA	**SASIS**	SWICA	**SASIS**	SWICA
Consultations (00.0010)	0-5y	**ns**	NA	↓	NA	↑	NA
	> 0-12m	**NA**	ns	**NA**	↓	**NA**	↑
	> 13-24m	**NA**	ns	**NA**	↓	**NA**	↑
	> 3-5y	**NA**	ns	**NA**	↓	**NA**	↑
	6-10y	**ns**	ns	↓	↓	**ns**	↑
	11-14y (SWICA) 11-15y (SASIS)	**ns**	ns	**ns**	ns	**ns**	ns
	15-18y (SWICA) 16-18y (SASIS)	**ns**	ns	**ns**	ns	**ns**	ns
Developmental pediatric consultations (03.0135)	0-5y	↑	NA	**ns**	NA	**ns**	NA
	> 0-12m	**NA**	↑	**NA**	ns	**NA**	ns
	> 13-24m	**NA**	ns	**NA**	ns	**NA**	ns
	> 3-5y	**NA**	-	**NA**	-	**NA**	-
	6-10y	↑	-	**ns**	-	**ns**	-
	11-14y (SWICA) 11-15y (SASIS)	**-**	-	**-**	-	**-**	-
	15-18y (SWICA) 16-18y (SASIS)	**-**	-	**-**	-	**-**	-

TARMED positions / ATC	Age group	Time		Pandemic (level effect)		Interaction time x pandemic	
Well-child visits (03.0020/30/40/50/60/70/80/ 90)	0-5y	**ns**	NA	↓	NA	↑	NA
	> 0-12m	**NA**	-	**NA**	-	**NA**	-
	> 13-24m	**NA**	-	**NA**	-	**NA**	-
	> 3-5y	**NA**	-	**NA**	-	**NA**	-
All telemedical consultations (00.0110)	0-5y	**ns**	NA	↑	NA	**ns**	NA
	> 0-12m	**NA**	↑	**NA**	↑	**NA**	ns
	> 13-24m	**NA**	-	**NA**	-	**NA**	-
	> 3-5y	**NA**	-	**NA**	-	**NA**	-
	6-10y	**ns**	-	↑	-	↓	-
	11-14y (SWICA) 11-15y (SASIS)	**ns**	-	↑	-	**ns**	-
	15-18y (SWICA) 16-18y (SASIS)	**ns**	-	↑	-	↓	-
Urgent health problems (00.2505/10/20/40/60/80)	0-5y	**ns**	NA	↓	NA	↑	NA
	> 0-12m	**NA**	-	**NA**	-	**NA**	-
	> 13-24m	**NA**	-	**NA**	-	**NA**	-
	> 3-5y	**NA**	-	**NA**	-	**NA**	-
	6-10y	**ns**	-	↓	-	**ns**	-
	11-14y (SWICA) 11-15y (SASIS)	**ns**	-	**ns**	-	**ns**	-
	15-18y (SWICA) 16-18y (SASIS)	**ns**	-	**ns**	-	**ns**	-
Measles/mumps/rubella/(varicella)	0-5y	↑	NA	↓	NA	↓	NA
	> 0-12m	**NA**	-	**NA**	-	**NA**	-
	> 13-24m	**NA**	ns	**NA**	↓	**NA**	↑
	> 3-5y	**NA**	-	**NA**	-	**NA**	-
	6-10y	**-**	-	**-**	-	**-**	-
	11-14y (SWICA) 11-15y (SASIS)	**-**	-	**-**	-	**-**	-
	15-18y (SWICA) 16-18y (SASIS)	**-**	-	**-**	-	**-**	-
Diphtheria/tetanus/polio	0-5y	↓	NA	**ns**	NA	**ns**	NA
	> 0-12m	**NA**	↓	**NA**	ns	**NA**	↑
	> 13-24m	**NA**	↑	**NA**	↓	**NA**	↓
	> 3-5y	**NA**	-	**NA**	-	**NA**	-
	6-10y	**ns**	-	**ns**	-	**ns**	-
	11-14y (SWICA) 11-15y (SASIS)	**-**	-	**-**	-	**-**	-
	15-18y (SWICA) 16-18y (SASIS)	**-**	-	**-**	-	**-**	-
Pneumococcos	0-5y	**ns**	NA	**ns**	NA	**ns**	NA
	> 0-12m	**NA**	ns	**NA**	ns	**NA**	ns
	> 13-24m	**NA**	ns	**NA**	ns	**NA**	ns
	> 3-5y	**NA**	-	**NA**	-	**NA**	-
	6-10y	**-**	-	**-**	-	**-**	-
	11-14y (SWICA) 11-15y (SASIS)	**-**	-	**-**	-	**-**	-
	15-18y (SWICA) 16-18y (SASIS)	**-**	-	**-**	-	**-**	-

TARMED positions / ATC	Age group	Time		Pandemic (level effect)		Interaction time x pandemic	
TBE	0-5y	**-**	NA	**-**	NA	**-**	NA
	> 0-12m	**NA**	-	**NA**	-	**NA**	-
	> 13-24m	**NA**	-	**NA**	-	**NA**	-
	> 3-5y	**NA**	-	**NA**	-	**NA**	-
	6-10y	↑	-	**ns**	-	↓	-
	11-14y (SWICA) 11-15y (SASIS)	**-**	-	**-**	-	**-**	-
	15-18y (SWICA) 16-18y (SASIS)	**-**	-	**-**	-	**-**	-
Psychiatric diagnostic/therapy first session (02.0010)	0-5y	**-**	NA	**-**	NA	**-**	NA
	> 0-12m	**NA**	-	**NA**	-	**NA**	-
	> 13-24m	**NA**	-	**NA**	-	**NA**	-
	> 3-5y	**NA**	-	**NA**	-	**NA**	-
	6-10y	**ns**	-	**ns**	-	**ns**	-
	11-14y (SWICA) 11-15y (SASIS)	**ns**	-	**ns**	-	**ns**	-
	15-18y (SWICA) 16-18y (SASIS)	**ns**	-	**ns**	-	**ns**	-
Psychiatric diagnostic/therapy subsequent session (02.0020)	0-5y	**ns**	NA	**ns**	NA	**ns**	NA
	> 0-12m	**NA**	-	**NA**	-	**NA**	-
	> 13-24m	**NA**	-	**NA**	-	**NA**	-
	> 3-5y	**NA**	-	**NA**	-	**NA**	-
	6-10y	**ns**	↓	**ns**	ns	**ns**	ns
	11-14y (SWICA) 11-15y (SASIS)	**ns**	ns	**ns**	ns	**ns**	ns
	15-18y (SWICA) 16-18y (SASIS)	**ns**	ns	**ns**	ns	**ns**	↑
Psychiatric diagnostic/therapy family (02.0040)	0-5y	**-**	NA	**-**	NA	**-**	NA
	> 0-12m	**NA**	-	**NA**	-	**NA**	-
	> 13-24m	**NA**	-	**NA**	-	**NA**	-
	> 3-5y	**NA**	-	**NA**	-	**NA**	-
	6-10y	↑	-	**ns**	-	↓	-
	11-14y (SWICA) 11-15y (SASIS)	**ns**	-	**ns**	-	**ns**	-
	15-18y (SWICA) 16-18y (SASIS)	↑	ns	**ns**	ns	**ns**	ns
Psychiatric crisis intervention (02.0080)	0-5y	**-**	NA	**-**	NA	**-**	NA
	> 0-12m	**NA**	-	**NA**	-	**NA**	-
	> 13-24m	**NA**	-	**NA**	-	**NA**	-
	> 3-5y	**NA**	-	**NA**	-	**NA**	-
	6-10y	**-**	-	**-**	-	**-**	-
	11-14y (SWICA) 11-15y (SASIS)	**ns**	-	**ns**	-	**ns**	-
	15-18y (SWICA) 16-18y (SASIS)	**ns**	-	**ns**	-	↑	-

TARMED positions / ATC	Age group	Time		Pandemic (level effect)		Interaction time x pandemic	
Psychiatric and psychological testing (02.0090)	0-5y	**-**	NA	**-**	NA	**-**	NA
	> 0-12m	**NA**	-	**NA**	-	**NA**	-
	> 13-24m	**NA**	-	**NA**	-	**NA**	-
	> 3-5y	**NA**	-	**NA**	-	**NA**	-
	6-10y	**ns**	-	**ns**	-	**ns**	-
	11-14y (SWICA) 11-15y (SASIS)	**ns**	-	**ns**	-	**ns**	-
	15-18y (SWICA) 16-18y (SASIS)	**ns**	-	**ns**	-	**ns**	-
Telemedical consultations psychiatrist (02.060/65/66)	0-5y	**-**	NA	**-**	NA	**-**	NA
	> 0-12m	**NA**	-	**NA**	-	**NA**	-
	> 13-24m	**NA**	-	**NA**	-	**NA**	-
	> 3-5y	**NA**	-	**NA**	-	**NA**	-
	6-10y	**-**	-	**-**	-	**-**	-
	11-14y (SWICA) 11-15y (SASIS)	**ns**	-	↑	-	↓	-
	15-18y (SWICA) 16-18y (SASIS)	**ns**	-	↑	-	↓	-

Note: ↑ significant increase; ↓ significant decrease; ns: non-significant; - : not reported since the rates are too low; NA not applicable because this age group did not exist in the respective data set. Data on long telemedical consultations (00.0120, 00.0125) and psychiatric diagnostic/therapy group (02.0050) as well as vaccination against meningococcus are not included in the Table because the rates were too low for all age groups.

3.2.2 Gender effects

For those TARMED positions and vaccines with high enough rates, almost no significant results for the *main effect of gender* emerged in the SASIS data, except for “psychiatric diagnostic/therapy family”, where rates were higher in males compared to females in the pre-pandemic phase (see Table 7). Furthermore, none of the *interaction terms that included gender* (including the interaction term gender x pandemic) were significant. Regarding data from SWICA, only consultations (00.0010) had high enough rates to be interpreted. Comparable to SASIS, no gender differences or significant interaction terms were yielded in this TARMED position. In summary, the pandemic did not seem to have different effects on gender in those TARMED positions / ATC for which reliable statements were possible.

Table 7: Gender differences in the pre-pandemic phase

	Female	
TP / ATC – all age groups	SASIS	SWICA
Consultations (00.0010)	ns	ns
Developmental pediatric consultations (03.0135)	ns	-
Well-child visits (03.0020/30/40/50/60/70/80/90)	ns	-
All telemedical consultations (00.0110)	ns	-
Urgent visits / consultations (00.2505/10/20/40/60/80)	ns	-
Diphtheria/tetanus/polio	ns	-
Pneumococcos	ns	-
Psychiatric diagnostic/therapy first session (02.0010)	ns	-
Psychiatric diagnostic/therapy subsequent sessions (02.0020)	ns	ns
Psychiatric diagnostic/therapy family (02.0040)	↓	-

Note: ↓ significant lower rates in females compared to males (reference category); ns: non-significant gender differences; - : not reported since the rates are too low. For some services / vaccines, rates were too low for both SASIS and SWICA and are therefore not included in the table (vaccinations: meningococcus, MMR, TBE; services: long telemedical consultations (00.0120, 00.0125); psychiatric diagnostic/therapy group (02.0050); psychiatric and psychological testing (02.0900); psychiatric crisis intervention (02.0080); telemedical consultations psychiatrist (02.060/65/66)).

3.2.3 Regional differences

In Table 8, regional differences are reported for those TARMED positions / vaccinations and for those age groups for which the rates were high enough to be interpreted in the SASIS data. Hence, vaccinations are mainly reported for the youngest age group, whereas findings regarding psychiatric health utilization are solely reported for older age groups. The findings in the table represent the *main effect for region during the pre-pandemic period*, i.e., utilization rates were compared between the German-speaking region (used as reference) and the French-speaking region and Ticino, respectively. In the French-speaking region, higher rates were found in 0-5-year-olds for regular and developmental pediatric consultations, as well as for the vaccination against diphtheria/tetanus/polio. Furthermore, higher rates were found for some psychiatric health services in the French-speaking region (for all age groups with high enough rates), including psychiatric diagnostic/therapy first session, psychiatric diagnostic / therapy subsequent sessions and in psychiatric diagnostic/therapy family. In Ticino, higher rates were found for developmental pediatric consultations in 0-5-year-olds and for telemedical consultations (all age groups). In contrast, lower utilization rates were observed for well-child visits (0-5-year-olds) and telemedical consultations (0-5-year-olds, 6-10-year-olds) in the French-speaking region and for urgent visits / consultations (6-10-year-olds), vaccination against pneumococcus (0-5-year-olds), and for psychiatric diagnostic/therapy family (11-15-year-olds, 16-18-year-olds) in Ticino relative to the German-speaking region. For the pre-pandemic time, no significant interaction effects with language-region were observed.

The *interactions "language regions x pandemic"* were mostly not significant. In other words, the (non)-significant impact of the pandemic on utilization rates did generally not differ between the German-speaking region vs. the French-speaking region or Ticino, respectively. The exception to this general pattern were the significant "French region x pandemic"-interaction terms for telemedical consultations in 0-5- (1.289 [1.062,1.565], $p<0.05$) and 6-10-year-olds (1.195 [1.003,1.424], $p<0.05$) which indicate that the average increases in the utilization rates of telemedicine in the pandemic compared with the pre-pandemic were higher in the French- compared to the German-speaking region.

For the most part, the *trends in the pandemic phase* relative to those in the pre-pandemic phase did not vary significantly by language regions. In other words, the interaction terms ”French region x time x pandemic” and “Ticino x time x pandemic” were mostly not significant. Exceptions were significant “French region x time x pandemic"- interaction terms for developmental pediatric consultations (1.019 [1.003,1.035], p<0.05) as well as telemedical consultations (0.986 [0.973,0.999], p<0.05) among 0–5-year-olds, indicating that for these TARMED positions, the post-pandemic trend with respect to the pre-pandemic trend differed from the one in the German-speaking region.

Table 8: Regional differences in the pre-pandemic phase (SASIS)

Effect compared to German region (Reference)	French region	Ticino
TARMED positions / ATC		
Consultations (00.0010)		
> 0-5y	↑	ns
> 6-10y	ns	ns
> 11-15y	ns	ns
> 16-18y	ns	ns
Developmental pediatric consultations (03.0135)		
> 0-5y	↑	↑
Well-child visits (03.0020/30/40/50/60/70/80/90)		
> 0-5y	↓	ns
All telemedical consultations (00.0110)		
> 0-5y	↓	↑
> 6-10y	↓	↑
> 11-15y	ns	↑
> 16-18y	ns	↑
Urgent visits/consultations (00.2505/10/20/40/60/80)		
> 0-5y	ns	ns
> 6-10y	ns	↓
Measles/mumps/rubella/ (varicella)		
> 0-5y	ns	ns
Diphtheria/tetanus/polio		
> 0-5y	↑	ns
Pneumococcus		
> 0-5y	ns	↓
Psychiatric diagnostic/therapy first session (02.0010)		
> 11-15y	↑	ns
> 16-18y	↑	ns
Psychiatric diagnostic/therapy subsequent sessions (02.0020)		
> 6-10y	↑	ns
> 11-15y	↑	ns
> 16-18y	↑	ns

Effect compared to German region (Reference)	French region	Ticino
Psychiatric diagnostic/therapy family (02.0040)		
> 11-15y	↑	↓
> 16-18y	↑	↓

Note: ↑ significant higher rates; ↓ significant lower rates; ns: non-significant regional differences (reference category: German-speaking region)For some services / vaccines, rates were too low for and are therefore not included in the table (vaccinations: meningococcus, TBE; services: long telemedical consultations (00.0120, 00.0125); psychiatric diagnostic/therapy group (02.0050); psychiatric and psychological testing (02.0900); psychiatric crisis intervention (02.0080); telemedical consultations psychiatrist (02.060/65/66)).

As mentioned in the Methods, another regional indicator was used in the SWICA data. Since the rates of the SWICA data were not robust for most TARMED positions / vaccinations, only the results for regular consultations are reported. As shown in Table 9, utilization rates in intermediate or rural regions were either lower or did not differ from utilization rates in urban regions (reference group). None of the interaction terms was significant, indicating that pre-pandemic and pandemic trends as well as the pandemic effects did not vary by urbanity.

Table 9: Differences by urbanity in consultations (00.0010) in the pre-pandemic phase (SWICA)

Age groups	Intermediate	Rural
0-12m	↓	↓
13-24m	↓	↓
3-5y	↓	↓
6-10y	↓	ns
11-14y	ns	ns
15-18y	ns	↓

Note: ↓ significant lower rates compared to urban region (reference category); ns: non-significant differences in urbanity

3.2.4 Stringency analyses

Stringency analyses are shown for regular consultations (TARMED position 00.0010) in Figure 3 (females) and Figure 4 (males) for the youngest age group. The red line in the graphs represents utilization rates over time, starting from 2018 to 2022. These utilization rates correspond to those that have been reported in previous sections. The blue line represents the KOF Stringency Indices, which are available from January 2020 onwards (see Methods for details). Even though utilization rates varied markedly over time, it seems that utilization decreased when the first and most stringent measures were put in place. Afterwards, the association between stringency and utilization is less clear.

Figure 3: Utilization rates for consultations by stringency measures, age 0-5years, females (SASIS, TARMED 00.0010)

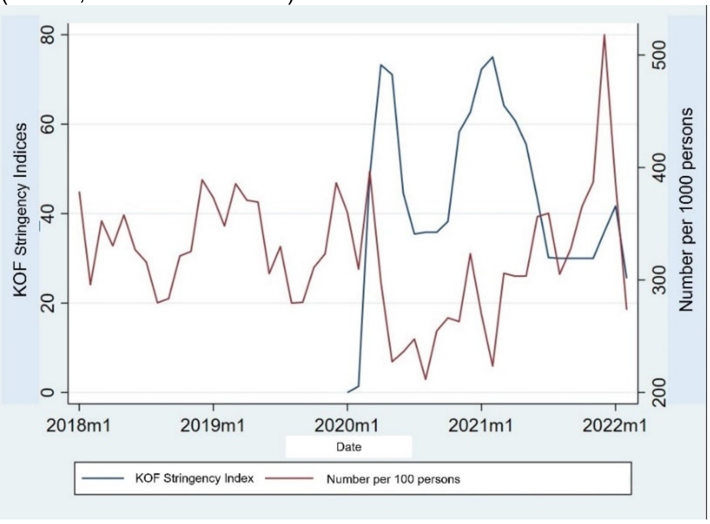
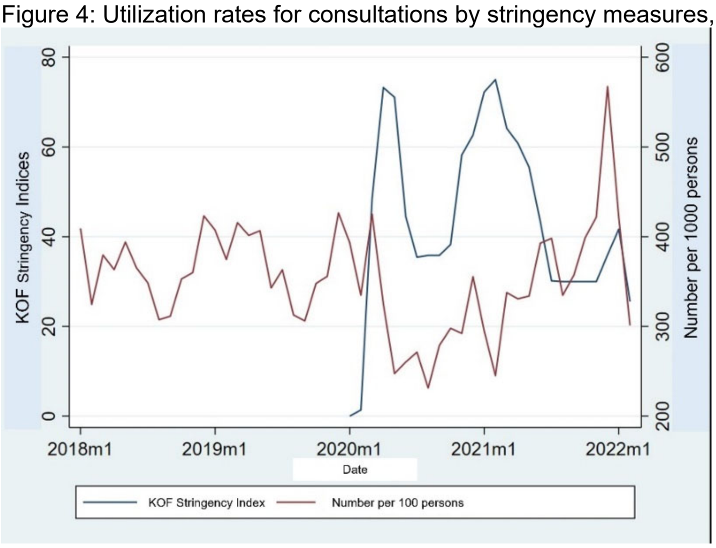


Figure 4: Utilization rates for consultations by stringency measures, age 0-5years, males (SASIS, TARMED 00.0010)



3.3 Discussion

3.3.1 Overall (methodological) considerations for the interpretation of the results

The data present a clear impact on utilization by the pandemic, especially immediately after the lockdown. 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 telemedical 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 (telemedicine 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 decrease in demand or need or a actual change in utilization. A downward change albeit unchanged or increased need would imply an under-utilization. A drop in utilization would be particularly problematic if the need for such a service increased during the pandemic. Assuming an increase in demand or need after the lockdown would imply that the observed drop is 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 a few 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. Such differences are not the case in the use of ATC codes. 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 "telemedical 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. Lastly, it must be considered that the health insurance data does not include certain information that might have been helpful in the interpretation of the results (e.g., on the diagnosis or health issue for which a particular health service was utilized, nor the severity of the consultation reason).

3.3.2 Pediatric health care utilization (including vaccinations)

3.3.2.1 Comparison of the results to previous scientific findings and interpretation of the findings

Internationally, some research indicated that vaccination rates (56) and utilization rates for well-child visits and/or ambulatory pediatric health services more generally (e.g., (57–61)) were lower during the pandemic. Corresponding to this, decreased average utilization in the pandemic compared to the pre-pandemic phase were found for well-child visits among 0-5-year-olds (analyses were limited to this age group) as well as for regular and urgent visits/consultations among 0-5-year- and 6-10-year-olds in the present study. Furthermore, decreased average MMR-vaccination rates during the pandemic vs. the pre-pandemic period were identified for 0-5-year-olds (SASIS) and 13-24-months-olds (SWICA).

The reduced average rates for well-child visits and MMR-vaccinations are not attributable to a reduced need for such services during the pandemic since well-child visits and routine vaccinations are preventative in nature. However, because the rates of well-child visits increased again over the pandemic phase, it is possible that some of the visits were caught-up. Similarly, studies from other countries found that well-child visits recovered over the pandemic, although no full recovery was identified in this previous work, possibly because the considered time horizons were too short (62,63). According to analyses of SASIS data, no such recovery occurred for MMR-vaccination rates. Rather MMR-vaccination rates decreased further over the pandemic period. The reduced MMR-vaccination rates during the pandemic contradicts the notion of the FOPH that coverage for MMR was higher in 2020-2022 compared to the pre-pandemic period 2017-2019 (64). It is, however, possible that the study on which the FOPH statement is based, overestimated actual vaccination coverage, since it relied on the parents' willingness to hand in vaccination booklets of their randomly selected child. However, it must also be pointed out, that analyses of SASIS and SWICA led to conflicting results regarding the development over the pandemic phase in our study: While SASIS indicates a further decrease in MMR vaccination rates, SWICA yielded a certain normalization for 13-24-months-olds. However, despite this normalization, the expected excess in MMR-vaccinations to compensate for missed MMR-vaccinations did not seem to have occurred over the observed study period. Hence, the notion that some children still did not caught-up on their MMR-vaccination still holds true for the SWICA-data.

Overall, the initial decrease in well-child visits was possibly due to parents' avoidance of going to the pediatrician's practice due to the fear being exposed to the COVID-19 virus and due to prioritizing to be protected against COVID-19 over adhering to scheduled well-child visits for their child (65). However, routine vaccinations that are typically carried out during well-child visits did not decrease uniformly. That a pandemic effect most consistently emerged for MMR (i.e., both found in SASIS and SWICA) rather than other routine vaccinations is in line with previous findings from Switzerland showing that MMR vaccination is the most frequently postponed basic vaccination (66). As exemplarily shown for regular consultations, the introduction of more stringent measures presumably contributed to a decrease in health care utilization (similar pattern has also be found in other studies (59)), possibly because more stringent measures helped to decrease the incidences of some infectious diseases (e.g., infections with the respiratory syncytial virus (67)) and therewith reduced the need for treatment for these particular health conditions. This would correspond to the reduced average utilization of regular and urgent visits/consultations during the pandemic. Reduced infection rates might have had a particularly strong effect on the health care utilization of the youngest age group, as confirmed by our analyses, because very young children are more likely of being severely affected by such infectious disease (68). However, in some instances, the observed pandemic effect might also have been caused by parents' delay in seeking professional care for their child due to fear of being exposed to COVID-19 (69). Not seeking professional help may be problematic for objectively urgent health conditions, but not for those that are objectively mild. In our study, urgent visits did not increase simultaneously to the decrease in regular visits, possibly indicating that the reduction in regular visits were mostly connected to mild health conditions. However, parents might have presented their child to the secondary or tertiary health system. In 0-5-year-olds, utilization of regular and urgent consultations increased again over the pandemic period and reached pre-pandemic rates in the fourth quartal of 2021, whereas no significant recovery was yielded for 6-10-year-olds in the more representative SASIS data. That a significant normalization of the utilization pattern was limited to the youngest age group might, at least partly, be due to parents' and/or pediatricians' higher need for a face-to-face visit when the child is still very young (due to the health issues of young children and due to parental insecurities in this regard).

Confirming previous research (61,63,70,71), our study yielded higher average utilization rates regarding telemedical consultations during the pandemic compared to the pre-pandemic phase in all age groups. It is likely that telemedical consultations at least partly substituted in-person visits in the youngest age groups for which reduced regular and urgent visits were found in the present study. Hence, telemedicine might have allowed maintaining access to professional pediatric care, while adhering to the introduced measures (e.g., physical distancing). In the youngest age group (0-5 years), the utilization of telemedical consultations remained on a high level over the pandemic phase, even though utilization of face-to-face regular and urgent consultations increased again. Hence, the total utilization of pediatric health services has increased in the pandemic phase in 0-5-year-olds. For 6-10-year-olds, a partial substitution of face-to-face by telemedical consultations seemed to have been limited to the initial phase of the pandemic since utilization rates for telemedical consultations decreased again over the pandemic phase despite persistently reduced utilization rates regarding regular and urgent consultations. In the two oldest groups (11-15 years, 16-18 years), on the other hand, average utilization rates of telemedical services were significantly higher in the pandemic, even though regular and urgent consultations were not affected by the pandemic in these age groups. Hence, the increase in average telemedicine consultations implies an increased health care need among the oldest age groups during the pandemic, e.g., due to parents or youth need of reassurance and guidance from pediatricians (e.g., regarding potential COVID-19-infections) or emerging mental health difficulties (see Section 3.3.3). The utilization of telemedical consultations remained on a high level in some age groups, possibly due to a reduced skepticism against and increased appreciation of such services. Accordingly, previous international

research has shown that health care providers and families (parents and children/adolescents) generally reported high satisfaction and usability of telemedicine (72,73).
To the best of our knowledge, most previous studies did not assess gender-specific pandemic effects on vaccination or utilization rates of the primary pediatric services that we assessed in our study (including regular, urgent, and well-child visits). A US-study, however, yielded that patients attending pediatric primary care visits had a similar distribution by sex in 2019 and 2020 (61). This is in-line with our findings that the pandemic did not impact females' or males' vaccination or utilization rates differently. However, gender differences potentially exist in terms of specific diagnoses or services (as found in (61)). However, this possibility cannot be studied based on the health insurance data.
In terms of regional differences, some main effects in utilization emerged (i.e., higher / lower utilization rates in French-speaking parts / Ticino vs. German-speaking parts) that might, among other things, have been caused by differences in the way that pediatricians use certain TARMED positions. Pandemic effects and trends over the pandemic period mostly did not differ by language region, although some exceptions from this general pattern were yielded. However, the health insurance data does not provide any information that could be used to interpret these isolated findings.

3.3.2.2 Implication of our results

Delayed or forgone well-child visits, which might persist even after a certain recovery, pose a risk for delayed detection of clinical/developmental abnormalities. Furthermore, missed vaccinations for MMR (as outlined above, the representative SASIS-data in particular point to this problem) increase the likelihood of infections and outbreaks, which can be particularly dangerous for the youngest children. **Therefore, promoting catch-up well-child visits and MMR-vaccinations is essential.**
Regarding well-child visits and vaccinations, it must be highlighted that pediatric associations and the FOPH communicated early in the pandemic that children up to two years should adhere to the scheduled appointments. The decrease in well-child visits after the lockdown in the youngest age group indicates that parents did not follow these recommendations initially. Hence, recommendations of health authorities might not be sufficient to bring about an immediate change in behavior. **Tailoring such messages more specifically to the target group (e.g., by addressing existing concerns) might make them more effective.** To do this, however, it would be imperative to know more about the reasons that prevented parents from attending the appointments. Timely assessing such reasons would be helpful in future crisis situations, and should be considered in the pandemic preparedness. However, effective communication strategies should not only be planned for future crisis situations. Rather, it is also important to **inform and remind parents now about the importance of catching-up on the MMR vaccination in particular and to decrease vaccination hesitancy**.
Our analyses also indicated that the pandemic increased the relevance of telemedical consultations in all age-groups, a pattern that is potentially maintained beyond the pandemic, at least in some age groups. Despite the advantages of such services, Switzerland is not yet equipped to expand and provide sustainable telemedicine. To **be able to offer telemedical services in a meaningful way (in day-to-day practice, but also during possible future crises),** it is important to further investigate the health contexts in which they are effective and safe, the motivational factors on the provider and the client side, as well as limitations and existing shortcomings (e.g., regarding data

security). Further, telemedical services are thought to replace a part of the face-to-face visits, not be an additional or on top service, to reduce health costs when possible in the long-run.
Lastly, our analyses show that for future pandemics or other health crises, **monitoring health care utilization and other relevant health indicators is important** to ensure a timely and continuous assessment of the effects, for instance, a shift in utilization (e.g., from face-to-face to telemedicine) or an underutilization of health services, and their potential impact on the health of children and adolescents. Although the pandemic effect mostly did not vary by region, regional differences should still be monitored in future health crisis.

3.3.3 Mental health care utilization

3.3.3.1 Comparison of the results to previous scientific findings and interpretation of the findings

Various systematic reviews and meta-analyses indicate that the COVID-19 pandemic and the introduced measures to curb local epidemics had a particularly negative impact on the mental health of young people (e.g., (74–76)), particularly on older adolescents (compared to younger adolescents and children) and on females (74,75). Furthermore, the impact was largest during times when pandemic-related restrictions were more stringent and schools were closed (76). Internationally, the prevalence of mental health symptoms increased over the pandemic period (74,75), although signs of recovery and stabilization were also observed (75). Similarly, publications from Switzerland indicate that the mental health (at least some indicators) of young people was negatively impacted by the pandemic (e.g., (77–79)), with no indication of recovery up to autumn 2022 (77). According to these findings, the need for professional treatment was heightened among youth during the pandemic internationally as well as in Switzerland.
In terms of utilization, our findings seem to differ from a Swiss OBSAN report (80) that described lower utilization of some outpatient mental health services during 2020 (year of the first lockdown) compared to pre-pandemic time points, that was followed by an increase in utilization over the pandemic (in youth, this increase was driven by females) (80). Even though we used the same data (SASIS), we did not find lower average utilization rates in any of the studied mental health services during the pandemic compared to the pre-pandemic time. This discrepancy is presumably due to differences in the considered age groups, mental health services, time frames, and time intervals as well as the statistical models (in the mentioned report, no ITS was used). A lower outpatient mental health care utilization than would have been expected in the absence of a pandemic was also found in a study that analyzed claims data from Helsana, but only for young males (especially those aged <20) (47). Our results also seem to partly contradict the assessment of child and adolescent psychiatrists and psychologists who described that treatment demand for youth with mental disorders initially decreased during the lockdown in 2020, but was followed by an alarming increase in treatment demand, a large increase in the waiting time before the initiation of treatments, and an increasing work overload with a peak after one year of the pandemic (81). However, the perceived increase in treatment demand over a relatively long period during the pandemic (81) corresponds to our finding that the utilization of psychiatric crisis intervention increased over the pandemic in the oldest age group. This particular finding from our research project also corresponds to the above-mentioned study that analyzed claims data from Helsana and found an increase in outpatient mental health care utilization in young females (<20 years) after the first shutdown (47). Lastly, our finding of higher average utilization rates for telemedical

consultations in the pandemic vs. the pre-pandemic period, followed by a decrease in the utilization of this service over the pandemic phase in the two oldest age group corresponds to the pattern that has been described in a previous report (80). A shift from in-person to teleconsultations was also described in the study that analyzed claims data from Helsana (47). This finding indicates that in-person appointments were (partially) substituted by telemedicine initially. The subsequent decrease in the utilization of telemedicine might have been due the mental health professional's preference to meet patients face-to-face (81).

Previous publications on mental health needs and mental health care utilization suggest that females were more affected by the pandemic compared to males. In our analyses, no significant interaction with gender were found. However, it must be emphasized that we cannot rule out gender differences, particularly for mental health services with low utilization rates. For instance, we did not report the findings regarding gender differences for psychiatric crises intervention since the rates were too low, even though gender-specific effect seemed to have occurred for this particular service. In terms of regional differences, some main effects for language region emerged for specific psychiatric health services (higher or lower utilization rates in the French region / Ticino compared to the German-speaking region), whereas the pandemic effect and the pandemic trend did not seem to differ by language region.

3.3.3.2 Implication of our results

In view of the assumed increase in treatment need in youth, the unchanged utilization patterns that we found for most mental health services might indicate an undersupply, possibly because not enough mental health services were available for youth. We consider this assumption to be valid, even though rates for telemedical consultations through a psychiatrist were – on average – higher during the pandemic compared to the pre-pandemic period in our study in adolescents (11-15y, 16-18y) for which rates were high enough to be interpreted. More specifically, the rates of these telemedical consultations only increased immediately after the lock-down in the mentioned age groups but decreased again over the pandemic phase. Furthermore, the rates of telemedical consultations by a psychiatrist were rather low, which makes it unlikely that these services fully substituted in-person visits. Furthermore, rates for psychiatric crisis interventions only increased in the oldest age group over the pandemic period. However, utilization rates for this service were also rather low and it is unlikely that this increase was sufficient to cover an increased need. Lastly, it must be pointed out that no increase in utilization rates was identified for those services with the highest utilization rates (e.g., for psychiatric diagnostic/therapy subsequent sessions). Therefore, the assumption that there was an undersupply of mental health services is plausible. Other researchers suggested that this undersupply already existed before COVID-19 (81,82), but was further exacerbated by the pandemic (81). Accordingly, a prospective Swiss study that surveyed adolescents during the first lockdown and one year later has shown that the stressor "having troubles getting medical care or mental health services" increased from 2020 to 2021 (83). This increase was, however, only noted for girls. Based on the described results and corresponding to others (e.g., (79,81))**, we recommend to increase treatment capacity for mental health services for youth, now,** to be better equipped for current demands, and to be prepared for potential future crises. **Consideration should also be given to how capacities of mental health services can be increased in the short term in the event of a future crisis** (e.g., by bringing in additional specialists, e.g., mental health nurses).

Related to the potential undersupply described above and based on the findings from other Swiss studies that at least some mental health indicators were negatively impacted by the pandemic we also recommend to **closely monitor mental health of youth,** right away, to capture potential further deterioration of youth' mental health, as well as their access to mental health services**.** **Further to continously monitor utilization of mental health services** as well as the mental health of youth continuously to be able to refer to previous data during future crises, and adapt health services accordingly**.**

As mentioned above, the results regarding telemedical consultations of our and a previous study (81) suggest that telemedical mental health consultations served as a substitute for in-person appointments. However, whether telemedicine is an adequate substitute for in-person mental health treatments was questioned by other authors for the target group of youth (81). Privacy concerns might, for instance, exist for adolescents if siblings or parents enter their room during a therapeutic session (81). Furthermore, technical difficulties and barriers regarding financing of telemedicine (81) might – besides mental health professional's preference to meet in-person (81) – also have hindered this mode of service provision. To be better prepared for future health crisis, it was recommended to resolve existing technical, data security and financial barriers of telemedicine now (81)**.** Hereby, it might also be useful to draw on experiences in other fields and from other professionals, e.g., from pediatricians who used telemedical consultations as substitute for regular consultations (also see previous section). Furthermore, mentioned disadvantages that a telemedical provision of mental health services might entail for youth (e.g., privacy issues; (81)) should be addressed now in order to establish these telemedical mental health services for the current and future mental health care demand. For this purpose, **it would be helpful to develop guidelines under which circumstances and in which contexts telemedicine is justifiable or even just as safe to implement than a personal contact** (e.g., when participation of several individuals that play a crucial role in a child's life is warranted (81)) and under which circumstances a personal contact is warranted, by considering research in this field of research and experts' opinions. However, it is also important to consider the scientific literature on Internet- and computer-based cognitive behavioral therapy because systematic reviews and meta-analyses indicate that such forms of treatment could be a useful alternative for some mental health problems in youth (e.g., anxiety) when evidenced-base face-to-face treatment is not feasible (e.g., (84,85)).

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.

For a deeper understanding of the effect of the COVID-19 pandemic on pediatric EDs in Switzerland, we conducted four different analyses:

- Interrupted time series modelling to assess the COVID-19 related impact and compare pre-pandemic and pandemic health service consultations

- Comparison of grouped diagnoses of patients treated in the ED of Zurich during the months of March and April from 2018 to 2021

- Euclidean distance matrix to analyze the travel distances for ED visits before, during, and after the lockdown in Zurich, Geneva, and Bellinzona (only preliminary results available)

- Descriptive visualization of the daily number of ED visits in each canton and comparison with the timing of the measures implemented in these cantons

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.

Postal Codes

The detailed data provided by the three tertiary pediatric hospitals included the postal code of each patient. For this analysis, only Swiss postal codes were included.

4.1.3 Statistical analyses

4.1.3.1 COVID-19 related impact: analysis using Interrupted time series modelling

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 (86).
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 (87) and the gcmr package (88) was used to fit negative binomial regressions with autocorrelated errors.

4.1.3.2 Geographic analysis: using Euclidean distance and distance matrix

To analyze the dynamics of the catchment areas of the three pediatric EDs before, during, and after the lockdown, we analyzed travel distances for ED visits based on two approaches, Euclidean distance and distance matrix.

A detailed analysis was conducted using a structured methodology involving three steps: (1) data preparation and normalization, (2) cohort characterization and distribution, and (3) visualization to investigate the spatial-temporal patterns of pediatric visitation rates. These steps are described as follows:

1. Data Preparation and Normalization: Firstly, the data was segmented into three distinct periods to reflect different phases in the context of the pandemic: before (March 1, 2018 - March 10, 2020), during (March 11, 2020 - March 21, 2021), and after (March 22, 2021 - March 1, 2022). This segmentation allows for a comparative analysis across these temporal phases. The children were further categorized by age (0-4, 5-12, 13-18 years) and severity of condition (severe: categories 1-3, mild: 4-5), considering the type of admission, whether outpatient or inpatient. Additionally, the distinction between cantonal and non-cantonal emergency admissions enabled a differentiated analysis to identify regional differences and the impact of COVID-19 on these areas.

A systematic approach was employed to compute normalized counts of pediatric visits. Initially, geographic units (postal codes by Swisstopo) aggregated the raw visitation data. The aggregation process involved counting the number of pediatric visits per postal code. These counts were normalized to ensure comparability across different regions. This normalization process adjusted the counts based on the total number of children (age 0-18) in each postal code, resulting in normalized visitation rates per 100 children. This adjustment is crucial for mitigating the effects of varying population densities and ensuring that the visitation rates are representative.

Using the normalized visitation rates, the change calculations between periods were done as follows:

- V_{pre}: Normalized visitation rate before the pandemic
- V_{during}: Normalized visitation rate during the pandemic
- V_{post}: Normalized visitation rate after the pandemic
- V_{max_pre}: Maximum normalized visitation rate before the pandemic

Compared to the pre-pandemic period, the changes in visitation rates during and after the pandemic are calculated as percentages:

$$\Delta \boldsymbol{V}_{during} = \left(\frac{\boldsymbol{V}_{during} - \boldsymbol{V}_{max\_pre}}{\boldsymbol{V}_{max\_pre}} \right) \times \mathbf{100}\% \qquad (1)$$

$$\Delta \boldsymbol{V}_{post} = \left(\frac{\boldsymbol{V}_{post} - \boldsymbol{V}_{max\_pre}}{\boldsymbol{V}_{max\_pre}} \right) \times \mathbf{100}\% \qquad (2)$$

2. Cohort Characterization and Distribution: The study incorporated travel distances for hospital visits based on two approaches: Euclidean distance and distance matrix. The Euclidean distance (km) was calculated as the shortest distance between the geometric centers of the postal code areas and the hospital locations in Geneva, Bellinzona, and Zurich. The distance matrix approach utilized Swiss traffic zones to compute the shortest driving distance (km) between each traffic zone on the Swiss road network, calculated by the Federal Office for Spatial Development from the UVEK. Distances were capped at 60 km, with greater distances treated as outliers. The distances above and below each city's median were compared to the pre-pandemic period to analyze travel distance changes over the three periods. Statistical analysis using Kolmogorov-Smirnov tests was conducted to determine significant differences in travel distances. Additionally, mean travel distances were calculated for each hospital location and period to identify trends.

3. Visualization: For visualization, a maximum limit for normalized visitation rates was calculated across all time periods to maintain consistency and allow for direct comparisons. This limit serves as a reference point for interpreting the visitation rates visually. The visualization step involved creating thematic maps for each time period. These maps were generated using R Studio to display the spatial distribution of normalized visitation rates, as well as changes in visitation rates (ΔV_{during} and ΔV_{post}). The maps were designed to highlight differences in visitation rates using a color gradient, where varying shades represented different levels of visitation intensity. Additionally, the maps included geographic layers such as city boundaries, postal code borders, and notable geographic features like lakes from Swisstopo. Each map was titled according to the specific period it represented: "Visitation Rates Before Pandemic," "Visitation Rates During Pandemic," and "Visitation Rates After Pandemic." The maps also included legends and scale bars to assist in understanding the spatial and quantitative aspects of the data.

Finally, the entire process was repeated for all three cities to ensure a comprehensive understanding of the geographic distribution of pediatric visitation rates across multiple urban areas. This repetitive application across various geographic regions allows for a broader analysis and comparison of spatial-temporal patterns.

This methodological framework provides a robust approach for analyzing and visualizing changes in pediatric visitation rates over time and across different geographic regions, considering population normalization, geographic context, and travel distances. Additionally, a Poisson regression model was used to determine the influence of variables such as age, gender, and triage category on hospital visits. This analysis was conducted for each period and hospital across all three hospitals and periods, providing insights into the factors influencing pediatric hospital visitation rates during the pandemic.

4.2 Results

In the appendix (7.3.7), you can find our published manuscript: *von Rhein, M., Chaouch, A., Oros, V. et al. The effect of the COVID-19 pandemic on pediatric emergency department utilization in three regions in Switzerland. Int J Emerg Med 17, 64 (2024). https://doi.org/10.1186/s12245-024-00640-2*

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 10 provides demographic information for the three EDs.

Table 10: 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 7.3. (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 7, Table

15). 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 15, Table 23). 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 11, Table 19). 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 14, Table 22).

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 7, Table 15). These trends were consistent across all three regions and mainly affected the youngest age group, with a drop exceeding 50% (see Figure 8, Table 16). 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 11, Table 19), 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 14, Table 22). 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 13, Table 21). 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 16.

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 15). Secondly, hospitalizations in Ticino even gradually decreased after the lockdown, as illustrated in Figure 11. 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 22).

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 11). 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 11: 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

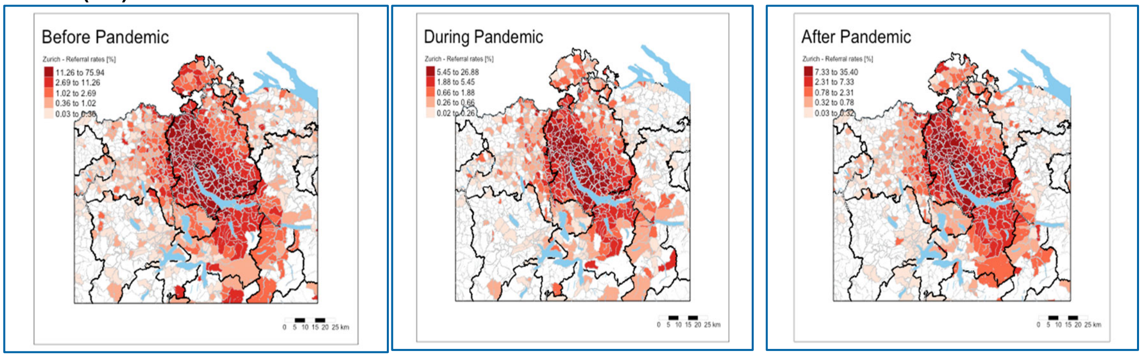
4.2.4 Spatial distribution before, during, and after the pandemic

Please be aware, at this point in time, we can provide first results; the finished publication can be submitted later

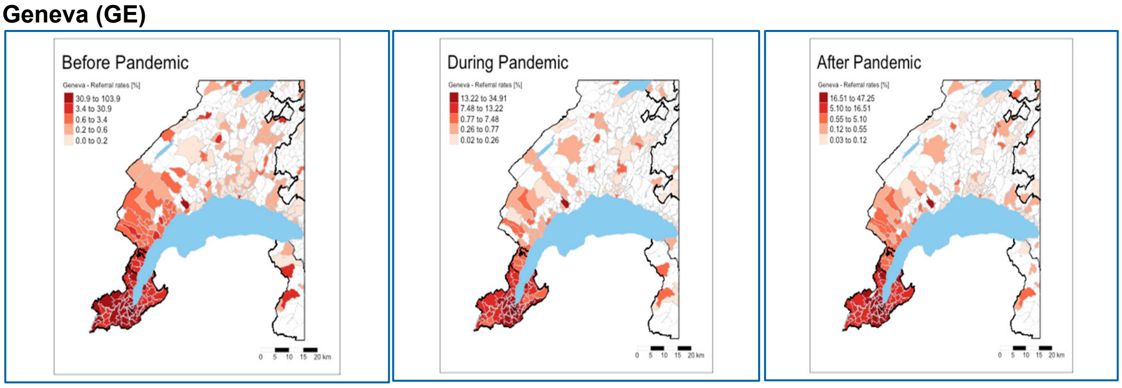
The maps show the utilization rates for the three cities of Zurich, Geneva, and Bellinzona for the three respective periods. The utilization rate is the percentage of children visiting the ED as a proportion of the total number of children in a postcode. The classifications are quantiles where each of the five classes covers 20% of the complete data set.

Figure 5: Utilization rates before, during, and after the pandemic in Zurich, Geneva, and Bellinzona

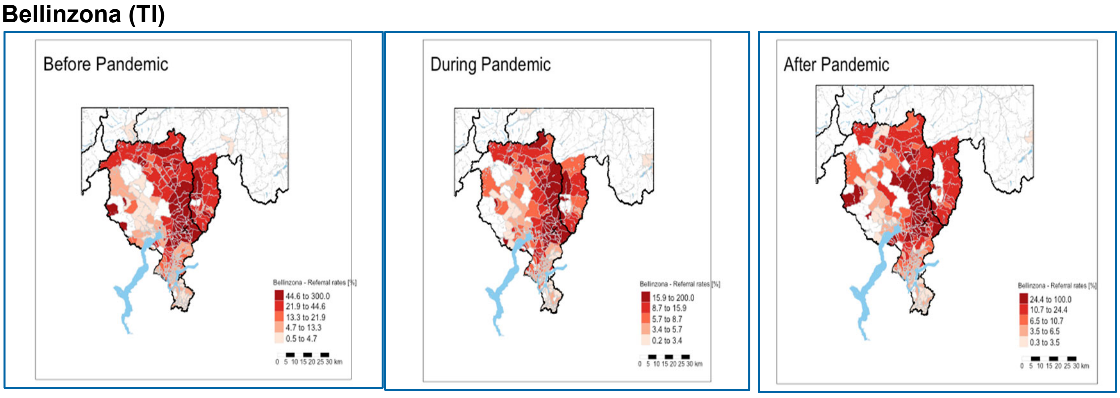
Zurich (ZH)



Geneva (GE)



Bellinzona (TI)

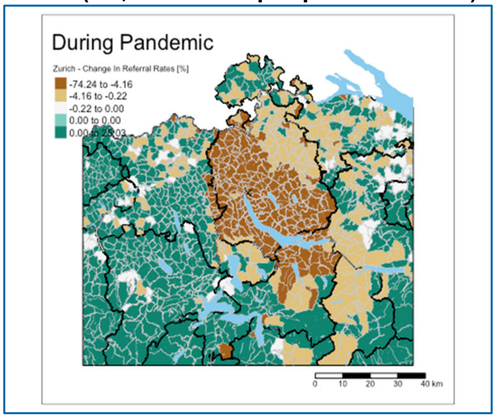


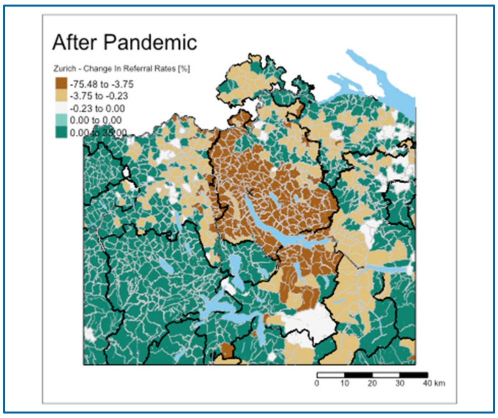
Relative change in number of visits

The following maps show the changes in the allocations for the three cities of Zurich, Geneva, and Bellinzona. The percentage change in admission rates is compared with the period before the pandemic. Again, the five classes are quantiles, covering 20% of the value range.

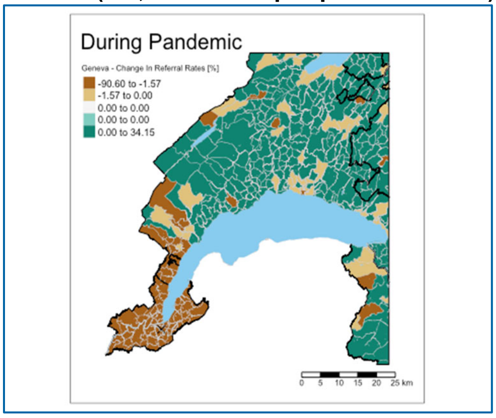
Figure 6: Relative change in admission rates during and after the pandemic compared to the pre-pandemic time in Zurich, Geneva, and Bellinzona

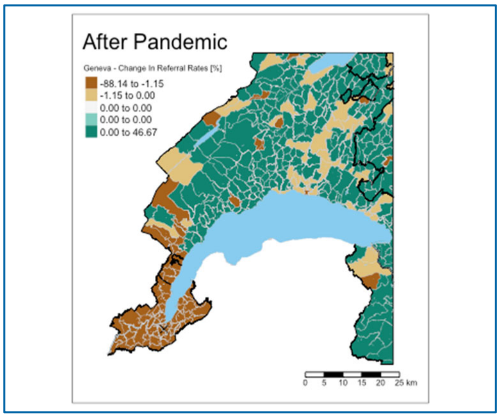
Zurich (ZH, reference: pre-pandemic time)



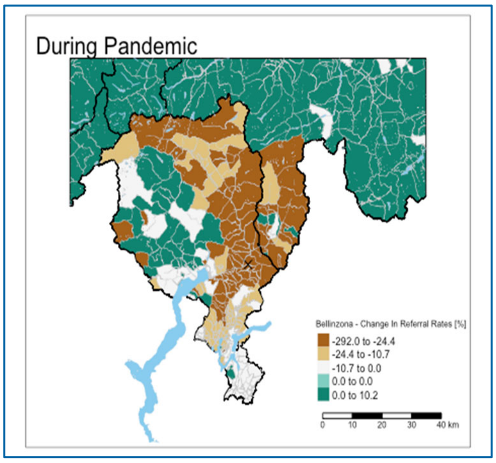


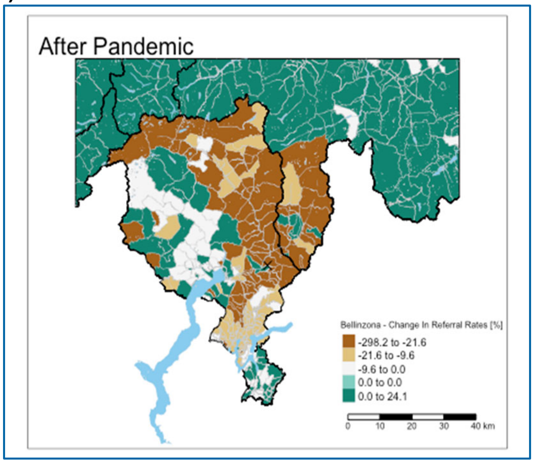
Geneva (GE, reference: pre-pandemic time)





Bellinzona (TI, reference: pre-pandemic time)





4.2.5 Effect of federal measures on ED visits

We identified no less than 7 (federal) measures aimed at slowing the spread of the COVID-19 and which were gradually implemented from the beginning of the pandemic in February 2020 until May 2021 throughout Switzerland. Some of these measures lasted for several months while others lasted only for a few weeks (with some overlap). Additionally, some of the measures were partially relaxed before being completely abandoned (see Table 12 for a list of the measures).

Table 12: (Federal) measures aimed at slowing the spread of the COVID-19 pandemic

Measure	Start	Partial relax	End
Closure of most shops (except food)	16.03.20	27.04.20	22.06.20
Closure of schools	16.03.20		11.05.20
Masks mandatory in public transportation	06.07.20		01.03.21
Wearing masks in public, less than 15 persons inside, only sitting in restaurants	18.10.20		01.03.21
Closure of night clubs, limited number of persons attending events	28.10.20		31.05.21
Closure of restaurants, leisure and cultural activities	22.12.20	19.04.21	31.05.21
Closure of shops (except food), home office mandatory	13.01.21		01.03.21

While it is legitimate to question the impact of these measures on the utilization of pediatric ED in Switzerland, we fear that such question cannot be answered in any simple and meaningful way given the data at hand, and this for several reasons.

First and foremost, the estimation of the causal effect of the anti-COVID measures on the ED utilization during the pandemic would require the construction of a credible counterfactual. This counterfactual should describe how the number of ED visits could have possibly evolved during the pandemic in absence of any measure. In our ITS modelling, we estimated the impact of the pandemic on the number of ED visits by using the pre-pandemic counts as controls, while adjusting for the season. Extrapolating the pre-pandemic trend to the pandemic period defined a counterfactual against which the pandemic trend could be compared. When the aim is to assess the effect of the measures on the ED utilization during the pandemic, the counterfactual becomes much more difficult to build. Indeed, our ITS modelling revealed that the pandemic did not only change the overall trend in the number of visits but did also severely alter the seasonal effect (which plays a major role in the observed number of ED visits over the time frame during which the measures were implemented). As a consequence, the pre-pandemic data cannot be used to extrapolate a seasonal pattern to the pandemic period. All we are left with is the data recorded during the pandemic period. Unfortunately, it is not possible to separate a proper seasonal effect from the effect of the measures on the pandemic data only because the observation window is rather short and the two effects are inseparable.

Secondly, a proper estimation of the effect of the measures on the number of visits in ED requires a good understanding on the factors (causes, confounders, mediators/moderators etc.) affecting the dynamics of the ED utilization over time. However, the evolution of the (e.g. daily) number of visits in ED is a non-specific composite outcome which can be influenced by so many external factors that building a clear picture of the context is challenging. Lagged effects of the measures are also very likely and the measures were implemented gradually overtime (with a limited observation period during the pandemic), which further complicates the overall picture.

Thirdly, even if a causal effect of the measures on pediatric ED utilization were to be estimated, it would still remain challenging to determine whether such effect is actually profitable or detrimental, which hampers the interpretability of such effect. For example, if a given measure (e.g. school closure) was found to be associated with a drop in the number of visits in ED, should we conclude that school closure had a negative impact (e.g. by restricting access of the young population to the health system), or in contrast, was beneficial (e.g. by preventing severe COVID infections and/or outdoor accidents)?

For all these reasons, we believe that it would be unreasonable at best and even dangerous to attempt any estimation of the direct effect of the anti-COVID measures implemented during the pandemic with the data at hand, at least within the scope of that report. As an alternative, we propose here to simply visualize the (smoothed) evolution of the daily number of visits in ED in each canton and compare it with the timing of the measures implemented in these cantons (see Figure 17), in a purely descriptive fashion, without pretending to unveil any direct association (let alone any causal effect) between the anti-COVID measures and pediatric ED utilization during the pandemic.

One of the most stringent measures implemented at the federal level at the start of the pandemic was the closure of schools and non-essential shops. The former were closed for 2 months between mid-March to mid-May of 2020 while the latter were completely closed from mid-March, with a gradual re-opening from end of May to end of June of 2020 (see Table 12). Despite these coercive measures, we observed a modest increase in the number of daily ED visits in all three cantons. As already mentioned, this does not suggest an absence of effect (or even a counter-productive effect) of those restrictive measures because we have no counterfactual for comparison. In the second half of 2020, the number of visits tends to stabilize and slightly decrease towards the end of the year, despite two peaks visible in the early summer and fall of 2020 in Geneva (and to a lesser extent in Zurich too). During this second half of 2020, wearing the mask became mandatory in all public transportation throughout the country, followed by the obligation to wear the mask in all public places. It could be tempting to attribute this decrease in the utilization of pediatric ED to a benefit of the mask wearing policy. While such positive effect cannot be excluded, we rather observe the number of visits in ED started to increase again in January 2021 in all 3 cantons, well before the obligation to wear a mask was relaxed and while additional measures (closure of night clubs, restaurant, non-essential shops, home office mandatory) were implemented as well. Shortly after all measures were finally abandoned by end of May 2021, the number of visits decreased drastically in Geneva (and to a lesser extent in Zurich) before stabilizing at a value approaching pre-pandemic levels. Note that the large drop visible during the summer of 2021 in Geneva is likely due to a vacation effect.

4.3 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% (89). 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 telemedical 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.
Our geographical analyses and their interpretation are still preliminary. As expected, they show utilization patterns with the clearest decreases during the pandemic for families with the longest travel distances to the hospitals. However, the visualization of these changes reveals a diverse pattern, with some regions experiencing increased visits while others observe a decrease compared to the pre-pandemic period. Interestingly, we noticed a rise in visits for some more distant areas, possibly attributable to disease severity or healthcare system modifications. During the pandemic, certain adult hospitals were designated as COVID hospitals, potentially influencing families to seek care at other EDs, even if they were farther away. Our geographic data demonstrate that the pandemic did not result in a scenario where only families living near these three hospitals were able to access the EDs. Families from more distant or rural areas also utilized EDs in Zurich, Geneva, and Bellinzona, despite the stay-home policy.
It is important to note that our analysis is based solely on Swiss data, and therefore, we cannot draw any conclusions regarding the effect of the pandemic on families living in neighboring countries and whether the continued so visit the EDs in Geneva and Bellinzona.

The effect of the federal measures taken to contain the pandemic cannot be assessed with our data for several reasons, as explained in detail. Primarily, this is because we would need to construct a counterfactual to determine how the number of ED visits could have evolved during the pandemic in absence of any measure, which is not feasible.

5 Overall recommendations

Based on the above implications, we developed three overarching recommendations (see page 52 -54).

The below titles specify the “who” and ”what” (including the role of the stakeholder), the “when”, if actions are needed now or in future, and the “how”, sketching some next steps. The next steps are not exhaustive and need to be developed further. These overarching recommendations should also be incorporated into the current revision of the Swiss influence pandemic plan.

Overarching recommendation I

AIM: MONITORING AND INTERPRETING HEALTH AND HEALTH CARE DATA, AND COMMUNICATION STRATEGIES

WHO and WHAT:

- Federal institutions (FOPH, OBSAN, FSO): set-up a continuous and timely monitoring system that concurrently considers data on health and health care utilization; to analyze and interpret monitoring data
- Researchers: use monitoring data for in-depth analyses
- Pediatricians: interpret the analyzed data and suggest actions
- FOPH: implement measures derived from the analyzed monitoring data; coordinate the collaborative process of different players involved in the monitoring

WHEN:

- Now: setting-up an ongoing monitoring system on the health / health care utilization of children and adolescents
- Future health crisis: incorporating additional indicators related to crisis, on particularly pressing health issues and health care utilization timely

HOW:

- Assessing existing sources that can provide data on health care utilization of children / adolescents (e.g., health insurance data, hospital data, outpatient data) and relevant indicators of health care utilization
- Building on the FOPH "Minimal Set of Indicators Kinder- und Jugendgesundheit" (MSI KJG) set-up a comprehensive monitoring system for health and health utilization
- Deciding on how data on the selected indicators should be collected (data source, frequency of data collection, etc.) to address the linkage between health care utilization and health
- Defining the process of how new indicators might be included into the existing monitoring system timely (for instance during a health crisis; including a specification of the involved entities)
- Setting-up the monitoring in a secure and sustainable system by considering critical cornerstones (e.g., in terms of data security)
- Establishing continuous data collection and quality management, regular analyses of the monitoring data, and access to researchers
- Interpreting the data and deriving conclusions / formulating recommendations and actions

1

Overarching recommendation II

AIM: IMPROVING AND FURTHER DEVELOPING TELEMEDICINE

WHO and WHAT:

- Pediatric societies: develop and establish guidelines on telemedicine for different contexts, advocate for such services
- Pediatricians with different fields of expertise (delegates from pediatric societies): implement technical systems and develop competencies
- Researchers: investigate efficacy and safety of telemedical services in different contexts, motivational factors and competencies of parents / adolescents and physicians, effect on health and access to health
- IT experts / data protection officers: improve and optimize the technical implementation of telemedical services
- FOPH / health insurers: clarify remaining questions of reimbursement of telemedical services

WHEN:

- Now: Thoroughly assessing the pros/cons, the facilitating/hindering factors and the prerequisites of telemedicine overall (e.g., regarding the technical implementation and digital health literacy of users of telemedicine) and specifically for different contexts (e.g., for mental or physical health care; for primary care or emergency situations (e.g., to help parents decide whether an ED visit is indicated or not))
- Future health crisis: Preparing means of upscaling telemedicine when in-person services are no longer possible

HOW:

- Assessment of current use and state of telemedicine from different perspectives, including:
  - qualitative interviews with pediatricians in primary and tertiary care regarding the chances / limitations / hurdles of such services for different contexts / health issues
  - qualitative data on the parental / adolescent utilization behavior of telemedicine, including enabling and hindering factors (e.g., high vs. low levels of digital health literacy; motivational factors that lead to the use of telemedicine instead of in-person services)
  - Impact of healthcare costs: potential savings compared to in-person visits
- Collaboratively improving existing telemedicine solutions with the various players (including pediatricians, IT experts, data protection officers, etc.)
- Developing guidelines regarding telemedicine, including a definition on the circumstances of the contexts that make the use of such services effective
- Communicate to all involved about safety, indication, technical solutions, reimbursements

Overarching recommendation III

AIM: DIFFERENTIATED COMMUNICATION AND ADAPTION HEALTH CARE UTILIZATION IN A POTENTIAL FUTURE CRISIS

WHO and WHAT:

- Pediatric societies: early and differentiated communication of general recommendations (e.g., stay home policies)
- Pediatricians: closer cooperation between primary and tertiary care (experiences in the cantons of Zurich and Ticino can serve as examples)

WHEN:

- Now: Establish local and regional networks including primary and tertiary care providers to collect and interpret data and improve the flow of information
- Future health crisis: utilize these networks to collect, analyze, and interpret necessary data on a local, regional, and national level, and to communicate up-to-date information, upscale telemedicine as a pre-triage tool

HOW:

- Strengthening and enlargement of existing local and regional networks of different levels of pediatric care providers (incl. infrastructure)
- Communication across various channels to ensure families know where to turn for questions regarding their sick or injured children. Also, to clarify what is specifically meant by general statements such as stay home policies
- Ensure families that EDs are safe and may be used when indicated
- Pre-triage (ideal telemedicine) to support parents in assessing whether a primary or tertiary care visit is indicated for their sick or injured child (reduction of physical visit if not indicated)

3

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7 Appendix

7.1 Scientific contributions as part of the project

7.1.1 Conferences

Jahreskongress pädiatrie schweiz, Interlaken, 15.-16. Juni 2023

Two oral presentations:

Seiler, M., Aziz, C., Oros, V., Manzano, S., Gualco, G., Sidler, M., Dratva, J. & Von Rhein, M. on behalf of the PedCov Consortium. (2023). The impact of the COVID-19 pandemic on pediatric emergency department utilization in three different language regions: assessment of trends and diagnosis-specific analyses.

Dey, M., Volken, T., Laasner, U., Seiler, M. & Dratva, J. on behalf of the PedCov Consortium (2023). Differences between pre-pandemic and pandemic (COVID-19) pediatric health service utilization in Switzerland. Analyses of Swiss insurance data between 2018 and 2022

Deutscher Kongress für Kinder- und Jugendmedizin, Hamburg, 20.-23. September 2023

Two oral presentations:

Dratva, J., Seiler, M., Altwicker-Hámori, S., von Rhein, M., Laasner, U. & Dey, M. im Namen des PedCov-Konsortiums (2023). Effekte der COVID-19-Pandemie auf die Inanspruchnahme von primär pädiatrischen Gesundheitsdienstleitungen in der Schweiz

Von Rhein, M., Dratva, J., Chaouch, A., Oros, V., Manzano, S., Gualco, G., Sidler, M., Seiler, M. im Namen des PedCov-Konsortiums (2023). The impact of the COVID-19 pandemic on pediatric emergency department utilization in three different language regions: assessment of trends and diagnosis-specific analyses

European Public Health Conference 2024

Poster:

Dey, M., von Rhein, M., Volken, T., Chaouch, A., Laasner, U., Seiler, M & Dratva, J. on behalf of the PedCov Consortium (2024). Longitudinal analyses (2018-2022) of the COVID-19 impact on Swiss pediatric healthcare utilization.

7.1.2 Scientific articles in peer-reviewed journals

von Rhein, M. et al., Chaouch, A., Oros, V., Manzano, S., Gualco, G., Sidler, M., Laasner, U., Dey, N., Dratva, J. & Seiler, M. on behalf of the PedCov consortium (2024). The effect of the COVID-19 pandemic on pediatric emergency department utilization in three regions in Switzerland. International Journal of Emergency Medicine, 17(1):64, doi: 10.1186/s12245-024-00640-2

Dey, M., Volken, T., Altwicker-Hámori, S., von Rhein, M., Seiler, M., Laasner, U., Wieber, F. & Dratva, J. (submitted: 05.04.2024; currently under review). Did the COVID-19 pandemic impact pediatric health service utilization in Switzerland? Interrupted time series models of health insurance data, Swiss Medical Weekly.

Special issue in Frontiers in Pediatrics

Members of the Pedcov consortium (Michael von Rhein and Julia Dratva) initiated a special issue in the journal "Frontiers in Pediatrics" on lessons learned from the COVID-19 pandemic. The Pedcov consortium will probably contribute the following publications (working title) to this special issue:

1. Urgent health care visits during the COVID-19 pandemic: Has there been a shift from primary to tertiary care? Interrupted time series models of health insurance and emergency department data from Switzerland
2. Spatial distribution of emergency visits in tertiary care before, during, and after the pandemic

7.2 Health insurance data

7.2.1 Detailed description of the TARMED positions / ATC-codes that were grouped together for the analyses

Table 13: 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	
Telemedicine		
	Telemedical consultation by the…	
00.0110	…physician, first 5 min.	All telemedical consultations
00.0120	…physician for persons over 6 years … of age, each additional 5 min.	Long telemedical 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 telemedical consultation, Mon-Sun 19-22, Sat 12-19, Sun 7-19	
00.2580	…E for telemedical consultation, Mon-Sun 22-7	
Mental health services		
02.0010	Psychiatric diagnostics and therapy, individual therapy, first session, per 5 min.	Psychiatric diagnostic/therapy first session (02.010)
02.0020	Psychiatric diagnostics/therapy, individual therapy, subsequent session	Psychiatric diagnostic/therapy subsequent session (02.0020)
02.0040	Psychiatric diagnostics and therapy, family therapy, per 5 min.	Psychiatric diagnostic/therapy family (02.0040)
02.0050	Psychiatric diagnostics and therapy, group therapy, per 5 min.	Psychiatric diagnostic/therapy group (02.0050)
02.0080	Psychiatric crisis intervention, per 5 min.	Psychiatric crisis intervention (02.0080)
	Telemedical consultations by a psychiatrist for persons…	Telemedical consultations psychiatrist (02.0060/65/66)
02.0060	…over 6 years of age and under 75 years of age, per 5 min.	
02.0065	...under 6 years of age and under 75 years of age, per 5 min.	
02.0066	…over 6 years of age and under 75 years of age with an increased need for treatment, per 5 min.	
02.0090	Psychological and psychiatric test assessment by the specialist, per 5 min., as the sole psychiatric service	Psychiatrics and psychological testing (02.0090)
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)

7.2.2 Detailed results of the ITS models

Table 14: Model estimates derived from interrupted time series for pediatric health services (including vaccinations), SASIS

	0-5y	**6-10y**	**11-15y**	**16-18y**
Consultations				
Time	1.000 [0.993-1.007]	1.000 [0.994-1.006]	0.999 [0.993-1.005]	1.000 [0.995-1.006]
Pandemic	0.760** [0.644-0.896]	0.850* [0.742-0.974]	0.925 [0.815-1.049]	0.906 [0.802-1.024]
Time x Pandemic	1.017** [1.007-1.028]	1.003 [0.994-1.013]	1.004 [0.996-1.012]	1.005 [0.997-1.013]
Developmental pediatric consultations				
Time	1.015** [1.006,1.023]	-	-	-
Pandemic	0.896 [0.747,1.076]			
Time x Pandemic	0.992 [0.980,1.004]			
Well-child visits up to 5 years				
Time	1.001 [0.995-1.006]	-	-	-
Pandemic	0.871* [0.765-0.992]			
Time x Pandemic	1.009* [1.000-1.018]			
All telemedical consultations				
Time	1.002 [0.995-1.008]	1.003 [0.997-1.008]	1.001 [0.996-1.006]	1.004 [0.998-1.010]
Pandemic	1.394*** [1.218-1.594]	1.547*** [1.387-1.726]	1.578*** [1.430-1.741]	1.831*** [1.614-2.076]
Time x Pandemic	1.002 [0.993-1.011]	0.989** [0.982-0.996]	0.995 [0.989-1.002]	0.988** [0.979-0.996]
Urgent visits/consultations				
Time	1.002 [0.992,1.013]	1.000 [0.991,1.008]	0.997 [0.991,1.004]	0.997 [0.991,1.004]
Pandemic	0.638*** [0.500,0.813]	0.810* [0.665,0.985]	0.951 [0.819,1.103]	0.913 [0.783,1.064]
Time x Pandemic	1.023** [1.008,1.040]	1.002 [0.989,1.015]	0.997 [0.987,1.007]	1.001 [0.991,1.011]
Measles/mumps/rubella/(varicella)				
Time	1.011** [1.004,1.017]	-	-	-
Pandemic	0.841* [0.729,0.971]			
Time x Pandemic	0.988* [0.977,0.998]			
Diphtheria/tetanus/polio				
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]		
Pneumococcos				
Time	1.002 [0.996,1.007]	-	-	-
Pandemic	1.002 [0.887,1.132]			
Time x Pandemic	1.001 [0.992,1.009]			
TBE				
Time	-	1.033*** [1.019,1.047]	-	-
Pandemic		0.883 [0.674,1.155]		
Time x Pandemic		0.949*** [0.930,0.969]		
Psychiatric diagnostic/therapy first session				
Time	-	1.000 [0.993,1.006]	1.002 [0.995,1.008]	1.005 [1.000,1.011]
Pandemic		0.963 [0.831,1.116]	0.920 [0.793,1.067]	0.968 [0.851,1.100]
Time x Pandemic		0.994 [0.984,1.004]	1.002 [0.992,1.012]	1.004 [0.996,1.013]

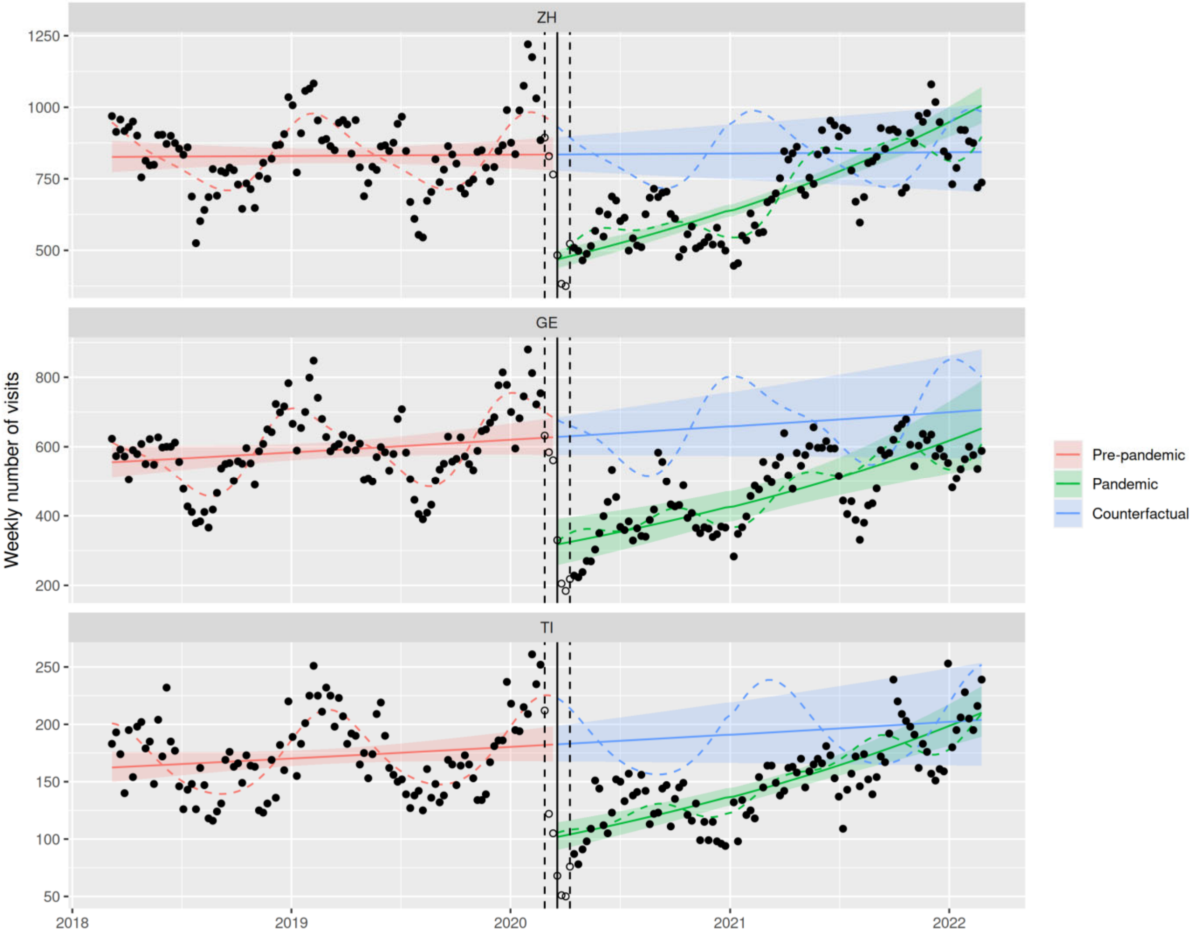
	0-5y	6-10y	11-15y	16-18y
Psychiatric diagnostic/therapy subsequent session				
Time	0.999 [0.991,1.006]	0.999 [0.992,1.006]	1.01 [0.994,1.008]	1.006 [1.000,1.013]
Pandemic	1.013 [0.860,1.192]	0.879 [0.746,1.035]	0.949 [0.809,1.113]	0.961 [0.836,1.106]
Time x Pandemic	1.001 [0.990,1.012]	0.879 [0.746,1.035]	1.004 [0.993,1.015]	1.007 [0.998,1.017]
Psychiatric diagnostic/therapy family				
Time	-	1.006* [1.000,1.013]	1.006 [1.000,1.011]	1.008** [1.003,1.014]
Pandemic		0.953 [0.829,1.096]	0.909 [0.802,1.031]	0.899 [0.795,1.017]
Time x Pandemic		0.989* [0.980,0.998]	0.997 [0.989,1.005]	1.001 [0.993,1.009]
Psychiatric and psychological testing				
Time	-	0.999 [0.986,1.012]	1.003 [0.991,1.016]	1.007 [0.994,1.020]
Pandemic		0.925 [0.691,1.237]	0.887 [0.674,1.167]	0.903 [0.678,1.202]
Time x Pandemic		1.000 [0.980,1.019]	0.998 [0.979,1.016]	1.000 [0.981,1.019]
Psychiatric crisis intervention				
Time	-	-	1.009 [0.999,1.018]	1.008 [1.000,1.017]
Pandemic			0.945 [0.779,1.147]	0.938 [0.786,1.121]
Time x Pandemic			1.006 [0.993,1.018]	1.015** [1.004,1.027]
Telemedical consultations				
psychiatrist			0.974*** [0.964,0.985]	1.006 [0.996,1.015]
Time	-	-	1.004 [0.997,1.012]	1.973*** [1.649,2.362]
Pandemic			1.813*** [1.553,2.118]	0.983** [0.971,0.995]
Time x Pandemic				

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; results are only reported if rates are high enough; no estimates are provided for long telemedical consultations (00.0120, 00.0125), for psychiatric diagnostic/therapy group (02.0050), and for the vaccination against meningococcus, because the rates were too low in all age groups.

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

7.3.1 Weekly number of ED visits (total)

Figure 7: 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 15: Model estimates for the weekly total number of visits in ED, by canton (ZH, GE, TI)

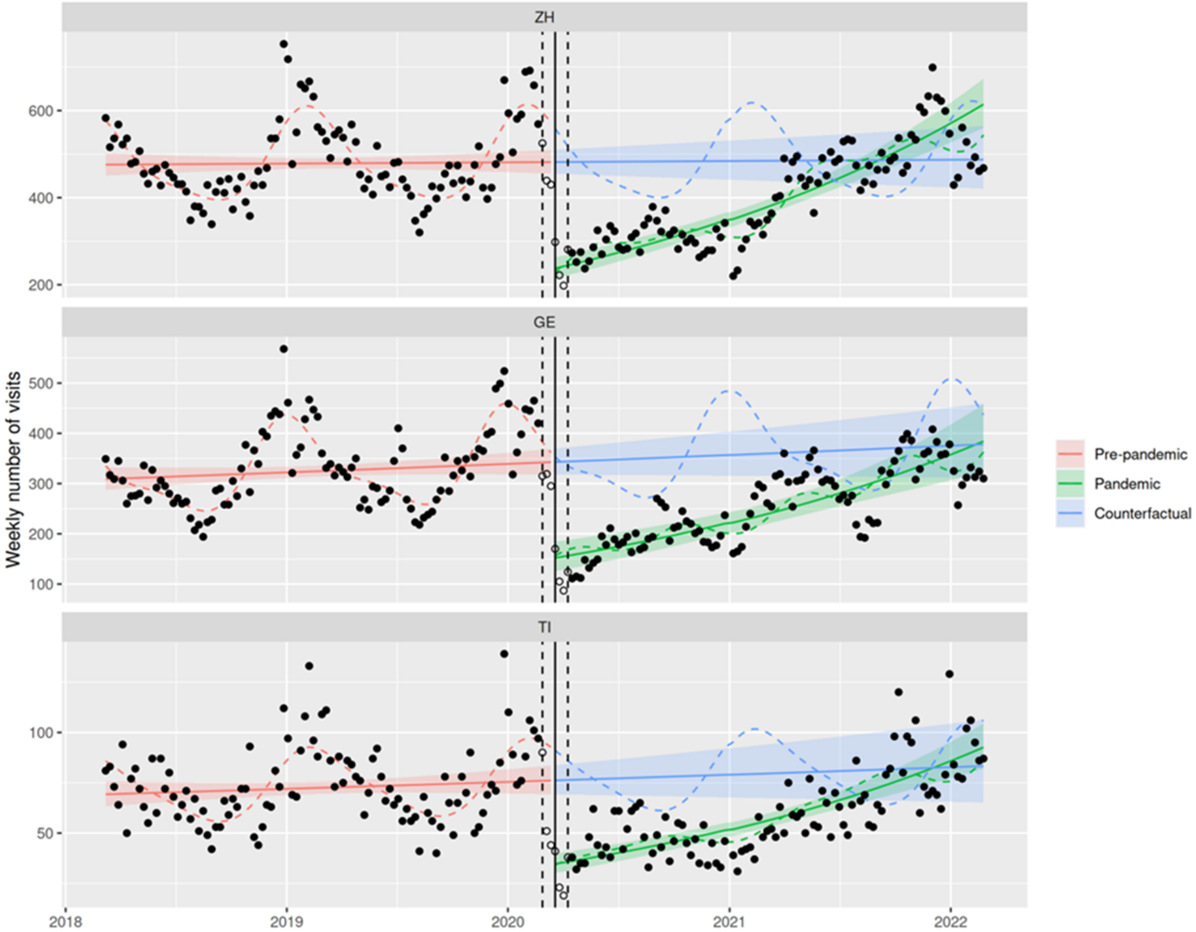
Canton	Time	Pandemic	Time x Pandemic
ZH	1.005 [0.947; 1.067]	0.561*** [0.509; 0.619]	1.480*** [1.359; 1.612]
GE	1.062 [0.988; 1.143]	0.506*** [0.404; 0.633]	1.369** [1.125; 1.665]
TI	1.059 [0.985; 1.139]	0.558*** [0.483; 0.645]	1.376*** [1.214; 1.560]

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

7.3.2 ED visits in different age groups

Age group 0-4 years old

Figure 8: 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).

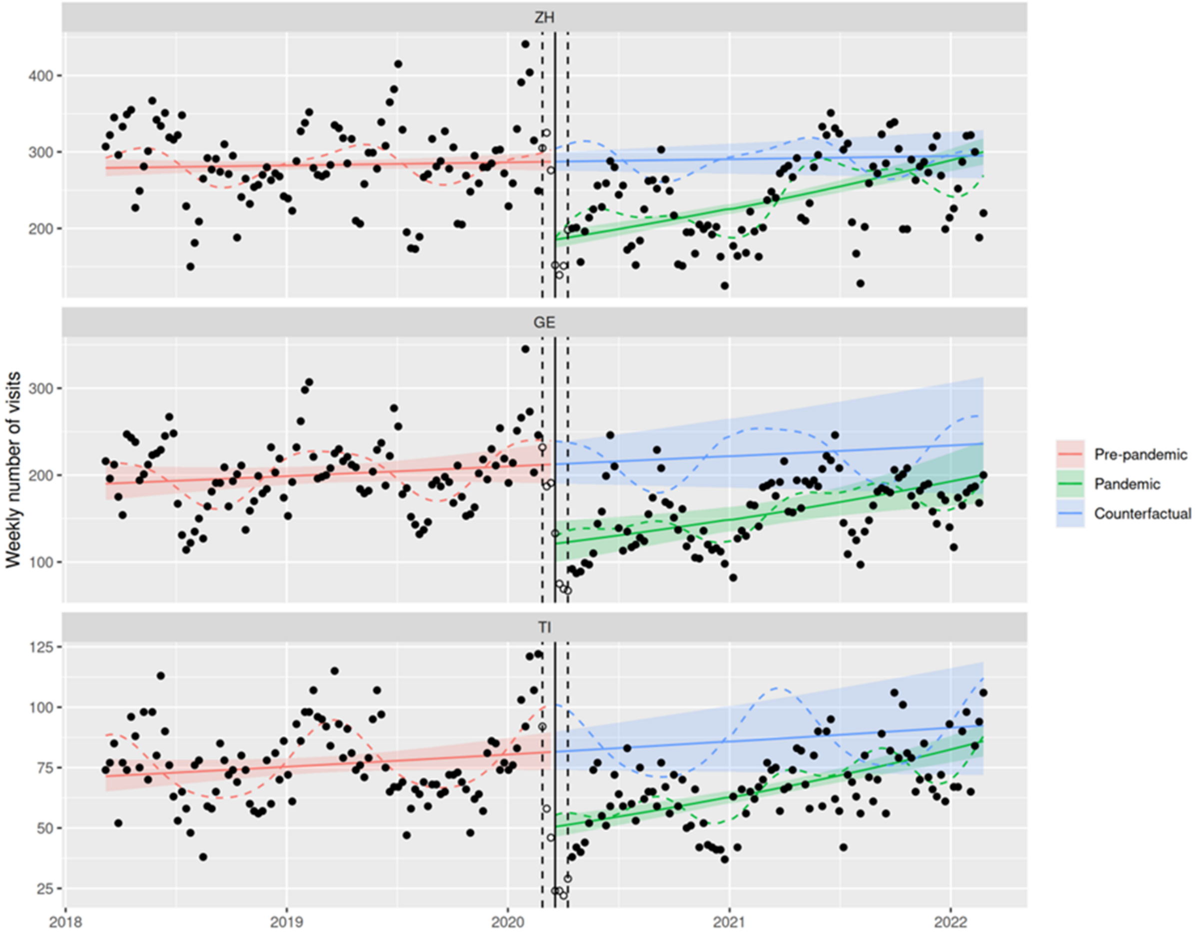
Table 16: Model estimates for ED number of visits in the age group 0-4 years old, by canton (ZH, GE, TI)

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 9: 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).

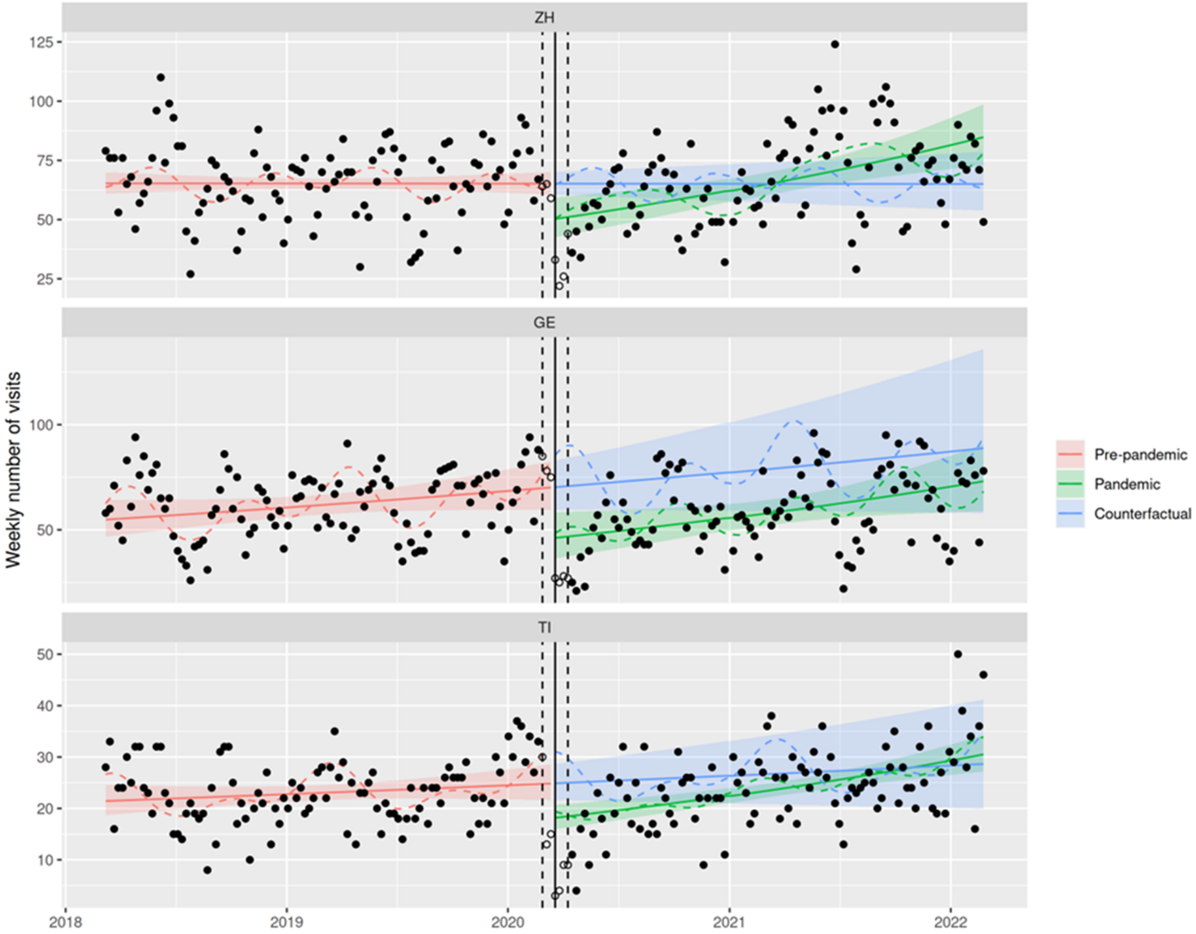
Table 17: Model estimates for ED number of visits in the age group 5-12 years old, by canton (ZH, GE, TI)

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 10: 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 18: Model estimates for ED number of visits in the age group 13-18 years old, by canton (ZH, GE, TI)

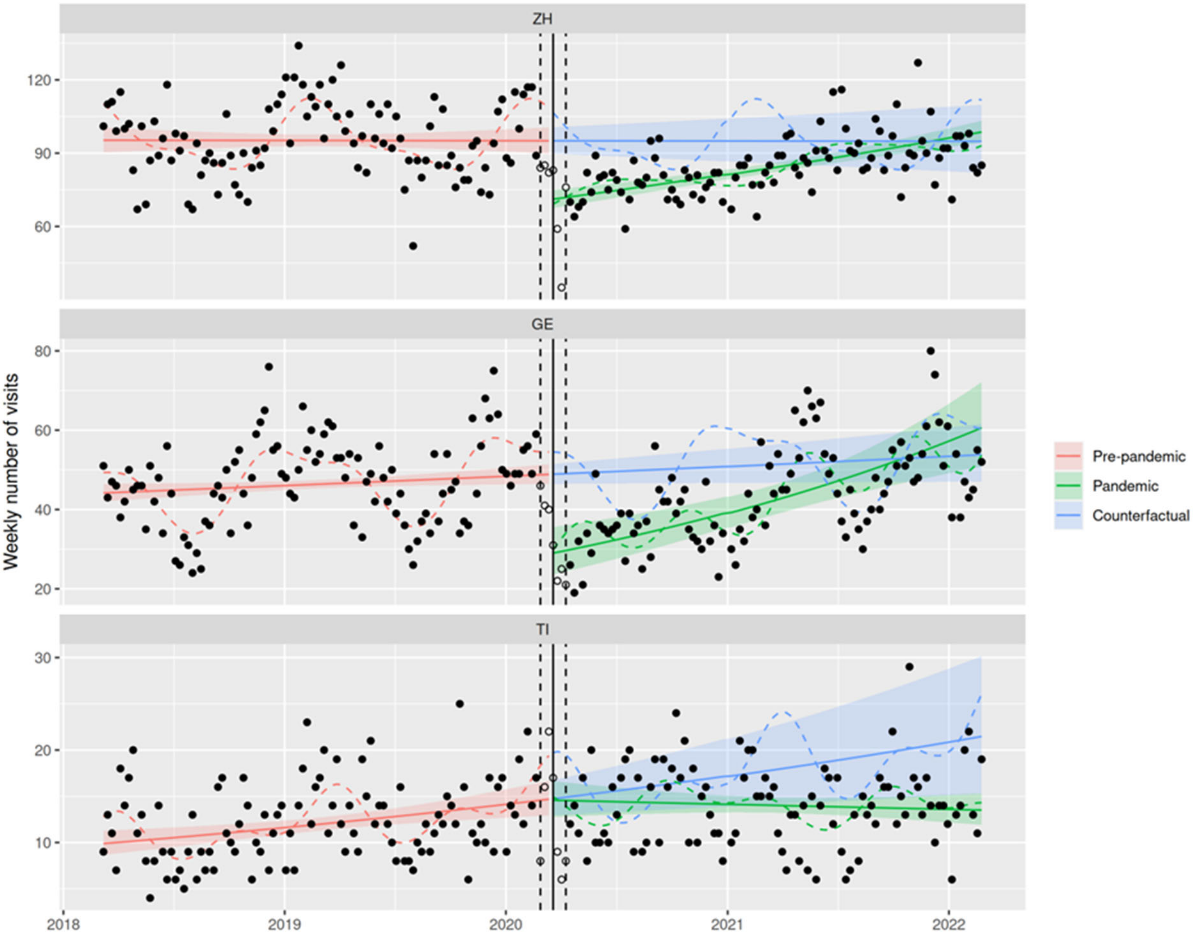
Canton	Time	Pandemic	Time x Pandemic
ZH	0.999 [0.938; 1.063]	0.771** [0.644; 0.923]	1.314*** [1.121; 1.539]
GE	1.129 [0.981; 1.300]	0.657** [0.493; 0.876]	1.125 [0.874; 1.446]
TI	1.076 [0.954; 1.214]	0.731** [0.603; 0.885]	1.216* [1.031; 1.435]

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

7.3.3 Inpatient or outpatient management

Weekly number of ED visits requiring hospitalization

Figure 11: 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).

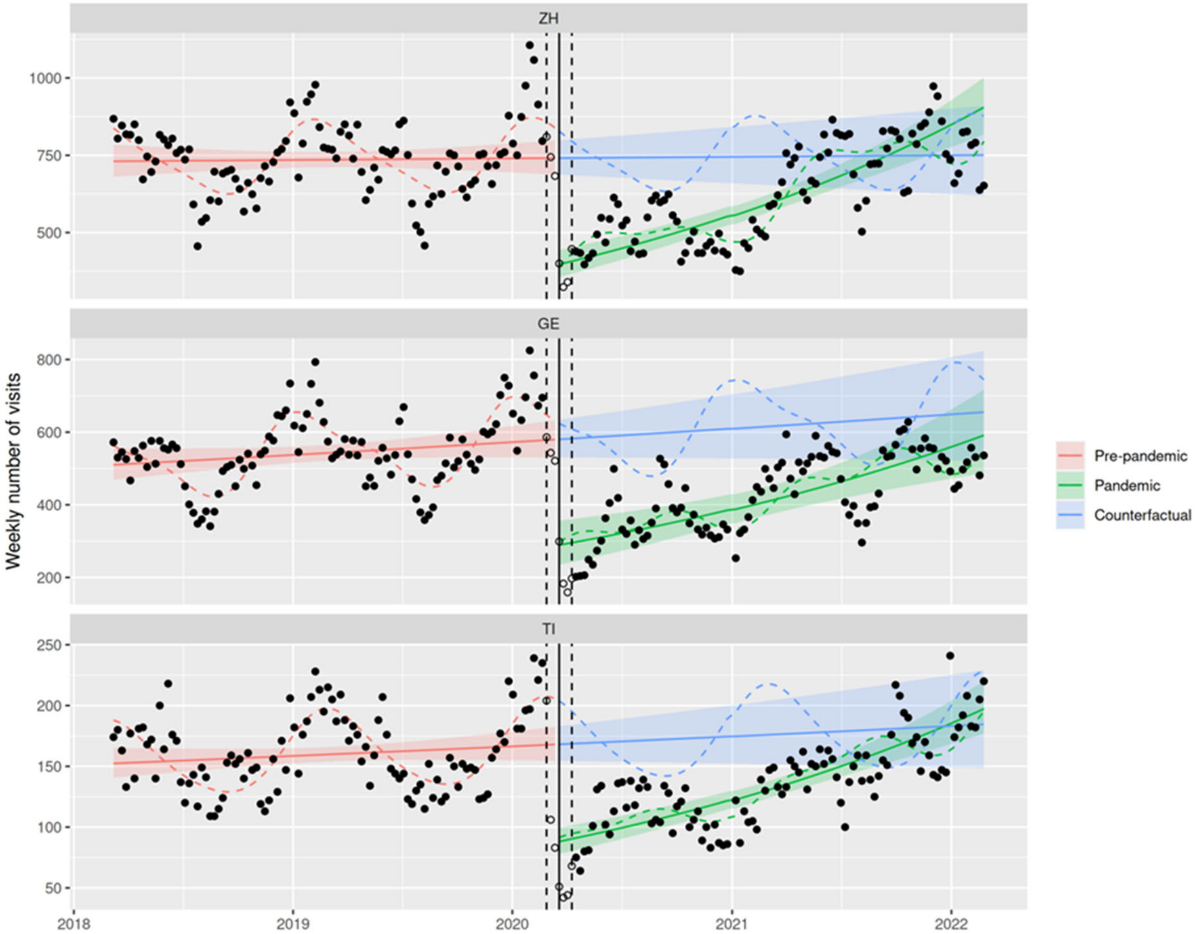
Table 19: Model estimates for the weekly number of hospitalizations, by canton (ZH, GE, TI)

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 12: 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 20: Model estimates for ED number of visits in ambulatory care, by canton (ZH, GE, TI)

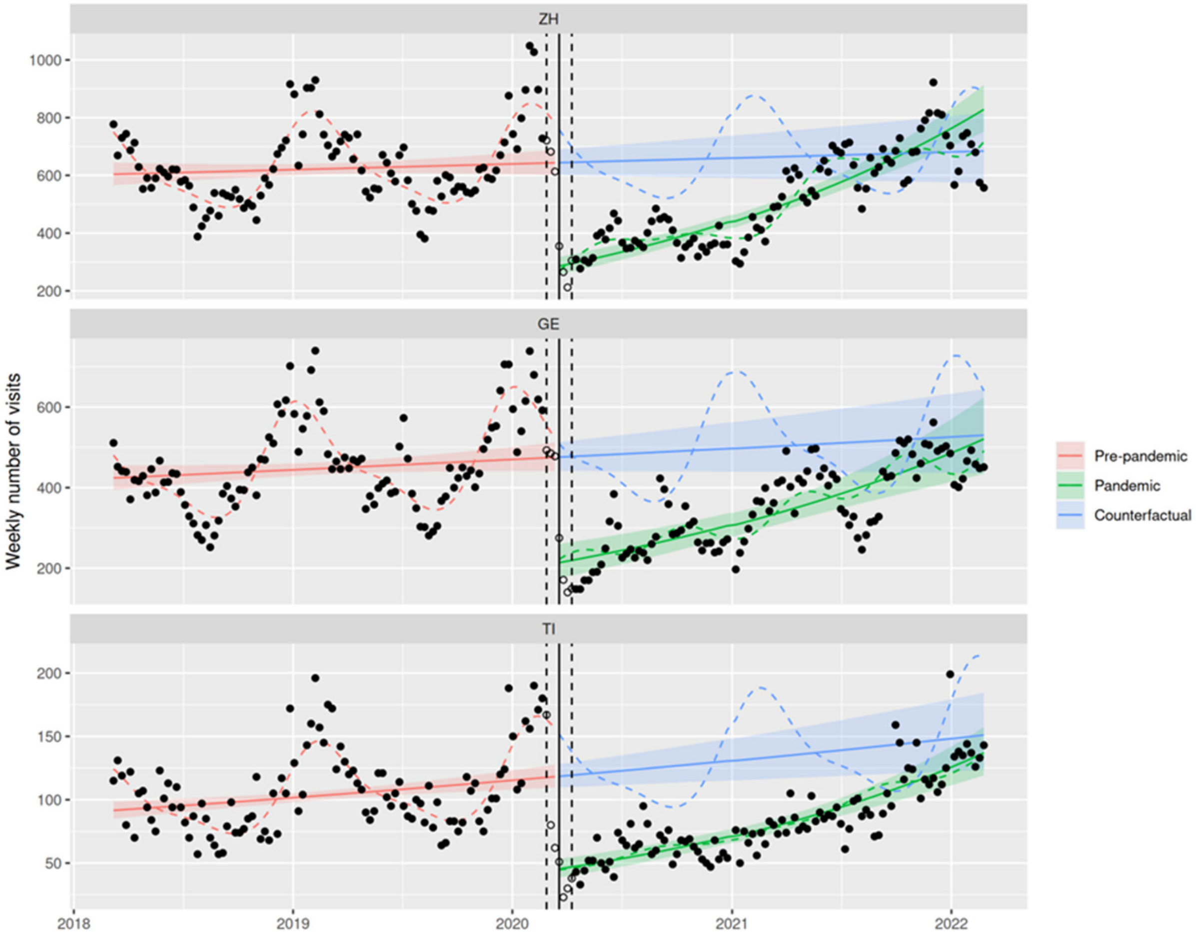
Canton	Time	Pandemic	Time x Pandemic
ZH	1.007 [0.945; 1.073]	0.536*** [0.470; 0.613]	1.524*** [1.356; 1.712]
GE	1.065 [0.988; 1.149]	0.498*** [0.398; 0.625]	1.362** [1.117; 1.660]
TI	1.049 [0.977; 1.128]	0.524*** [0.452; 0.608]	1.449*** [1.274; 1.648]

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

7.3.4 ED visits due to non-accidental and accidental causes

<u>ED visits related to non-accidents (e.g. diseases)</u>

Figure 13: 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).

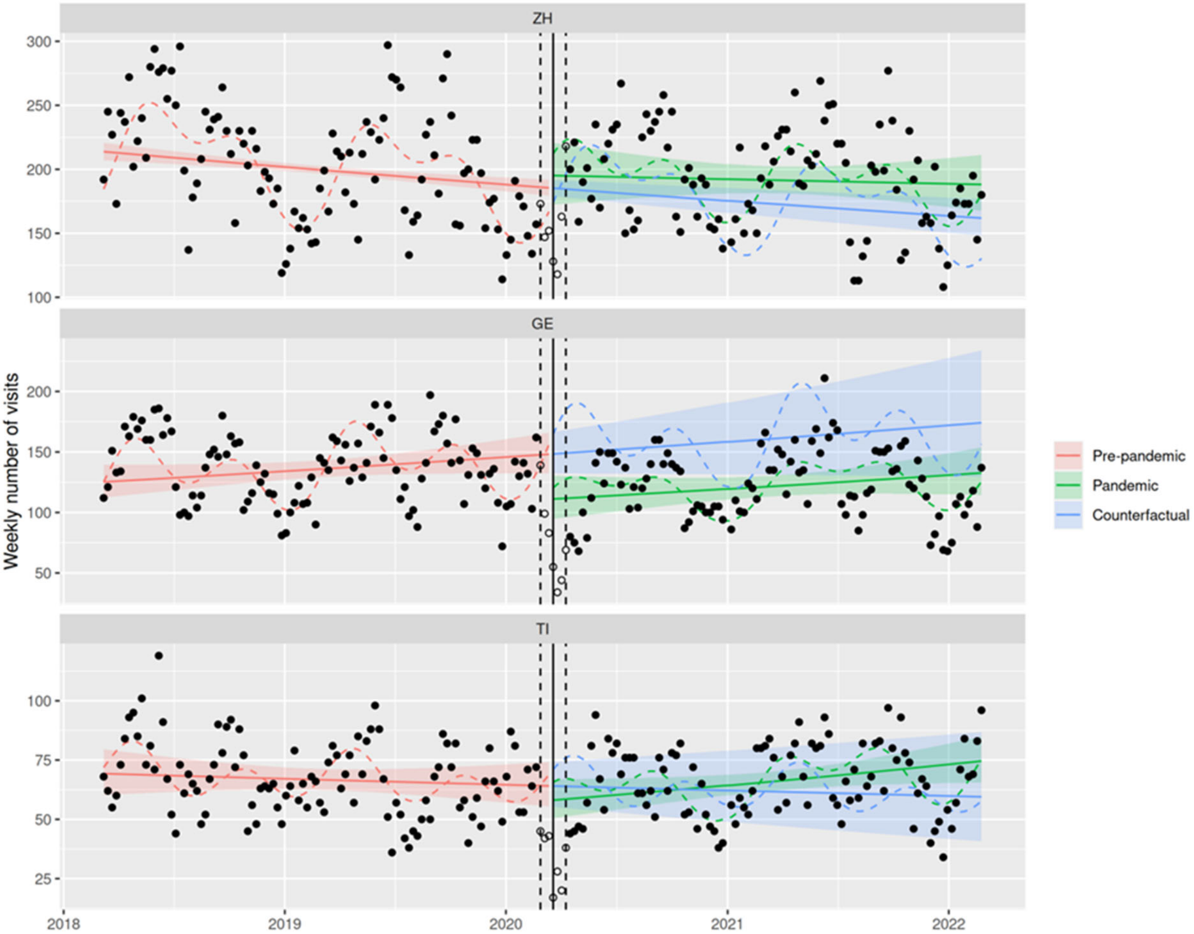
Table 21: Model estimates for ED number of visits due to other reasons than accidents, by canton (ZH, GE, TI)

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 14: 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 22: Model estimates for ED number of visits due to accidents, by canton (ZH, GE, TI)

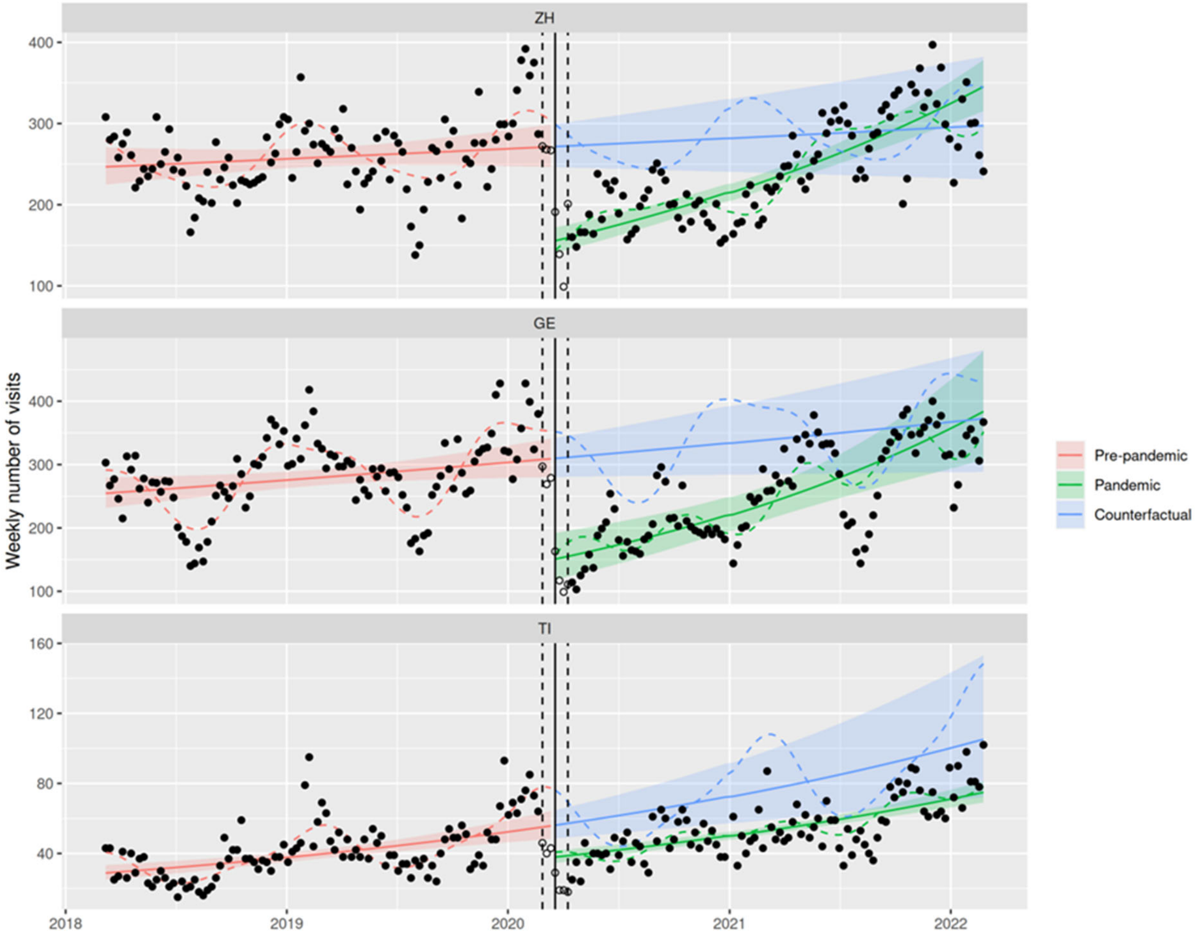
Canton	Time	Pandemic	Time x Pandemic
ZH	0.932*** [0.906; 0.960]	1.053 [0.927; 1.197]	1.053 [0.939; 1.180]
GE	1.087 [0.986; 1.198]	0.749** [0.615; 0.911]	1.009 [0.849; 1.198]
TI	0.962 [0.850; 1.090]	0.909 [0.744; 1.110]	1.181 [0.993; 1.405]

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

7.3.5 Urgency of ED visits (triage categories)

Urgent ED visits (triage category ≤3)

Figure 15: 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)

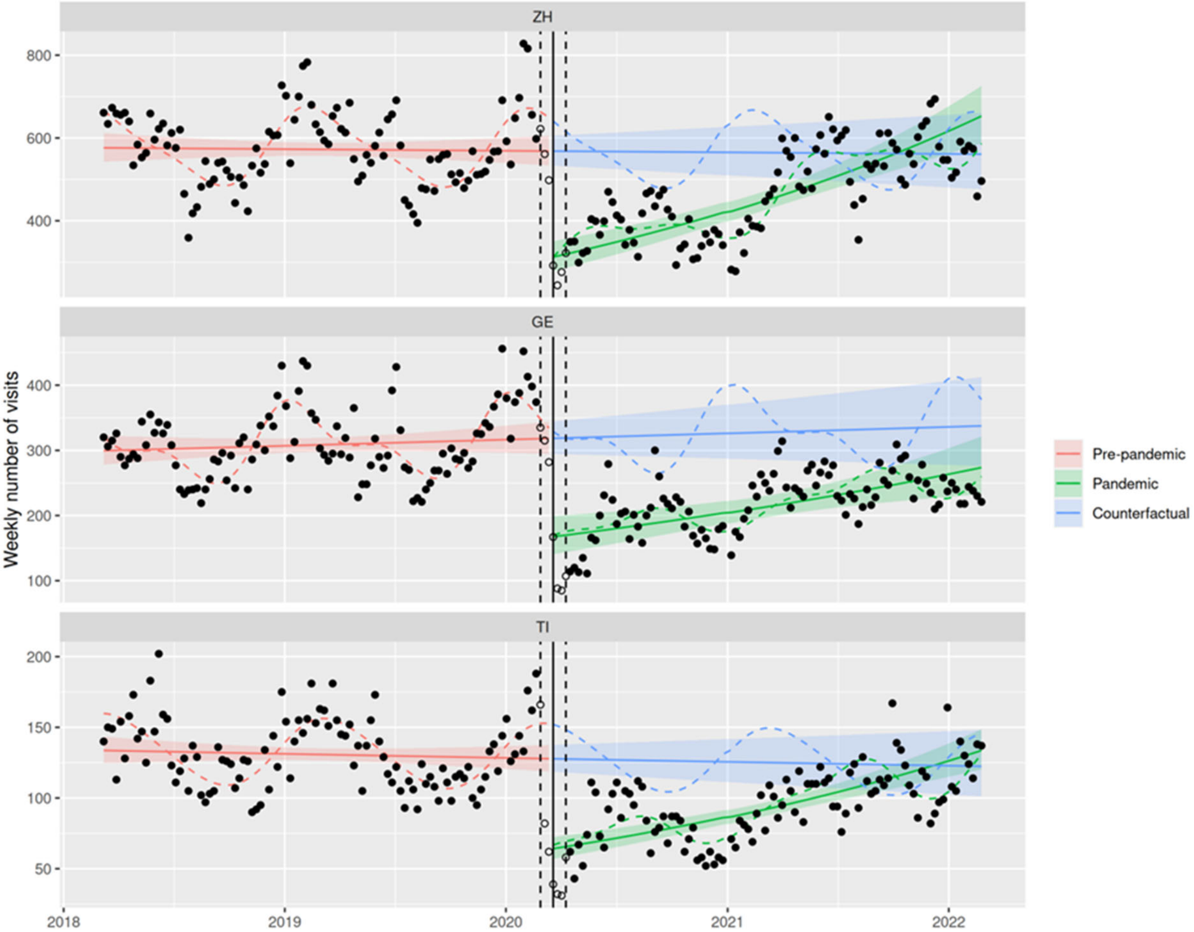
Table 23: Model estimates for the weekly number of ED visits in triage category ≤3 (urgent), by canton (ZH, GE, TI)

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 16: 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).

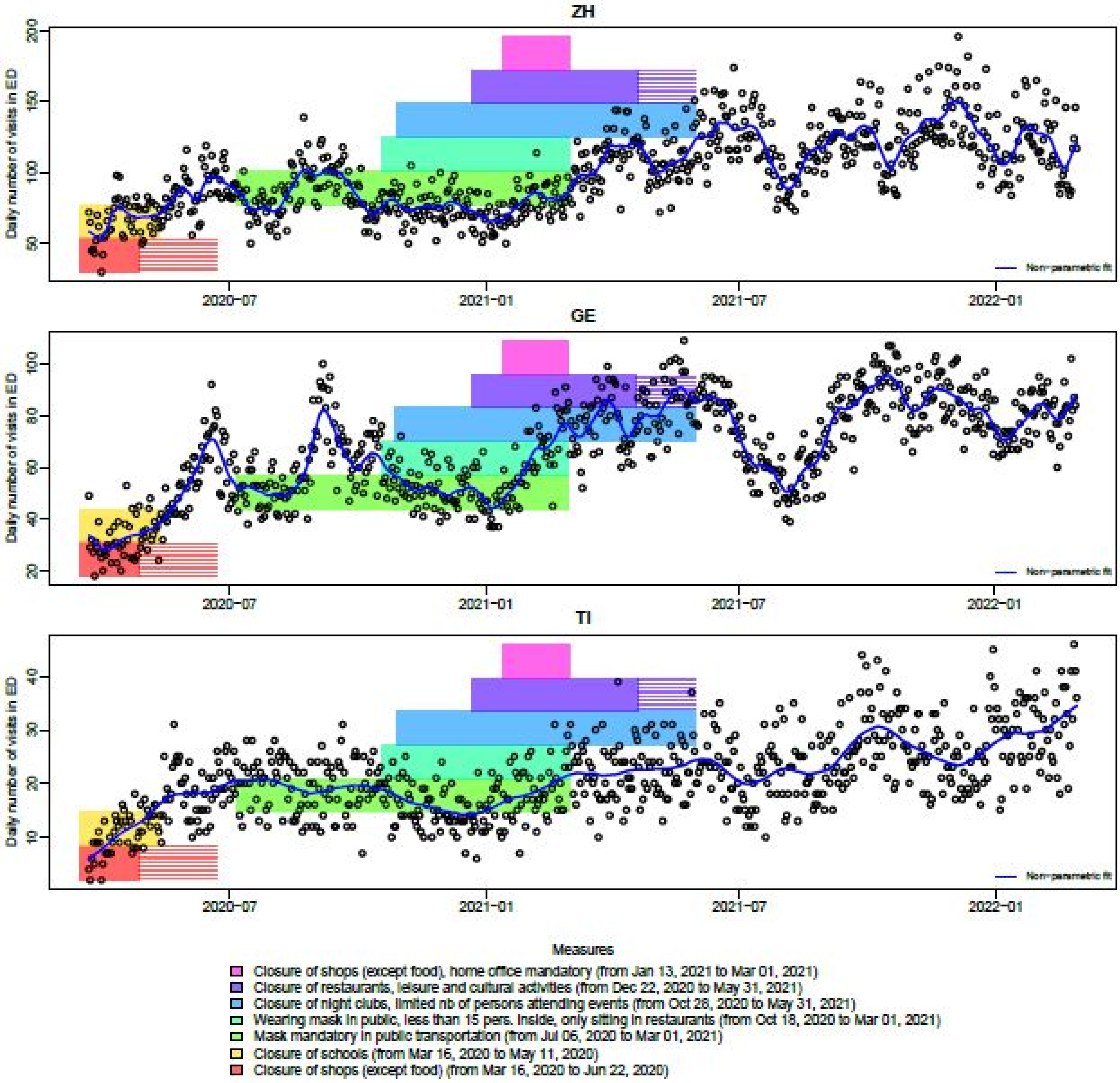
Table 24: Model estimates for the weekly number of ED visits in triage category >3 (non-urgent), by canton (ZH, GE, TI)

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

7.3.6 Daily ED visits per Canton and corresponding implementation of measures

Figure 17: Descriptive evolution of the daily number of ED visits in each canton, compared with the timeline of implemented measures.



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The effect of the COVID-19 pandemic on pediatric emergency department utilization in three regions in Switzerland

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Abstract

Purpose The COVID-19 pandemic was associated with a decrease in emergency department (ED) visits. However, contradictory, and sparse data regarding children could not yet answer the question, how pediatric ED utilization evolved throughout the pandemic. Our objectives were to investigate the impact of the pandemic in three language regions of Switzerland by analyzing trends over time, describe regional differences, and address implications for future healthcare.

Methods We conducted a retrospective, longitudinal cohort study at three Swiss tertiary pediatric EDs (March 1st, 2018—February 28th, 2022), analyzing the numbers of ED visits (including patients' age, triage categories, and urgent vs. non-urgent cases). The impact of COVID-19 related non-pharmaceutical interventions (NPIs) on pediatric ED utilization was assessed by interrupted time series (ITS) modelling.

Results Based on 304'438 ED visits, we found a drop of nearly 50% at the onset of NPIs, followed by a gradual recovery. This primarily affected children 0–4 years, and both non-urgent and urgent cases. However, the decline in urgent visits appeared to be more pronounced in two centers compared to a third, where also hospitalization rates did not decrease significantly during the pandemic. A subgroup analysis showed a significant decrease in respiratory and gastrointestinal diseases, and an increase in the proportion of trauma patients during the pandemic.

Conclusions The COVID-19 pandemic had substantial effects on number and reasons for pediatric ED visits, particularly among children 0–4 years. Despite equal regulatory conditions, the utilization dynamics varied markedly between the three regions, highlighting the multifactorial modification of pediatric ED utilization during the pandemic. Furthermore, future policy decisions should take regional differences into account.

Keywords Children, COVID-19, Emergency department, Pandemic, Utilization, Variation

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