

# How did the COVID-19 pandemic affect inpatient care for children in Germany? An exploratory analysis based on national hospital discharge data

Dimitra Panteli (✉ [dimitra.panteli@tu-berlin.de](mailto:dimitra.panteli@tu-berlin.de))

European Observatory on Health Systems and Policies

Nicole Mauer

European Observatory on Health Systems and Policies

Florian Tille

European Observatory on Health Systems and Policies

Ulrike Nimptsch

Technische Universität Berlin

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## Research Article

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## Abstract

## Background -

The COVID-19 pandemic created substantial disruptions in the delivery of health services around the world. Reductions in hospital admissions have been reported for several conditions in the adult population; less evidence currently exists for children. To what extent such changes reflect a risk for patients due to unmet care needs, or a "correction" of previous overprovision of care has not been thoroughly examined yet.

## Methods -

Based on complete national hospital discharge data available via the German National Institute for the Reimbursement of Hospitals (InEK) data browser, we compare the top 30 diagnoses for which children were hospitalised in 2019, 2020 and 2021. We analyse the development of monthly admissions between January 2019 and December 2021 for three tracers of variable urgency and severity: acute lymphoblastic leukaemia (ALL), appendicitis/appendectomy and tonsillectomy/adenoidectomy.

## Results -

Total admissions were approximately 20% lower in 2020 and 2021 compared to 2019. The composition of the most frequent principal diagnoses did not change dramatically across years, although changes in rank were observed. Large decreases were observed in 2020 for respiratory and gastrointestinal infections, with cases picking up again for some in 2021. The number of ALL admissions showed a slight increasing trend and a periodicity *prima vista* unrelated to pandemic factors. Appendicitis admissions decreased by about 9% in 2020 and a further 8% in 2021, while tonsillectomies/adenoidectomies decreased by more than 40% in 2020 and a further 30% in 2021; for these tracers, monthly changes are in line with pandemic waves.

## Conclusions -

Observed variations in child hospitalisations reflect the effects of pandemic mitigation measures and/or changes in demand. In Germany, inpatient care for critical conditions appears to have been largely upheld, potentially at the expense of elective treatments. Complementary data on ambulatory care and health outcomes would enable a better understanding of change in healthcare patterns and effects on children's health.

## Introduction

The COVID-19 pandemic has caused substantial disruptions in the delivery of health services across all service areas and delivery platforms around the world.<sup>1</sup> Drops in physician contacts and non-COVID-19 hospital admissions have been reported for several conditions and a range of countries.<sup>2-4</sup>

These disruptions were likely influenced by a range of both supply and demand-side factors. On the one hand, the high numbers of COVID-19 patients put unprecedented pressure on health systems, restricting already limited capacities to provide health services. As a result, a range of measures were implemented to ensure adequate capacities for COVID-19 care and minimise exposure of those seeking care for other reasons.<sup>5</sup> Routine visits and elective procedures were often postponed or cancelled on all levels of care, and post-surgery and palliative care services were discontinued.<sup>5</sup> At the same time, people may have refrained from or delayed seeking in-person medical support to avoid exposure to SARS-CoV-2. Contractions in emergency department admissions for life-threatening conditions, such as stroke and myocardial infarction, have been reported and could impact health outcomes.<sup>2,4</sup>

The majority of research on the disruption of health care services during the COVID-19 pandemic has focused on the adult population<sup>2-4</sup>; less attention seems to have been paid to paediatric care. However, there is evidence from different countries on delayed presentations to paediatric assessment units and general paediatric care<sup>6</sup>, reductions in hospital admissions<sup>7</sup> and emergency department visits<sup>8</sup>, declining immunisation rates<sup>9</sup>, as well as an increase in severe cases of certain conditions such as new onset diabetic ketoacidosis for type 1 diabetes.<sup>10</sup> These patterns are also reflected in findings from Germany for the first wave of the pandemic.<sup>11</sup>

The above observations have been raising concerns about access to appropriate and timely care for children during the COVID-19 pandemic. For some of the observed phenomena, it remains unclear whether they reflect a risk for patients due to unmet care needs, or a correction of previous overprovision or inefficient provision of services. Against the backdrop of the detrimental effects of the COVID-19 pandemic and its implications, particularly on those under the age of 18<sup>12</sup>, it is pivotal to explore this issue further.

This study aims to compare hospitalisations for children before and during the COVID-19 pandemic using complete national data from German hospitals and explore potential differences in patterns for conditions and interventions with different levels of urgency and severity. It investigates the top 30 diagnoses for which children were admitted to German hospitals in 2019, 2020 and 2021 and then zooms into three different tracers to provide preliminary insights on the relationship between changes in admission rates and time-sensitivity of care: acute lymphoblastic leukaemia (ALL) (acute

essential care<sup>13</sup>); appendicitis (acute care with a potential alternative to immediate hospitalisation<sup>14</sup>); and tonsillectomy/adenoidectomy (planned care to address chronic conditions<sup>15</sup>).

## Methods

### Data

We used complete national hospital discharge data according to § 21 Hospital Remuneration Act (*Krankenhausentgeltgesetz*)<sup>16</sup> available through the open access data browser of the German National Institute for the Reimbursement of Hospitals (*Institut für das Entgeltsystem im Krankenhaus*, InEK), to which all German hospitals routinely report performance and billing data (see section 1 of the online Appendix). The data browser was created in response to the COVID-19 pandemic and provides access to aggregated discharge data on all inpatient cases discharged from hospitals in 2019, 2020 and 2021, including inter alia information on principal and secondary diagnoses (coded according to ICD-10, German modification), performed procedures (coded according to the German Operation and Procedure Classification "OPS"), as well as limited sociodemographic indicators (age group, sex) and other relevant clinical information, such as average length of hospital stay (ALOS) and distribution of hospitalisations by hospital bed capacity.<sup>16</sup> The data captures cases with inpatient stays but not those who were treated as outpatients (e.g., for emergency care or day surgery).

### Data extraction

We obtained data for children aged 28 days to 17 years who were admitted to German hospitals between 1 January 2019 and 31 December 2021 via the InEK data browser interface (<https://datenbrowser.inek.org/>). We first extracted data on the total number of cases admitted between 1 January and 31 December each year to identify overall changes in volume and the breakdown of annual cases by principal diagnosis. Furthermore, we extracted monthly admissions for a) cases with ALL (identified via ICD-10 principal diagnosis C91.00); b) cases with appendicitis (see Table 1 for ICD-10 principal diagnoses used) and cases with appendicitis who underwent an appendectomy (identified via the same ICD-10 principal diagnoses plus OPS procedure codes in Table 1); and c) cases who underwent a tonsillectomy and/or adenoidectomy (identified via OPS procedure codes, see Table 1). First data samples to conceptualise the study were downloaded in April 2021; data for the final analysis were extracted between 15 and 28 February 2022.

### Data analysis

Data was analysed using Microsoft Excel. Annual total case numbers for 2019, 2020 and 2021 were compared and differences were calculated (absolute numbers and percent changes). The 30 principal diagnoses (three-digit ICD-10 categories) with the highest number of cases were listed for each year, and differences to previous years were calculated (absolute numbers and percent changes). For the three tracers (ALL, appendicitis/appendectomy, and tonsillectomy/adenoidectomy), annual and monthly data across the three years were compared and plotted graphically. Differences in sex, age group, ALOS, patient clinical complexity level (PCCL; a measure of the cumulative effect of a patient's complications and comorbidities calculated for each episode of care), and hospital size were explored descriptively.

## Results

### Overall case numbers and most frequent reasons for hospitalisation

The total number of admissions dropped by more than 20% in 2020 compared to 2019 (from 1,278,814 to 1,003,312). In 2021, admissions increased by 2.7% compared to 2020 (1,030,063) but remained 19.5% lower than in 2019. Annual ALOS marginally increased in 2020 and then remained stable (in days, 2019: 3.2; 2020: 3.3; 2021: 3.3). No obvious or sizeable patterns emerged in the composition of annual admitted cases regarding sex, age group or patient complexity (see section 2 of the online Appendix).

Figure 1 shows the principal diagnoses for which children received inpatient care in 2019, 2020 and 2021. Percent changes from previous years are colour-coded to highlight decreases (red) or increases (green). The overall composition of the 30 most frequent diagnoses did not change dramatically across years, but changes in rank can be observed. In 2020, large decreases (between 30%-70% of admissions) were observed for respiratory and gastrointestinal infections. For many of these conditions, admissions in 2021 remained lower than 2019, but increased compared to 2020, in some cases considerably. In contrast, hospitalised influenza cases increased by almost 20% in 2020 compared to 2019, and almost disappeared in 2021 (there were 172 hospitalised cases with an ICD-10 code J10 in 2021, indicating a 98% drop from 2020 and 2019). Increases in acute bronchiolitis cases were observed in 2021 compared to both 2020 and 2019 (by 83% and 27%, respectively); these were mainly driven by increases in infections with respiratory syncytial virus (ICD-10 code J20.5), an effect which is masked in Fig. 1 due to the aggregation of cases to three-digit ICD-10 categories.

The largest decreases in hospitalisations among the most frequent non-communicable conditions or clinical signs in 2020 (> 20% of the 2019 value) were observed for chronic diseases of the tonsils and adenoids (43%), mental and behavioural disorders due to use of alcohol (36%), abdominal and pelvic pain (28%), syncope and collapse (28%) and certain functional gastrointestinal disorders (22%). While admissions for chronic diseases of the tonsils and adenoids showed a further substantial decrease in 2021 compared to 2020 (33%), cases for the other conditions decreased by less than 10% or not at all, thus remaining at levels at least 20% lower than 2019. For some serious acute conditions, the number of cases decreased by less than 5% (e.g., acute tubulo-interstitial nephritis), or even increased (e.g., ALL) over the observation period.

Injuries of the head and extremities remained among the most frequent reasons for hospitalisation during the observation period. Admissions due to intracranial injuries and superficial injuries of the head decreased by 21% and 12% respectively in 2020 compared to 2019 and remained fairly stable in 2021. Fractures of the forearm increased slightly in 2020 and decreased again in 2021 (both changes below 5%), whereas injuries of the upper arm and shoulder decreased by 7% in 2020 and then stayed at this new level in 2021. Fractures of the lower leg decreased in 2020 (12%) and picked up again in 2021 but remained slightly below 2019 levels.

## **Acute lymphoblastic leukaemia (ALL)**

The total number of children hospitalised for ALL increased by 127 (1.3%) from 2019 to 2020, and by a further 477 (4.7%) in 2021 (see Table 1). Monthly case numbers show fluctuations throughout the year that follow a similar pattern across the observation period: there are four discernible “peaks” in January, April, July, and October each year (see Fig. 2). ALOS ranges from 3.2 days (December 2019) to 10.5 days (October 2021), with a median of 5.7 days. The composition of ALL cases regarding sex, age group and patient complexity shows small variations throughout the observation period (see Table 1 and section 3 of the online Appendix). Regarding the location of care, the share of cases treated in large tertiary hospitals of 1000 beds or more decreased by approximately 10 percentage points during the pandemic, as can be seen in the online Appendix; these cases seem to have been distributed among smaller hospitals.

Table 1

Characteristics of paediatric inpatient cases with acute lymphoblastic leukaemia, appendicitis/appendectomy, and tonsillectomy/adenoidectomy.

	2019	2020	2021
<b>Acute lymphoblastic leukaemia<sup>1</sup></b>			
Hospital admissions, n	10119	10246	10723
Age, %	1.62	0.61	1.80
28 d – 1 yo <sup>2</sup>	14.58	16.28	17.95
1–2 yo	33.14	35.83	32.56
3–5 yo	20.87	20.05	20.28
6–9 yo	24.88	21.16	21.52
10–15 yo	4.91	6.07	5.88
16–17 yo			
Sex, %	56.61	58.65	57.71
Male	43.39	41.35	42.29
Female			
PCCL, % <sup>3</sup>	60.28	57.36	59.21
0	39.72	42.64	40.79
1–6			
Duration of stay, mean ± SD	5.5 ± 9.7	5.6 ± 8.9	6.3 ± 11.2
<b>Appendicitis (underwent appendectomy)<sup>4</sup></b>			
Hospital admissions, n	22454 (20885)	20363 (19040)	18774 (17341)
Age, %	0.01 (0.01)	0.04 (0.03)	0.08 (0.07)
28 d – 1 yo	0.90 (0.72)	0.91 (0.74)	0.86 (0.70)
1–2 yo	4.66 (4.39)	5.03 (4.78)	5.73 (5.45)
3–5 yo	17.59 (17.35)	19.31 (19.02)	19.83 (19.66)
6–9 yo	53.18 (53.19)	52.22 (52.30)	50.97 (50.94)
10–15 yo	23.67 (24.34)	22.49 (23.13)	22.53 (23.18)
16–17 yo			
Sex, %	50.90 (50.98)	52.33 (52.44)	53.02 (53.23)
Male	49.09 (49.01)	47.66 (47.55)	46.97 (46.76)
Female			
Principal diagnosis, %	82.53 (82.52)	80.40 (80.06)	79.82 (78.99)
K35.30, K35.8, K36, K37 - uncomplicated appendicitis	17.47 (17.48)	19.60 (19.94)	20.18 (20.60)
K35.2, K35.31, K35.32 - complicated appendicitis			

<sup>1</sup> Cases with a principal diagnosis of C91.00 (ICD-10)

<sup>2</sup> yo = years of age.

<sup>3</sup> PCCL = Patient Clinical Complexity Level; levels 0 (no comorbidities/complications), 1 (light comorbidities/complications) to 6 (most severe comorbidities/complications)

<sup>4</sup> Cases with a principal diagnosis in K35, K36, K37 (ICD-10); cases with appendectomy (principal diagnosis in K35, K36, K37 and procedure code in 5-470, 5-455.3) are shown in brackets.

<sup>5</sup> Cases with a procedure code in 5-281, 5-282, 5-285 (OPS)

	2019	2020	2021
PCCL, %	83.99 (83.61)	82.33 (81.99)	81.26 (80.77)
0	16.01 (16.39)	17.67 (18.01)	18.74 (19.23)
1–6			
Duration of stay, mean ± SD	4.3 ± 2.8 (4.3 ± 2.7)	4.3 ± 2.9 (4.3 ± 2.8)	4.2 ± 2.7 (4.2 ± 2.7)
Tonsillectomy or Adenoidectomy <sup>5</sup>			
Hospital admissions, n	51370	29148	19896
Age, %	0.65	0.82	1.27
28 d – 1 yo <sup>4</sup>	19.51	18.71	23.00
1–2 yo	46.97	47.49	45.84
3–5 yo	16.42	16.07	12.05
6–9 yo	10.71	10.49	10.00
10–15 yo	5.74	6.42	7.83
16–17 yo			
Sex, %	56.02	56.52	56.00
Male	43.97	43.47	43.97
Female			
Principal diagnosis, %	29.48	26.04	27.93
J35.2 (hypertrophy of adenoids)	28.68	29.54	27.18
J35.3 (hypertrophy of tonsils & adenoids)	17.26	17.61	16.30
J35.0 (chronic tonsillitis & adenoiditis)	11.99	13.48	13.90
J35.1 (hypertrophy of tonsils)	12.52	13.33	14.70
Other principal diagnosis			
PCCL, % <sup>3</sup>	93.87	93.66	92.48
0	6.13	6.34	7.52
1–6			
Duration of stay, mean ± SD	2.5 ± 2.2	2.5 ± 2.2	2.4 ± 2.1
<sup>1</sup> Cases with a principal diagnosis of C91.00 (ICD-10)			
<sup>2</sup> yo = years of age.			
<sup>3</sup> PCCL = Patient Clinical Complexity Level; levels 0 (no comorbidities/complications), 1 (light comorbidities/complications) to 6 (most severe comorbidities/complications)			
<sup>4</sup> Cases with a principal diagnosis in K35, K36, K37 (ICD-10); cases with appendectomy (principal diagnosis in K35, K36, K37 and procedure code in 5-470, 5-455.3) are shown in brackets.			
<sup>5</sup> Cases with a procedure code in 5-281, 5-282, 5-285 (OPS)			

## Appendicitis and appendectomy

Hospital admissions for children diagnosed with appendicitis dropped by 9.3% between 2019 and 2020 and a further 7.8% between 2020 and 2021 (see Table 1). The starkest monthly reductions were observed between March and May 2020 (March 2020: -413 cases, April 2020: -249, May 2020: -538) and January to February 2021 (January 2021: -613, February: -409) compared to the same periods in 2019. Smaller decreases were detected in autumn-winter 2020 and late summer-autumn 2021 (see Fig. 3).

There were slightly more male patients hospitalised for appendicitis than females across all years; the proportion of male cases increased from 50.1% in 2019 to 53.0% in 2021. Case numbers increased progressively with age with most cases presenting in patients aged 10 to 15 years (Table 1). No substantial shifts in numbers for age groups across observation years were apparent. Among cases admitted for appendicitis, the vast majority underwent appendectomy (2019: 93.0%, 2020: 93.5%, 2021: 92.4%).

The majority of hospitalised appendicitis cases had an uncomplicated clinical presentation based on ICD-10 diagnosis<sup>17</sup> (see Fig. 3; 2019: 82.5%, 2020: 80.4%, 2021: 79.8%), of which unspecified acute appendicitis (ICD-10 code K35.8; 2019: 45.6%, 2020: 43.3%, 2021: 43.1%) and acute appendicitis with local peritonitis (K35.30; 2019: 27.9%, 2020: 30.5%, 2021: 30.2%) made up the largest shares. The share of cases with complications such as generalised peritonitis, abscess formation, rupture or perforation increased across years (2019: 17.5%, 2020: 19.6%, 2021: 20.2%). The share of cases without complications/comorbidities (PCCL level 0) decreased between 2019 and 2021, while the share with complications/comorbidities of PCCL level 1 and above rose from 16.0–18.7% in all cases and from 16.4–19.2% in cases with appendectomy, respectively. ALOS did not vary considerably across years (see Table 1).

The distribution of cases across hospitals of different sizes mirrored the overall reduction in admissions for appendicitis in 2020 and 2021 (see Section 4 in the online Appendix). Across all three years, small- to medium-sized hospitals (200–599 beds) hosted the majority of cases, followed by large centres of 1000 beds and more. The greatest reduction in admissions occurred in hospitals with fewer than 400 beds.

## Tonsillectomy and adenoidectomy

The number of cases hospitalised for tonsillectomy and/or adenoidectomy dropped by 43.2% from 2019 to 2020 and decreased by a further 31.7% in 2021 (see Table 1 for absolute numbers). The starkest monthly reductions in 2020 compared to the same months in 2019 were observed in April (-82.8%) and May (-55.6%), as well as in November (-52.2%) and December (-62.6%). Comparing single months of 2021 with the same months in 2019, all but November (-45.7%) indicate a drop of over 50% of cases (Fig. 4). Monthly case numbers in 2021 were also lower than in 2020 for most months, except April (+83.2%), November (+13.8%) and December (+29.7%). Figure 4 shows monthly changes in absolute numbers and ALOS.

Changes in sex composition during the observation period were minor (see Table 1). Most patients who underwent tonsillectomy and/or adenoidectomy were 3 to 5 years old; the shares of both very young children (1–2 years) and 16-17-year-olds increased the most from 2019 to 2021, while the largest decrease was observed for the share of 6-to 9-year-olds (over four percentage points; see also section 5 in the Online Appendix).

In all three years, the most frequent underlying diagnoses for tonsillectomies and/or adenoidectomies were hypertrophy of the adenoids (ICD code J35.2), hypertrophy of the tonsils with hypertrophy of adenoids (J35.3), chronic tonsillitis and adenoiditis (J35.0) and hypertrophy of the tonsils only (J35.1), adding up to over 85% of diagnoses for all cases (see Table 1). The share of cases with a PCCL of level 1 and above increased slightly from 6.1% in 2019 to 7.5% in 2021.

The distribution of tonsillectomies and adenoidectomies among hospitals of different sizes remained largely the same during the observation period, except for hospitals with less than 200 beds, where the proportion of cases increased by nearly 3 percentage points (9.9–12.7%) from 2019 to 2021 (see section 5 of the online Appendix).

## Comparison of changes for ALL, appendicitis, and tonsillectomies/adenoidectomies

Figure 5 plots the monthly admission numbers for the three tracers against lockdown measures in Germany, which affected the functioning of hospitals to varying extents.<sup>5</sup>

Germany is a federal republic; lockdown measures were mandated by the national government but implemented at the federal state level, resulting in some regional and local variation. The first national lockdown was officially announced on 13 and 17 March 2020 and implemented as of 16 March, with social distancing measures persisting at least until early June 2020, and longer in some federal states. The second national lockdown was preceded by a “light” lockdown which came into force on 2 November 2020. Restrictions were hardened in mid-December 2020 and lasted until March 2021. This was followed by revised legislation on health protection in Germany that allowed for further flexibility in implementing public health and social measures across the individual federal states as of April 2021.<sup>18,19</sup> During lockdowns, hospitals were advised to postpone elective non-urgent treatments to preserve capacity for the treatment of patients with COVID-19.<sup>20,21</sup>

Lockdown periods coincide with substantial drops in admissions for tonsillectomies/adenoidectomies and less pronounced decreases in admissions for appendicitis, while admissions for ALL do not seem to be similarly affected. Linear trend lines show an overall steep decrease for tonsillectomies/adenoidectomies, a slight decrease for appendicitis and no change for ALL.

## Discussion

The number of paediatric hospitalisations in Germany fell in total by 20 percent in 2020 compared to 2019. Although they increased again slightly in 2021, numbers of inpatient cases did not return to pre-pandemic levels by the end of the study period. Similar findings have been reported in adult populations, with persistent reductions in both elective and emergency routine hospital care documented in Germany and worldwide.<sup>22,23</sup> Previous work on a sample of German paediatric patients showed a drop of around 40% for overall admissions and surgeries in the first months of the pandemic.<sup>11</sup>

Overall, the composition of the most frequent clinical indications for admission did not change significantly. However, individual diagnoses displayed important fluctuations throughout the pandemic. In particular, respiratory and gastrointestinal infections plummeted in 2020, likely as a result of COVID-19 restrictions; this confirms previous findings from the German and international literature.<sup>24,25</sup> Remarkably, influenza cases displayed an initial soar in 2020, as many children were likely admitted on suspicion of a SARS-CoV-2 infection, but subsequently reached a record low in 2021.<sup>24</sup> The rise in admissions for acute bronchiolitis in 2021, which was largely driven by an increase in respiratory syncytial virus (RSV) infections, has also been observed elsewhere and linked to the restrictions implemented to halt viral transmission.<sup>26</sup> The distribution of non-communicable conditions and injuries is in line with behavioural changes produced by restrictions such as the closure of schools and reduced social interactions with other children.<sup>11</sup> The number of admissions to German hospitals due to behavioural and mental disorders triggered by alcohol consumption decreased during the pandemic, but it remains unclear whether this is related to a decrease in alcohol consumption or a rise in unmet care needs.

Hospitalisation rates for the three tracers were affected to varying degrees throughout the observation period. The lack of substantial shifts in ALL hospital admissions suggests that inpatient services for severe conditions, such as haematologic cancers, were upheld throughout the pandemic. There was even a slight increase in cases during the observation period; an increase of newly diagnosed leukaemia in children during the first year of the pandemic has also been reported based on data from the German Childhood Cancer Registry<sup>27</sup>, and merits further investigation. Despite this increase in cases, the share of ALL patients treated in large tertiary centres ( $\geq 1000$  beds) dropped by ten percentage points in favour of smaller hospitals, which may reflect the reallocation of patients and resources implemented as part of the pandemic response. Notably, the distribution of hospitalisations for ALL displayed the same four peaks in every year of the study period (the first month of every quarter), which could be related to therapeutic regime planning or other contextual factors.

Observed reductions in appendicitis hospitalisations were most pronounced for the months overlapping with the pandemic mitigation measures implemented by the government and federal states. There was a slight increase in the proportion of complicated clinical presentations, with similar findings reported in the literature.<sup>28</sup> However, without comparable data from ambulatory and emergency department settings, it is impossible to judge whether this was due to reluctance to seek care and related delays due to fear of exposure to SARS-CoV-2 or other factors.<sup>29</sup>

The reductions in tonsillectomy and/or adenoidectomy procedures reflect the widespread postponement of elective interventions, as first called for by the German government in mid-March 2020 and found in a recent population-wide analysis across all age groups.<sup>21</sup> Similar to the reduction in appendicitis hospitalisations, this drop may indicate a change in demand due to concerns about SARS-CoV-2 exposure.<sup>21</sup> However, it must be acknowledged that the evolution of clinical practice increasingly favours minimally invasive approaches that are performed in ambulatory settings<sup>21</sup>; it is conceivable that the pandemic further accelerated this development. While shifts from inpatient to outpatient treatment could not be investigated in this study due to the nature of the data, the plausibility of ambulatory care fully offsetting the difference in inpatient procedures is questionable, given the substantial decrease in outpatient care visits that has also been observed in Germany since the beginning of the COVID-19 pandemic.<sup>21</sup>

Our study has several limitations. Since the InEK data browser only contains pre-pandemic data for 2019, it was impossible to account for particularities in hospital admission numbers of that year or compare hospitalisation trends over several years, including decreasing tendencies in admissions for appendicitis and/or tonsillectomies/adenoidectomies before the pandemic; a better comparison would have been the five-year-average before the pandemic. The three tracers are not fully representative of all urgent or elective care in the German health system; our analysis of the most frequent 30 diagnoses can provide impetus for further investigations. Moreover, the data browser only provides a limited set of sociodemographic indicators, only for inpatient cases (not patients) and at an aggregate level; this precludes stratification by specific patient subgroups as well as following up on individual patients to identify those with multiple hospitalisations. Thus, the data available through the data browser does not lend itself to further inferential analyses, which were therefore not attempted here. Hospital discharge data are typically prone to entry and codification errors; however, German hospital billing data is considered fairly reliable with regard to reimbursement-relevant content.<sup>30</sup>

## Conclusions

This is the first nationally complete study capturing all paediatric inpatient cases in Germany in the immediate pre-pandemic and pandemic periods. Our study demonstrates that paediatric care for critical and urgent conditions was largely upheld, potentially at the expense of elective treatments. This must be interpreted in the context of Germany's health system, which has a large inpatient sector and relative overcapacity in terms of hospital beds<sup>31</sup>; it is likely that the situation has been quite different in other settings. Indeed, there are growing concerns over looming backlogs of health services, which threaten to put additional strain on health systems globally.<sup>32</sup> As policies to address this issue are developed, particularly understudied and vulnerable groups like children should stay in focus. This study also demonstrates the need for comprehensive, intersectoral data that enables a better understanding of changing demand, unmet need, and forgone care as well as shifts from inpatient to outpatient care, and their link to patient outcomes and health care efficiency.



## Declarations

### Ethics approval and consent to participate

This study was exempt from ethical approval because the data are deidentified and publicly available for download from the InEK data browser.

### Consent for publication

Not applicable.

### Availability of data and materials

The data used for the analysis are publicly available and freely downloadable from the German National Institute for the Reimbursement of Hospitals (InEK) data browser. All analyses have been documented using Microsoft Excel and will be made publicly available in an open repository prior to publication.

### Competing interests

None.

### Funding

None.

### Authors' contributions

DP conceived the study. DP and UN developed the methodological approach. DP, NM and FT had full access to the data, undertook the data analysis, and take full responsibility for the integrity and accuracy of the analysis. DP, NM, FT, and UN wrote several drafts and produced the final version of the manuscript. All authors have approved the final version.

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## References

1. World Health Organization. Third round of the global pulse survey on continuity of essential health services during the COVID-19 pandemic [Internet]. 2022. Available from: [https://www.who.int/publications/i/item/WHO-2019-nCoV-EHS\\_continuity-survey-2022.1](https://www.who.int/publications/i/item/WHO-2019-nCoV-EHS_continuity-survey-2022.1)
2. Sofi F, Dinu M, Reboldi G, Stracci F, Pedretti RFE, Valente S, et al. Worldwide differences of hospitalization for ST-segment elevation myocardial infarction during COVID-19: A systematic review and meta-analysis. *International Journal of Cardiology*. 2022 Jan;347:89–96.
3. Moynihan R, Sanders S, Michaleff ZA, Scott AM, Clark J, To EJ, et al. Impact of COVID-19 pandemic on utilisation of healthcare services: a systematic review. *BMJ Open*. 2021 Mar;11(3):e045343.
4. Bodilsen J, Nielsen PB, Sogaard M, Dalager-Pedersen M, Speiser LOZ, Yndigegn T, et al. Hospital admission and mortality rates for non-covid diseases in Denmark during covid-19 pandemic: nationwide population based cohort study. *BMJ*. 2021 May 24;n1135.
5. Webb et al. Transforming delivery of essential health services during the COVID-19 pandemic. *Eurohealth*. 2022;28.
6. Jansen DEMC, Illy KE. Delayed presentation to regular Dutch paediatric care in COVID-19 times: a national survey. *bmjpo*. 2020 Oct;4(1):e000834.
7. Pelletier JH, Rakkar J, Au AK, Fuhrman D, Clark RSB, Horvat CM. Trends in US Pediatric Hospital Admissions in 2020 Compared With the Decade Before the COVID-19 Pandemic. *JAMA Netw Open*. 2021 Feb 12;4(2):e2037227.
8. Goldman RD, Grafstein E, Barclay N, Irvine MA, Portales-Casamar E. Paediatric patients seen in 18 emergency departments during the COVID-19 pandemic. *Emerg Med J*. 2020 Oct 29;emermed-2020-210273.
9. McDonald HI, Tessier E, White JM, Woodruff M, Knowles C, Bates C, et al. Early impact of the coronavirus disease (COVID-19) pandemic and physical distancing measures on routine childhood vaccinations in England, January to April 2020. *Eurosurveillance* [Internet]. 2020 May 14 [cited 2022 Apr 25];25(19). Available from: <https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2020.25.19.2000848>
10. Sellers EAC, Pacaud D. Diabetic ketoacidosis at presentation of type 1 diabetes in children in Canada during the COVID-19 pandemic. *Paediatrics & Child Health*. 2021 Jun 11;26(4):208–9.
11. DAK Gesundheit. Corona-Pandemie: Folgen fuer die Krankenhausversorgung von Kindern und Jugendlichen. DAK Gesundheit; 2020.
12. United Nations International Children's Emergency Fund. COVID-19 and children [Internet]. 2022. Available from: <https://data.unicef.org/covid-19-and-children/>

13. Brown P, Inaba H, Annesley C, Beck J, Colace S, Dallas M, et al. Pediatric Acute Lymphoblastic Leukemia, Version 2.2020, NCCN Clinical Practice Guidelines in Oncology. *Journal of the National Comprehensive Cancer Network*. 2020 Jan;18(1):81–112.
14. Di Saverio S, Podda M, De Simone B, Ceresoli M, Augustin G, Gori A, et al. Diagnosis and treatment of acute appendicitis: 2020 update of the WSES Jerusalem guidelines. *World J Emerg Surg*. 2020 Dec;15(1):27.
15. Berner R, Steffen G, Toepfner N, Waldfahrer F, Windfuhr JP. Therapie entzündlicher Erkrankungen der Gaumenmandeln - Tonsillitis. 2015.
16. Institut fuer das Entgeltsystem im Krankenhaus. Datenlieferung gem. § 21 Abs.1 KHEntgG [Internet]. 2022. Available from: [https://www.g-drg.de/Datenlieferung\\_gem.\\_21\\_KHEntgG/Datenlieferung\\_gem.\\_21\\_Abs.1\\_KHEntgG](https://www.g-drg.de/Datenlieferung_gem._21_KHEntgG/Datenlieferung_gem._21_Abs.1_KHEntgG)
17. Stöß C, Nitsche U, Neumann PA, Kehl V, Wilhelm D, Busse R, et al. Acute Appendicitis: Trends in Surgical Treatment. *Deutsches Ärzteblatt international* [Internet]. 2021 Apr 9 [cited 2022 Apr 25]; Available from: <https://www.aerzteblatt.de/10.3238/arztbl.m2021.0118>
18. Gesetz zur Änderung des Infektionsschutzgesetzes und weiterer Gesetze anlässlich der Aufhebung der Feststellung der epidemischen Lage von nationaler Tragweite. [Internet]. Sect. Bundesgesetzblatt Jahrgang 2021 Teil I Nr. 18 2021. Available from: [https://www.bgbl.de/xaver/bgbl/start.xav?startbk=Bundesanzeiger\\_BGBI&jumpTo=bgbl121s0802.pdf#\\_bgbl\\_%2F%2F\\*%5B%40attr\\_id%3D%27bgbl121s0802.pdf%27%5D\\_\\_1650918134192](https://www.bgbl.de/xaver/bgbl/start.xav?startbk=Bundesanzeiger_BGBI&jumpTo=bgbl121s0802.pdf#_bgbl_%2F%2F*%5B%40attr_id%3D%27bgbl121s0802.pdf%27%5D__1650918134192)
19. Gesetz zur Änderung des Infektionsschutzgesetzes und weiterer Gesetze anlässlich der Aufhebung der Feststellung der epidemischen Lage von nationaler Tragweite. [Internet]. Sect. Bundesgesetzblatt Jahrgang 2021 Teil I Nr. 79 2021. Available from: <https://www.bundesgesundheitsministerium.de/ministerium/gesetze-und-verordnungen/guv-20-lp/ifsg-aend.html>
20. Corona-Regelungen: Das haben Bund und Laender veinbart [Internet]. Bundesregierung. [cited 2022 Mar 16]. Available from: <https://www.bundesregierung.de/breg-de/themen/coronavirus/corona-regeln-und-einschrankungen-1734724>
21. Windfuhr JP, Günster C. Impact of the COVID-pandemic on the incidence of tonsil surgery and sore throat in Germany. *Eur Arch Otorhinolaryngol* [Internet]. 2022 Feb 26 [cited 2022 Apr 25]; Available from: <https://link.springer.com/10.1007/s00405-022-07308-8>
22. Kuhlen R, Winklmair C, Schmithausen D, Schick J, Scriba P. The Effects of the COVID-19 Pandemic and Lockdown on Routine Hospital Care for Other Illnesses. *Deutsches Ärzteblatt international* [Internet]. 2020 Jul 6 [cited 2022 Mar 17]; Available from: <https://www.aerzteblatt.de/10.3238/arztbl.2020.0489>
23. Arsenault C, Gage A, Kim MK, Kapoor NR, Akweongo P, Amponsah F, et al. COVID-19 and resilience of healthcare systems in ten countries. *Nat Med* [Internet]. 2022 Mar 14 [cited 2022 Mar 17]; Available from: <https://www.nature.com/articles/s41591-022-01750-1>
24. Schranz M, Ullrich A, Rexroth U, Hamouda O, Schaade L, Diercke M, et al. Die Auswirkungen der COVID-19-Pandemie und assoziierter Public-Health-Maßnahmen auf andere meldepflichtige Infektionskrankheiten in Deutschland (MW 1/2016–32/2020). 2021 Feb 12 [cited 2022 Mar 17]; Available from: <https://edoc.rki.de/handle/176904/7780>
25. Angoulvant F, Ouldali N, Yang DD, Filser M, Gajdos V, Rybak A, et al. Coronavirus Disease 2019 Pandemic: Impact Caused by School Closure and National Lockdown on Pediatric Visits and Admissions for Viral and Nonviral Infections—a Time Series Analysis. *Clinical Infectious Diseases*. 2021 Jan 27;72(2):319–22.
26. Williams TC, Sinha I, Barr IG, Zambon M. Transmission of paediatric respiratory syncytial virus and influenza in the wake of the COVID-19 pandemic. *Eurosurveillance* [Internet]. 2021 Jul 22 [cited 2022 Mar 17];26(29). Available from: <https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2021.26.29.2100186>
27. Erdmann F, Wellbrock M, Trübenbach C, Spix C, Schrappe M, Schüz J, et al. Impact of the COVID-19 pandemic on incidence, time of diagnosis and delivery of healthcare among paediatric oncology patients in Germany in 2020: Evidence from the German Childhood Cancer Registry and a qualitative survey. *The Lancet Regional Health - Europe*. 2021 Oct;9:100188.
28. Grossi U, Gallo G, Ortenzi M, Piccino M, Salimian N, Guerrieri M, et al. Changes in hospital admissions and complications of acute appendicitis during the COVID-19 pandemic: A systematic review and meta-analysis. *Health Sciences Review*. 2022 Mar;100021.
29. Lazzerini M, Barbi E, Apicella A, Marchetti F, Cardinale F, Trobia G. Delayed access or provision of care in Italy resulting from fear of COVID-19. *The Lancet Child & Adolescent Health*. 2020 May;4(5):e10–1.
30. Nimptsch U, Spoden M, Mansky T. Variablendefinition in fallbezogenen Krankenhausabrechnungsdaten – Fallstricke und Lösungsmöglichkeiten. *Gesundheitswesen*. 2020 Mar;82(S 01):S29–40.
31. Blümel M, Spranger A, Achstetter K, Maresso A, Busse R. Germany: Health System Review. *Health Syst Transit*. 2020 Dec;22(6):1–272.
32. van Ginneken Ewout, Siciliani Luigi, Reed Sarah, Eriksen Astrid et al. Addressing backlogs and managing waiting lists during and beyond the COVID-19 pandemic. *Eurohealth*. 2022;28(1):35–40.

## Figures

2019			2020				2021					
Rank	ICD10 Category	# Cases	ICD10 Category	# Cases	Diff 2019	%Change 2019	ICD10 Category	# Cases	Diff 2019	%Change 2019	Diff 2020	%Change 2020
1	S06 Intracranial injury	80631	S06 Intracranial injury	63828	-16803	-21%	S06 Intracranial injury	64321	-16310	-20%	493	1%
2	A09 Other gastroenteritis and colitis of infectious and unspecified origin	46705	J20 Acute bronchitis	27864	-14962	-35%	J20 Acute bronchitis	37005	-5321	-13%	9641	35%
3	J35 Chronic diseases of tonsils and adenoids	46040	J35 Chronic diseases of tonsils and adenoids	26152	-19888	-43%	A09 Other gastroenteritis and colitis of infectious and unspecified origin	30898	-15807	-34%	5709	23%
4	J20 Acute bronchitis	42326	G40 Epilepsy	25854	-3366	-12%	G40 Epilepsy	26739	-2481	-8%	885	3%
5	G40 Epilepsy	29220	A09 Other gastroenteritis and colitis of infectious and unspecified origin	25189	-21526	-46%	S52 Fracture of forearm	22463	-989	-4%	-1172	-5%
6	R10 Abdominal and pelvic pain	28790	S52 Fracture of forearm	23635	233	1%	S00 Superficial injury of head	20365	-2691	-12%	-32	0%
7	J06 Acute upper respiratory infections of multiple and unspecified sites	27275	R10 Abdominal and pelvic pain	20612	-8178	-28%	J06 Acute upper respiratory infections of multiple and unspecified sites	20020	-7255	-27%	2119	12%
8	A08 Viral and other specified intestinal infections	25016	S00 Superficial injury of head	20397	-2659	-12%	R10 Abdominal and pelvic pain	19273	-9517	-33%	-1339	-6%
9	S52 Fracture of forearm	23402	K35 Acute appendicitis	19015	-1429	-7%	J35 Chronic diseases of tonsils and adenoids	17643	-28397	-62%	-8509	-33%
10	S00 Superficial injury of head	23056	J06 Acute upper respiratory infections of multiple and unspecified sites	17901	-9374	-34%	K35 Acute appendicitis	17564	-2880	-14%	-1451	-8%
11	I18 Pneumonia, organism unspecified	21232	K59 Other functional intestinal disorders	14663	-4063	-22%	J12 Acute bronchitis	15569	3323	27%	6020	33%
12	K35 Acute appendicitis	20444	C91 Lymphoid leukaemia	12129	404	3%	K59 Other functional intestinal disorders	14214	-4511	-24%	-448	-3%
13	K59 Other functional intestinal disorders	18725	E10 Type 1 diabetes mellitus	12088	-2106	-15%	E10 Type 1 diabetes mellitus	13015	-1179	-8%	927	8%
14	F10 Mental and behavioural disorders due to use of alcohol	14440	I18 Pneumonia, organism unspecified	11675	-9557	-45%	A08 Viral and other specified intestinal infections	12722	-12294	-49%	5526	77%
15	E10 Type 1 diabetes mellitus	14194	N10 Acute tubulo-interstitial nephritis	10684	-430	-4%	C91 Lymphoid leukaemia	12690	965	8%	561	5%
16	J21 Acute bronchitis	12346	S42 Fracture of shoulder and upper arm	10452	-773	-7%	I18 Pneumonia, organism unspecified	10774	-10458	-49%	-901	-8%
17	R55 Syncope and collapse	12092	J10 Influenza due to identified seasonal influenza virus	10240	1603	19%	N10 Acute tubulo-interstitial nephritis	10484	-630	-6%	-200	-2%
18	R56 Convulsions, not elsewhere classified	11987	R56 Convulsions, not elsewhere classified	9802	-2185	-18%	S42 Fracture of shoulder and upper arm	10410	-815	-7%	-42	0%
19	C91 Lymphoid leukaemia	11725	R78 Adverse effects, not elsewhere classified	9266	-283	-3%	R56 Convulsions, not elsewhere classified	10314	-1673	-14%	512	5%
20	S42 Fracture of shoulder and upper arm	11225	F10 Mental and behavioural disorders due to use of alcohol	9221	-5219	-36%	J12 Acute bronchitis	10136	532	6%	3622	56%
21	N10 Acute tubulo-interstitial nephritis	11134	R55 Syncope and collapse	8758	-3334	-28%	R55 Syncope and collapse	9347	-2745	-23%	589	1%
22	J03 Acute tonsillitis	11068	M21 Other acquired deformities of limbs	8176	-899	-10%	T78 Adverse effects, not elsewhere classified	9211	-338	-4%	-55	-1%
23	J12 Viral pneumonia, not elsewhere classified	9604	S82 Fracture of lower leg, including ankle	7914	-1042	-12%	F10 Mental and behavioural disorders due to use of alcohol	8815	-5625	-39%	-406	-4%
24	T78 Adverse effects, not elsewhere classified	9549	J21 Acute bronchitis	7282	-4964	-41%	M21 Other acquired deformities of limbs	8664	-411	-5%	488	6%
25	M21 Other acquired deformities of limbs	9075	A08 Viral and other specified intestinal infections	7196	-17820	-71%	S82 Fracture of lower leg, including ankle	8454	-502	-6%	540	7%
26	S82 Fracture of lower leg, including ankle	8956	K40 Inguinal hernia	7000	-794	-10%	Z03 Medical observation and evaluation for suspected diseases and conditions, ruled out	7196	-686	-9%	238	3%
27	J10 Influenza due to identified seasonal influenza virus	8637	Z03 Medical observation and evaluation for suspected diseases and conditions, ruled out	6958	-924	-12%	K40 Inguinal hernia	7032	-762	-10%	32	0%
28	Z03 Medical observation and evaluation for suspected diseases and conditions, ruled out	7882	J12 Viral pneumonia, not elsewhere classified	6514	-3090	-32%	R11 Nausea and vomiting	6640	-805	-11%	1217	22%
29	K40 Inguinal hernia	7794	R06 Abnormalities of breathing	6381	-974	-13%	R34 Viral infection of unspecified site	6409	-1103	-15%	1192	23%
30	R34 Viral infection of unspecified site	7512	N39 Other disorders of urinary system	6120	-829	-12%	R06 Abnormalities of breathing	6403	-952	-13%	22	0%

Figure 1

Thirty most frequent discharge diagnoses for hospitalised children in 2019, 2020 and 2021.

Legend: Shading of percent change numbers is based on the following increments from lighter to darker: 0-10%, 11-25%, 26-50%, >50%. The three tracers analysed in detail are highlighted in different colours (blue, yellow, purple); numbers in the table reflect cases for the three-digit categories and thus do not exactly match data in the detailed analysis. Greyed cells denote conditions not appearing in previous/subsequent years.

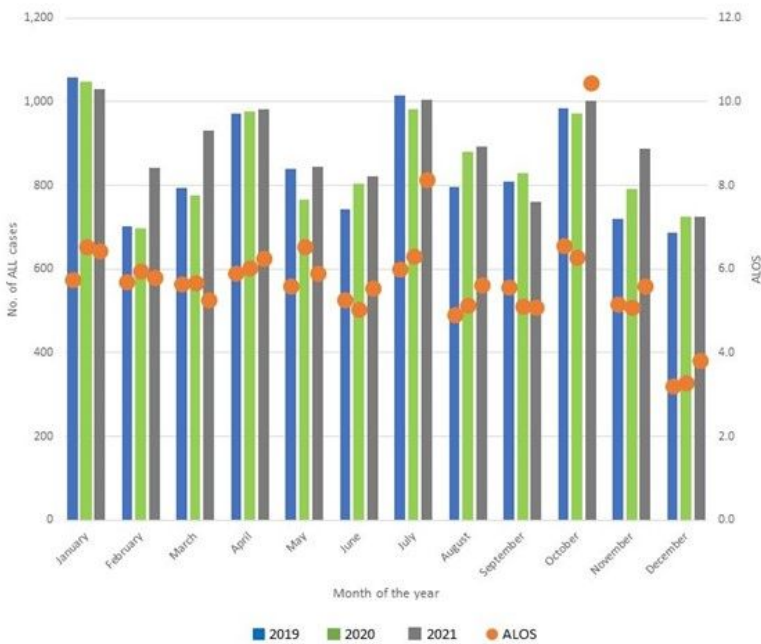
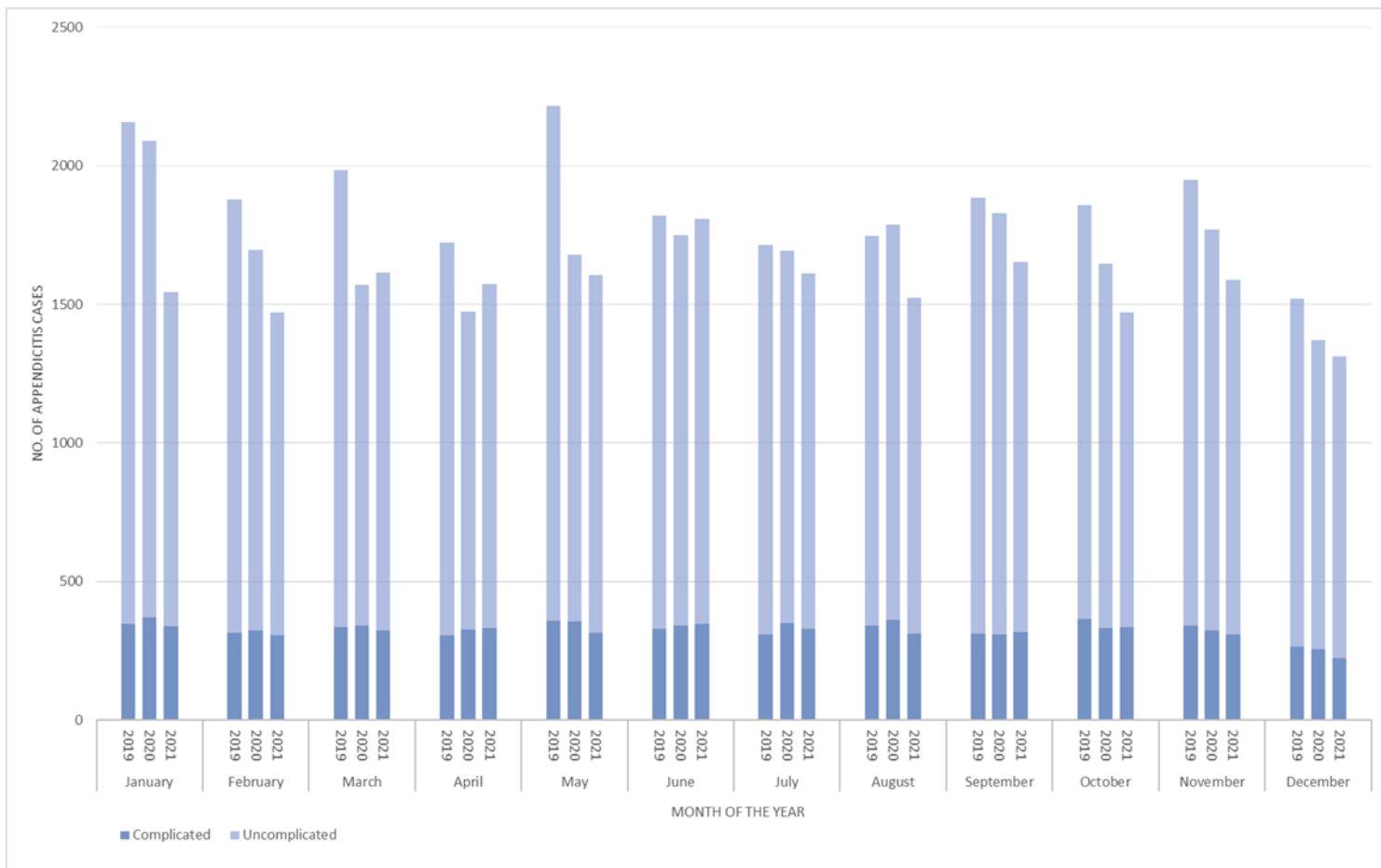


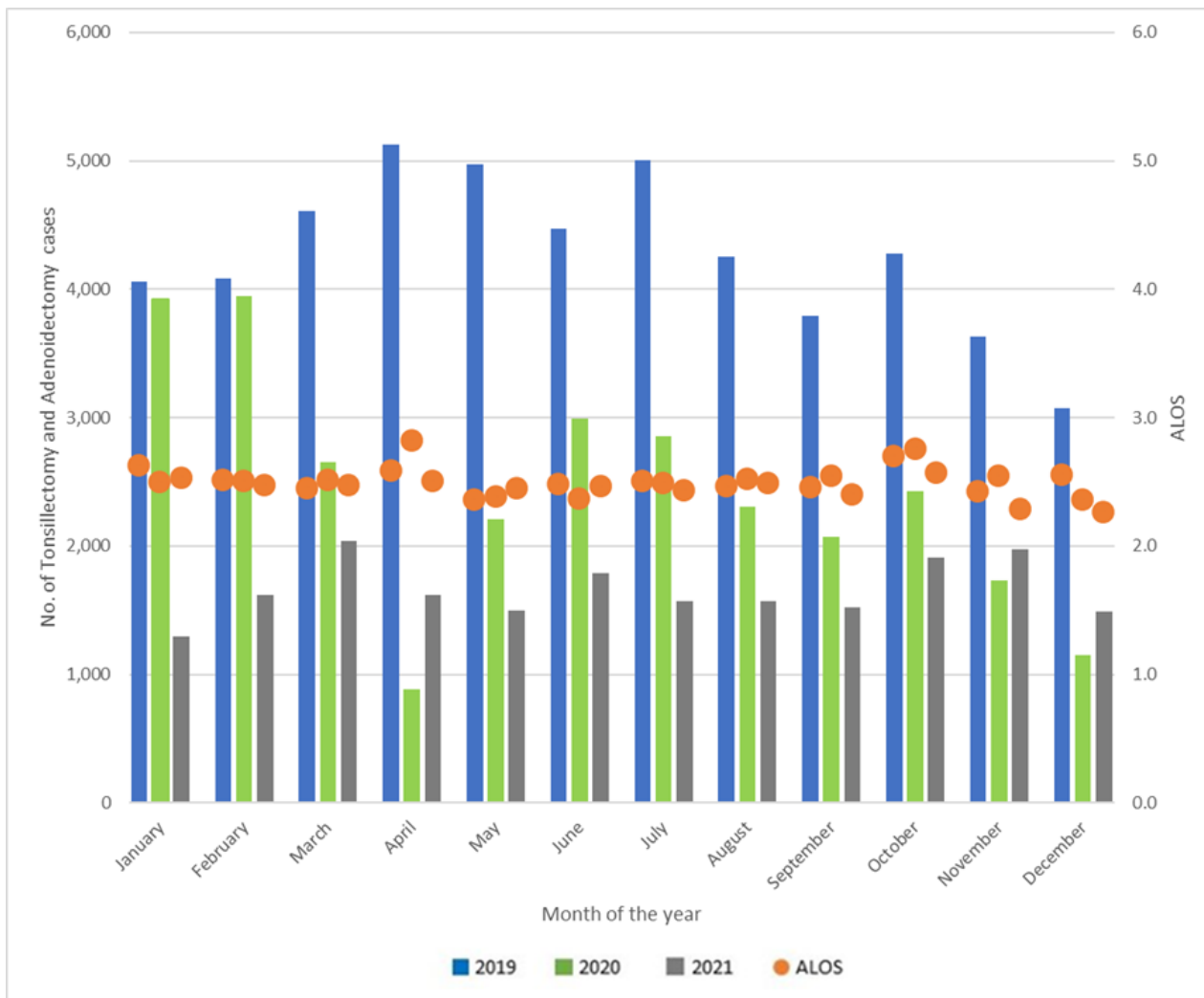
Figure 2

Monthly hospital admissions and ALOS for ALL, January 2019 – December 2021.



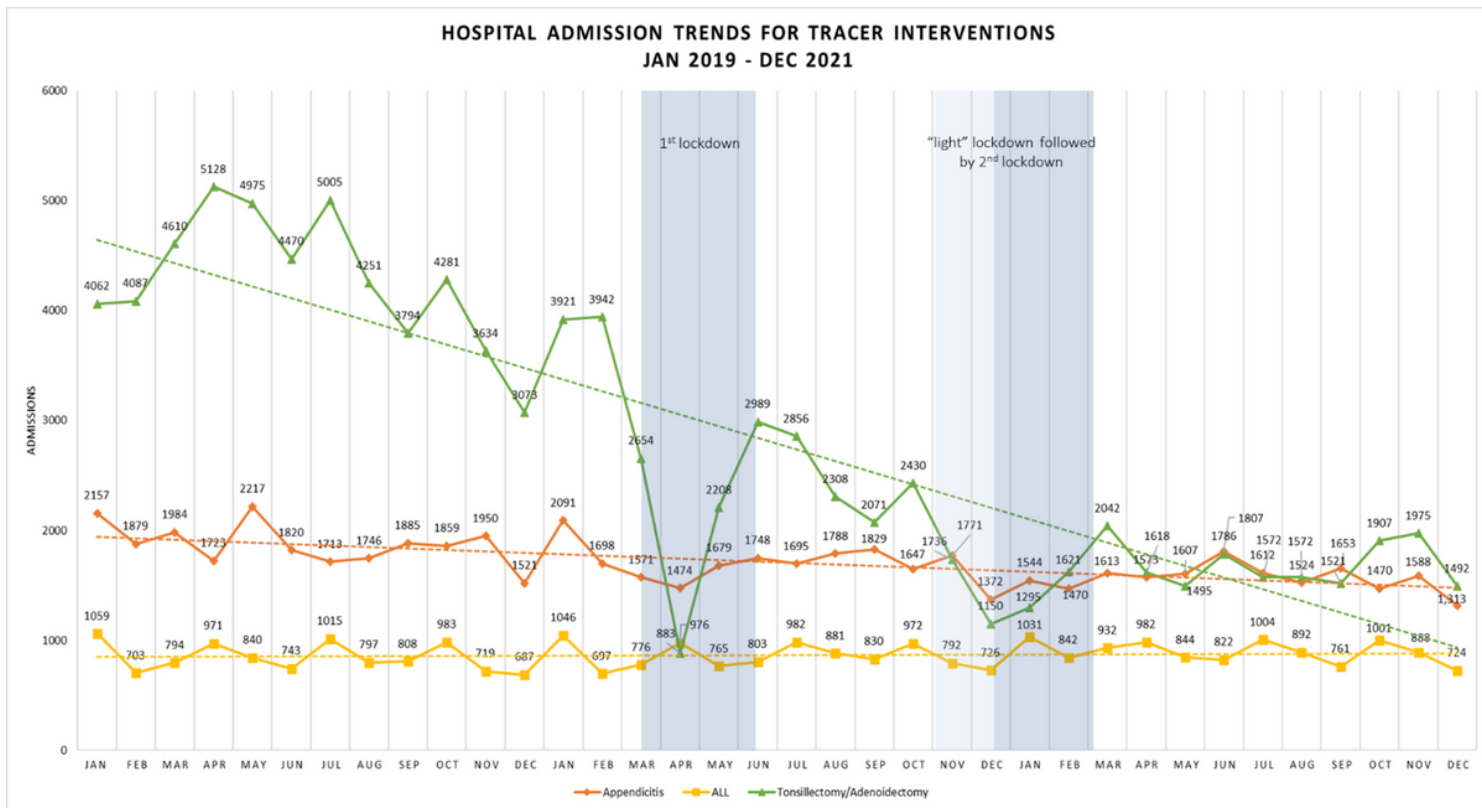
**Figure 3**

Monthly hospital admissions for appendicitis by level of complication, January 2019 - December 2021.



**Figure 4**

Monthly hospital admissions for tonsillectomy/adenoidectomy, January 2019 - December 2021.



**Figure 5**

Monthly case numbers for the tracers between January 2019 and December 2021 in relation to federal lockdown measures in Germany (state level measures at the end of 2021 are not depicted).

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryMaterial.docx](#)