Tampere University

SAARA JÄNTTI

Provision of Acute Care Services During the COVID-19 Pandemic in Finland

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ABSTRACT

The first case of COVID-19 was reported in Finland in January 2020. Thereafter, the number of COVID-19 cases increased rapidly, and the Finnish Government declared a state of Emergency on 16 March 2020, leading to several social restrictions. New peaks in the number of COVID-19 cases were seen during the years 2020 and 2021. During the later waves of the pandemic, regional restrictions were implemented instead of a national lockdown. The number of ED admissions during the pandemic decreased in Finland when compared to previous years. Moreover, a decrease in surgical volumes and major surgical operations was also seen. The main aim of this dissertation was to evaluate the effect of the COVID-19 pandemic on emergency departments and emergency surgical operations, acute care services, in Finland during the first and second waves of the pandemic.

The study was conducted at three large Finnish hospitals: Tampere University Hospital (tertiary level unit), Mikkeli Central Hospital (secondary level unit) and Central Finland Hospital (secondary level unit). Information on the number of emergency department visits and emergency surgeries in adult patients (aged 18 or older) was collected from the patient information systems of the participating hospitals using the International Classification of Diseases 10th Revision (ICD-10) and NOMESCO Classification of Surgical Procedures (NCSP) procedure codes (Finnish version). The data cover the years 2017-2020. In study V, we also included the year 2021.

After the declaration of the national lockdown in spring 2020, the incidence of ED visits due to abdominal pain, back pain and traumatic brain injury decreased. The incidence of abdominal pain visits was lowest in March (IRR 0.83, CI: 0.76 to 0.90) when the lockdown was first declared. Similar findings were seen in the incidence of back pain visits, the lowest being in March (IRR 0.67, CI: 0.57 to 0.78). In traumatic brain injuries, the first decrease in the incidence of ED visits was seen in March (IRR 0.86, CI: 0.73 to 1.02), and the incidence was lowest in April (IRR 0.83, CI: 0.68 to 1.01). When the lockdown ended, the incidence rebounded to its previous level. A second decrease was seen during the second wave of the pandemic in November and December 2020. During the first wave of the pandemic, the incidence of acute abdominal surgeries remained at the same level as in previous

years, but a decrease was seen in December 2020 (IRR 0.84, CI: 0.71-1.00). When comparing the incidence of urgent spine surgeries, the incidence remained at the same level during 2020 as in previous years. However, a decrease in incidence of trauma craniotomies and craniectomies was seen during the first wave of the pandemic in April (IRR 1.90, CI: 0.54 to 6.75). During the second wave of the pandemic, the incidence remained at the same level when compared to the reference years.

The incidence of ICU admissions for all reasons decreased during the lockdown period in 2020 when compared to previous years. In February, the IRR of all-cause ICU admissions was 1.02 (CI: 0.89 to 1.18) and then decreased during the lockdown period to 0.78 (CI: 0.67 to 0.90) in March. After the lockdown, the incidence rebounded to its previous level and remained there until the end of that year. During 2021, the incidence of all-cause ICU admissions was at the same level as in previous years. The number of COVID-positive patients in ICUs remained low during the pandemic. In 2020, 110 COVID-positive patients were treated in ICUs (2.5% of all ICU admissions) and 141 patients (2.9% of all ICU admissions) in 2021.

In conclusion, we found that the incidence of ED visits and ICU admissions decreased when the COVID-19 pandemic and national lockdown began in Finland in 2020. A second decrease in ED visits was also seen during the second wave of the pandemic at the end of that year. When comparing the incidence of emergency surgeries, a decrease was seen in trauma craniotomies and craniectomies, while acute abdominal surgeries and urgent spine surgeries remained at the same level as in previous years.

TIIVISTELMÄ

Suomessa ensimmäinen COVID-19-tapaus raportoitiin tammikuussa 2020. Tämän jälkeen COVID-19-tapausten määrä kasvoi nopeasti ja Suomen hallitus julisti hätätilan 16. maaliskuuta 2020 johtaen useisiin rajoituksiin. Seuraavia pandemia-aaltoja nähtiin vuosina 2020 ja 2021. Pandemian myöhemmissä vaiheissa alueellisia rajoituksia otettiin tarvittaessa käyttöön kansallisen sulkutilan sijaan. COVID-19-pandemian aikana ensiavun käyntimäärät vähenivät Suomessa verrattuna edellisiin vuosiin. Lisäksi päivystyksellisten ja elektiivisten leikkausten määrät vähenivät. Tämän tutkimuksen tarkoituksena on arvioida COVID-19-pandemian vaikutuksia suurten päivystysten käyntimääriin ja päivystyksellisiin leikkauksiin ensimmäisen ja toisen COVID-19 aallon aikana Suomessa.

Tämä tutkimus suoritettiin kolmessa suuressa sairaalassa Suomessa: Tampereen yliopistollinen sairaala, Mikkelin keskussairaala ja Keski-Suomen keskussairaala. Ensiapukäynnit sekä päivystykselliset leikkaukset aikuispotilailla (18-vuotiaat ja sitä vanhemmat) kerättiin osallistuvien sairaaloiden potilastietojärjestelmistä käyttäen ICD-10 diagnoosikoodeja (ICD-10) sekä kirurgisten toimenpiteiden NOMESCO-koodeja (NCSP). Tiedot kerättiin vuosilta 2017–2020. Tutkimuksessa 5 mukaan otettiin myös vuosi 2021.

Sulkutilan julkistamisen jälkeen keväällä 2020 ensiapukäynnit vatsakivun, selkäkivun ja aivovammojen vuoksi vähenivät. Vatsakipukäyntien ilmaantuvuus oli alhaisin maaliskuussa (IRR 0,83, 95 % luottamusväli: 0,76–0,90) sulkutilan alettua Suomessa. Samankaltaisia havaintoja tehtiin selkäkipukäynneistä, joissa ilmaantuvuus oli alhaisin maaliskuussa (IRR 0,67, 95 % luottamusväli: 0,57–0,78). Ensiapukäynnit aivovammojen vuoksi lähtivät laskuun maaliskuussa (IRR 0,86, 95 % luottamusväli: 0,73–1,02) ja alin ilmaantuvuus nähtiin huhtikuussa (IRR 0,83, 95 % luottamusväli: 0,68–1,01). Sulkutilan päätyttyä ilmaantuvuus palautui aiempien vuosien tasolle. Seuraava lasku nähtiin toisen pandemia-aallon aikana marras-joulukuussa 2020. Päivystyksellisten vatsaleikkausten ilmaantuvuus pysyi edellisten vuosien tasolla ensimmäisen pandemia-aallon aikana, mutta laski joulukuussa 2020 toisen tautiaallon aikana (IRR 0,84, 95 % luottamusväli: 0,71–1,00). Päivystyksellisten selkäleikkausten ilmaantuvuudessa ei havaittu muutoksia COVID-19 pandemian aikana vuonna 2020. Traumaattisten kraniotomioiden ja kraniektomioiden ilmaantuvuus väheni

ensimmäisen pandemia-aallon aikana huhtikuussa (IRR 1,90, 95 % luottamusväli: 0,54–6,75). Toisen pandemia-aallon aikana ilmaantuvuus pysyi samalla tasolla aiempiin vuosiin verrattuna.

Tehohoitoa tarvitsevien potilaiden määrä väheni kansallisen sulkutilan aikana vuonna 2020 verrattuna edellisiin vuosiin. Helmikuussa tehohoitoon otettujen potilaiden IRR oli 1,02 (95 % luottamusväli: 0,89–1,18) ja laski sulkutilan aikana ollen 0,78 (95 % luottamusväli: 0,67–0,90) maaliskuussa. Sulkutilan jälkeen ilmaantuvuus palautui edellisvuosien tasolle ja pysyi siellä vuoden loppuun saakka. Vuonna 2021 tehohoitoon otettujen potilaiden ilmaantuvuus pysyi samalla tasolla kuin edellisinä vuosina. COVID-positiivisten potilaiden määrä tehohoidossa pysyi alhaisena koko pandemian ajan. Vuonna 2020 koronainfektion vuoksi tehohoidossa oli 110 potilasta (2,5 % kaikista tehohoitoon otetuista) ja vuonna 2021 koronapotilaiden määrä tehohoidossa oli 141 potilasta (2,9 % kaikista tehohoitoon otetuista).

Yhteenvetona tässä tutkimuksessa havaittiin, että ensiavun käyntimäärät ja tehohoitopotilaiden määrä väheni COVID-19 pandemian ja kansallisen sulkutilan aikana Suomessa vuonna 2020. Uusi lasku ensiavun käyntimäärissä nähtiin vuoden 2020 lopussa toisen pandemia-aallon aikana. Traumaattisten kraniotomioiden ja kraniektomioiden ilmaantuvuus laski COVID-19 pandemian aikana, kun taas päivystyksellisten vatsa- ja selkäleikkausten ilmaantuvuus pysyi samalla tasolla kuin edellisinä vuosina.

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ABBREVIATIONS

CI	Confidence Interval
CoV	Coronavirus
C-TAP COVID-19	Technology Access Pool
ED	Emergency Department
ICD-10	International Classification of Diseases 10th Revision
ICU	Intensive Care Unit
IQR	Interquartile Range
IRR	Incidence Rate Ratio
MERS	Middle East Respiratory Syndrome
NCSP	NOMESCO Classification of Surgical Procedures
NIHR	National Institutes for Health Research
SAH	Subarachnoid Hemorrhage
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
SARS	Severe Acute Respiratory Syndrome
TBI	Traumatic Brain Injury
WHO	World Health Organization

ORIGINAL PUBLICATIONS

This dissertation is based on the following original publications I-V.

Publication I Jäntti Saara, Ponkilainen Ville, Kuitunen Ilari, Hevonkorpi Teemu, Paloneva Juha, Ukkonen Mika, Mattila Ville. Trends in acute abdominal pain visits to EDs and rate of abdominal surgeries during the COVID-19 pandemic in Finland: A retrospective register study. Scand J Surg. 2022 Jan-Mar;111(1):14574969211049055. doi: 10.1177/14574969211049055.

Publication II Jäntti Saara, Ponkilainen Ville, Kuitunen Ilari, Hevonkorpi Teemu, Paloneva Juha, Ukkonen Mika, Mattila Ville. Trends in appendicectomy during the COVID-19 pandemic. Br J Surg. 2021 Jan 27;108(1):e35-e36. doi: 10.1093/bjs/znaa086.

Publication III Jäntti Saara, Ponkilainen Ville, Mäntymäki Heikki, Uimonen Mikko, Kuitunen Ilari, Mattila Ville. Trends in emergency department visits due to back pain and spine surgeries during the COVID-19 pandemic in Finland. Medicine (Baltimore). 2022 Jun 10;101(23):e29496. doi: 10.1097/MD.0000000000029496.

Publication IV Jäntti Saara, Ponkilainen Ville, Kuitunen Ilari, Uimonen Mikko, Luoto Teemu, Mattila Ville. Trends in Emergency Department Visits and Surgeries due to Traumatic Brain Injury During the COVID-19 Pandemic in Finland. SN Compr Clin Med. 2023;5(1):103. doi: 10.1007/s42399-023-01437-9.

Publication V Jäntti Saara, Ponkilainen Ville, Kuitunen Ilari, Uimonen Mikko, Huttunen Tuomas, Mattila Ville. Intensive care unit admissions with and without COVID-19 in Finland from 2017 to 2021: a retrospective register-based study. BMC Anesthesiol. 23, 251 (2023). doi: 10.1186/s12871-023-02207-9

AUTHOR'S CONTRIBUTION

The author designed and performed the data analysis and analyzed the data. The first versions of manuscripts were carried out by the author in all studies.

1 INTRODUCTION

In November 2019, a new type of coronavirus was reported in China. The first patients known to have contracted the virus had visited the Huanan seafood market in Wuhan, where live animal species were sold. The market was subsequently shut down on 1 January 2020. Within a few days, the number of cases with pneumonia of unknown cause increased and patients were transferred to hospital. (*Pneumonia of unknown cause - China. 5 January 2020.*; Zhu et al., 2020) Typical symptoms related to the novel coronavirus were fever, cough and myalgia or fatigue. In severe cases, organ dysfunction, shock or even death were reported. (Wang et al., 2020)

On 13 January, the first case outside China was reported in Thailand. During January and February 2020, COVID-19 spread to all continents and caused thousands of deaths. (*Coronavirus disease 2019 (COVID-19) Situation Report – 41*) The first case of COVID-19 in Finland was reported in a Chinese tourist on 29 January 2020 (Haveri et al., 2020). Thereafter, the number of COVID-19 cases increased rapidly, and the Finnish Government declared a state of emergency on 16 March 2020, leading to the implementation of several social restrictions. (*Government Communications Department, Ministry of Education and Culture, Ministry of Social Affairs and Health. Government, in cooperation with the President of the Republic, declares a state of emergency in Finland over coronavirus outbreak*) Schools were closed, gatherings were limited to 10 persons and travelling was restricted. Furthermore, citizens were encouraged to work from home and all individuals older than 70 years were instructed to stay in quarantine and to minimize social contacts. Restaurants and bars were also closed. (*Koronaepidemian ensimmäinen vaihe Suomessa vuonna 2020*)

During May and June 2020, the number of COVID-19 infections began to decrease, and restrictions in Finland were subsequently lifted. The state of emergency ended on 15 June (*Hallitus päätti luopua valmiuslain käytöstä, Suomi palaa normaalioloihin – pääministeri Marin: "Epidemian uhka ei ole ohi"*). The second wave of the pandemic began in Finland in September 2020. However, instead of declaring a national lockdown, the government implemented regional restrictions and recommendations to prevent the spread of the virus. The epidemiological situation was divided into three levels: base level, acceleration level and spreading level. (*Koronavirustartuntojen* *määrä on kasvanut merkittävästi*, 2020) During the year 2021, several peaks in new cases of COVID-19 were seen. Again, instead of declaring a national lockdown, regional restrictions were implemented, where necessary. However, increasing vaccination coverage in spring 2021 resulted in a decrease in the number of serious cases. (*State of emergency and use of powers under Emergency Powers Act to end on 27 April*)

Emergency departments (ED) play a crucial role in hospitals, as they are usually the first point of contact for patients during disasters, serious incidents and epidemics. Disasters can cause a rapid increase in demand for hospital services and can easily overwhelm the capacity and safety of a hospital and its emergency department. (*Hospital emergency response checklist. An all-hazards tool for hospital administrators and emergency managers.*) During the COVID-19 pandemic in Finland, the number of ED admissions decreased when compared to previous years. (Kuitunen et al., 2020; Tuominen et al., 2020) In addition, a decrease in surgical volumes was also seen. A further decrease occurred in the number of all major surgical operations when compared to the same period in 2019. (Cano-Valderrama et al., 2020; Mattingly et al., 2021) This decrease in ED admissions and surgical volumes may have been the result of numerous changes in people's behaviour during the pandemic and the restrictive measures implemented by the authorities. Individuals may also have been reluctant to seek medical care due to the fear of being exposed to COVID-19. To ensure adequate healthcare resources were available, elective operations were postponed. These changes could have altered the dynamics of emergency care and increased the overall risk for sustaining injuries. This resulted in the launch of Studies I-IV of this dissertation. The main aim of studies I-IV was to evaluate the incidence of ED visits and emergency surgeries during the COVID-19 pandemic by comparing the incidence in 2017-2019 (reference years) to the incidence in 2020 (the study period).

The intensive care unit (ICU) is a special department of a hospital that provides care for patients with severe or potentially life-threatening medical conditions (Adhikari et al., 2010). During the COVID-19 pandemic, ICUs worldwide faced numerous challenges, including an increase in the number of patients with COVID-19 and a large number of patients needing respiratory support. In addition to other patients requiring ICU treatment, the COVID-19 situation put a strain on ICU capacity (Phua et al., 2020). At the start of the pandemic in Finland, critical care resources were elevated to deal with a possible surge in COVID-19 patients requiring ICU treatment. Although the number of ICU admissions due to COVID-19 started to increase in March 2020, the overall number of patients needing ICU treatment during the pandemic remained low in Finland (*Koronatilastot*). As there was a lack of information on the extent of the changes in overall ICU admissions and the length of ICU stays during the COVID-19 pandemic, Study V was specifically planned to analyse the changes in ICU admissions and the length of ICU stays in Finland.

2 REVIEW OF THE LITERATURE

2.1 The COVID-19 pandemic

2.1.1 First reports of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)

Coronaviruses (CoVs) are single-stranded RNA viruses belonging to the family Coronaviridae. In humans, coronaviruses cause respiratory tract infections, varying from mild to fatal. (Cui et al., 2019; Su et al., 2016) The clinical importance of human coronaviruses was recognized during the earlier outbreaks of the SARS (severe acute respiratory syndrome) and MERS (Middle East respiratory syndrome) epidemics (Drosten et al., 2003; Zaki et al., 2012). In 2002, SARS-CoV caused an outbreak of severe acute respiratory disease in China, which became a global infection in 2003. One decade later in 2012, the outbreak of Middle East respiratory disease in Saudi Arabia was caused by MERS-CoV. (Azhar et al., 2019; Ksiazek et al., 2003)

In November 2019, a new type of coronavirus was reported in Wuhan, a city in the Hubei province of China (Zhu et al., 2020). Four cases of pneumonia of unknown aetiology were reported on 29 December. The first cases were linked to the Huanan seafood market, where live animal species were sold. (The-nCo & Li, 2020) Chinese bats were indicated as a reservoir host for the new virus, and most of the first patients had a history of visiting the Huanan seafood market. (Zhou et al., 2020) Thereafter, the local health authority released an epidemiological alert, the seafood market was shut down on 1 January and suspected cases with pneumonia of unknown cause were transferred to hospital. On 3 January 2020, a total of 44 cases had been reported and 11 of these patients were severely ill (Pneumonia of unknown cause - China. 5 January 2020.). On 21 January, a total of 270 cases were reported, and the Chinese government imposed a lockdown in Wuhan city on 23 January, (Zheng, 2020).

Initially, the diagnosis of the unknown infection was based on clinical characteristics, such as ruling out other common pathogens that cause pneumonia and chest imaging. (Huang et al., 2020) However, in January 2020, a novel humaninfecting coronavirus associated with SARS-CoV and MERS-CoV was identified using genome sequencing from bronchoalveolar lavage fluid samples (Lu et al., 2020). Typical symptoms related to the novel coronavirus were fever, cough, and myalgia or fatigue, while some patients also had headache, diarrhoea and dyspnoea. In severe cases, organ dysfunction, shock or even death were reported. (Wang et al., 2020) According to the Chinese Center for Disease Control and Prevention (China CDC), the infection was mild for 80.9% of patients, and the overall case fatality rate was 2.3% during the first months (The Novel Coronavirus Pneumonia Emergency Response Epidemiology, 2020).

2.1.2 Spreading of the COVID-19 pandemic globally in spring 2020

The first case of COVID-19 outside China was reported in Thailand on 13 January in a Chinese woman who lived in Wuhan City. During the following few days, new cases were reported in Japan and the Republic of Korea, all of which had been exported from Wuhan city. (*COVID-19 - Republic of Korea - (ex-China).* ; *Novel Coronavirus (2019-nCoV). SITUATION REPORT-1 21 January 2020.*) On 23 January, the first case in the United States of America was confirmed and a further 581 confirmed cases of novel coronavirus were reported globally (*Novel Coronavirus (2019-nCoV) SITUATION REPORT - 3*). The US President declared a public health emergency in the US on 31 January, and all flights arriving from China were restricted (*THE CORONAVIRUS CRISIS. Trump Declares Coronavirus A Public Health Emergency And Restricts Travel From China.*). By the end of the January 2020, COVID-19 had spread to 19 countries, 9826 cases had been confirmed globally and 213 deaths reported, all of them in China (*Novel Coronavirus(2019-nCoV) Situation Report - 11*).

On 2 February 2020, the first death outside of China was reported in the Philippines. At this point, COVID-19 had spread to 23 countries and the total number of cases globally had risen to 14 557. (*Novel Coronavirus(2019-nCoV) Situation Report - 13*) The majority of patients with COVID-19 were adults, 87% aged between 30 and 79 years and only 1% below the age of 10 years. (Wu & McGoogan, 2020)

The first case in Australia was reported on 25 January (*Novel Coronavirus (2019-nCoV) SITUATION REPORT - 5*). Australia, along with many other individual states, closed its borders to all non-residents in March 2020 in response to the pandemic (*Australia closes borders to stop coronavirus*). By March 2020, the number of confirmed cases globally had risen to 87 137, with 2873 deaths reported in China and 104 deaths in other countries (*Coronavirus disease 2019 (COVID-19) Situation*

Report – 41). The number of cases and deaths continued to increase rapidly, and the total number of deaths from COVID-19 surpassed 100 000 on 12 April. In addition, 1.69 million confirmed cases had been reported globally. (*Coronavirus disease 2019 (COVID-19) Situation Report – 83*)

The first confirmed case of COVID-19 on the African continent was reported on 14 February in Egypt (*Coronavirus disease 2019 (COVID-19) Situation Report – 26*). The only African state to have remained free of any COVID-19 cases, Lesotho, recorded a case in May 2020 (*Remote Lesotho becomes last country in Africa to record COVID-19 case*). At the end of the May 2020, 5.9 million cases had been reported globally and the total number of deaths had risen to 367 166. (*Coronavirus disease (COVID-19). Situation Report – 132.*)

2.1.3 A summary of the COVID-19 pandemic in Europe 2020-2021

The first cases of SARS-CoV-2 in Europe were confirmed in France on 24 January 2020, all of whom had a travel history to Wuhan. Within a few days, new cases were also reported in Finland, Germany and Italy (*Novel Coronavirus(2019-nCoV) Situation Report - 11*). The first death due to COVID-19 was reported on 15 February in a Chinese tourist visiting France (*Coronavirus disease 2019 (COVID-19) Situation Report – 27*). By 25 February 2020, Italy had more than 320 confirmed cases and 10 reported deaths. Most affected areas in the country were placed in lockdown and several restrictions were set to limit social interactions and prevent virus spread. (*Politics goes viral as Italy struggles with outbreak*) In addition to the first three countries reporting COVID-19 cases, the virus had also spread to Israel, the UK, the Russian Federation, Spain, Belgium and Sweden (*Coronavirus disease 2019 (COVID-19) Situation Report – 36*)

WHO declared Europe the epicentre of the COVID-19 pandemic on 13 March 2020. The most affected countries were Italy with more than 15 000 cases followed by Germany, France, and Spain with more than 2000 cases each. All countries in Europe were advised to use strict measures and social distancing to prevent virus spread. In more than ten countries in Europe, borders and schools were closed and gatherings limited. Moreover, several countries declared a state of emergency. (*Coronavirus: Europe now epicentre of the pandemic, says WHO*) As of 20 March 2020, Italy had the largest number of confirmed cases worldwide outside of China. The number of total deaths in Italy had risen to 3407 and the number of COVID-19 cases was 41 035. After Italy, the most affected countries in the European Union were still

Germany, France and Spain, with all reporting more than 10 000 cases. Regarding the number of total deaths, Spain had reported 767 deaths, France 372 deaths but Germany only 20 deaths. (*Coronavirus disease 2019 (COVID-19) Situation Report – 60*) The number of confirmed COVID-19 cases in Europe at the end of March 2020 is shown in Figure 1.

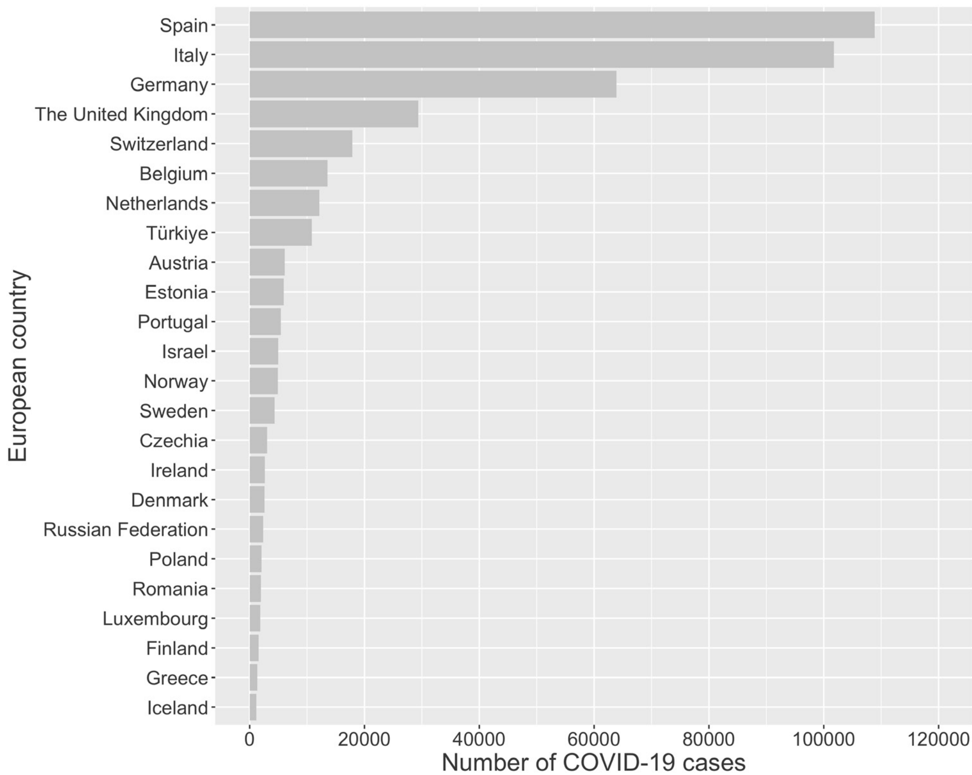

Figure 1. The number of COVID-19 cases in European countries on 31 March 2020. Data: https://covid19.who.int/WHO-COVID-19-global-data.csv, accessed: 28.7.2023

By 19 April, more than 100 000 deaths had been reported in Europe and more than 1 million cases of COVID-19 had been recorded (*Coronavirus disease 2019 (COVID-19) Situation Report – 90*). Many countries started to plan the exit from lockdowns as the number of cases started to decline. In May and June 2020, restaurants were re-opened, social distancing measures were eased and Europe slightly returned to normal. However, local restrictions still remained in force in certain areas where the virus continued to spread. (*How COVID-19 upended life in*

Europe throughout 2020) As of 15 June 2020, the total number of cases in Europe was 2.4 million and the number of deaths was more than 188 000 (*Coronavirus disease (COVID-19). Situation Report – 147*).

In July 2020, a second wave of COVID-19 infections started in Europe. After a decrease in the number of cases during the summer, an increase in infections was seen in the autumn. Starting in August, the number of positive tests increased and the epidemiological situation worsened. An increasing trend in hospitalisations, ICU admissions and deaths was seen. As the number of cases increased, countries were advised to set regional lockdowns, limit gatherings and close public places to reduce the transmission of the virus. (*How COVID-19 upended life in Europe throughout 2020*) (*Rapid Risk Assessment: Increased transmission of COVID-19 in the EU/EEA and the UK – thirteenth update*)

As of 27 November 2020, 17 million cases had been reported in Europe, and the five countries reporting the most cases were Russia, France, Spain, the UK, and Italy. In addition, a total of 394 000 deaths had also been reported in Europe. (*COMMUNICABLE DISEASE THREATS REPORT*) On 21 December, the first COVID-19 vaccine developed by BioNTech and Pfizer was authorised for use in Europe. (*COVID-19 vaccines: authorised*) However, during December, new variants of SARS-CoV-2 started to emerge and the European Centre for Disease Prevention and Control estimated the risk related to the spread of the new variants was high or very high. (*Risk Assessment: Risk related to the spread of new SARS-CoV-2 variants of concern in the EU/EEA – first update*)

Reducing the transmission of COVID-19 during the year 2020 was based on societal restrictions and minimizing contacts. The authorisation of vaccines at the start 2021 offered a new solution for reducing virus spread. However, the emergence of new, more transmissible, variants of SARS-CoV-2 delayed and limited the effectiveness of the vaccination programme. In January 2021, countries in Europe witnessed an increase in the number of COVID-19 cases. Public health interventions and measures were again recommended to control virus transmission and ensure healthcare capacity. (*Risk assessment: SARS-CoV-2 - increased circulation of variants of concern and vaccine rollout in the EU/EEA, 14th update*)

In March 2021, the number of COVID-19 cases had risen to 25 million in Europe and more than 592 000 deaths had occurred. (*COMMUNICABLE DISEASE THREATS REPORT*) The new variants of SARS-CoV-2 continued to spread during the spring of 2021 while COVID-19 vaccine coverage remained at low levels in all European countries. The European Centre for Disease Prevention and Control advised countries to retain measures and restrictions until more information about the new variants was released. (*Emergence of SARS-CoV-2 B.1.617 variants in India and situation in the EU/EEA*)

The epidemiological situation in June 2021 was classified into four categories (low, moderate, high, and very high) based on the risk of being infected with SARS-CoV-2. When the local level of transmission was low, it was possible to ease the restrictions and measures. Travel was allowed for fully vaccinated passengers with proof of a negative test before travel or on arrival and possible quarantine. Monitoring of the epidemiological situation was important for mass gatherings and full vaccination status was mandatory to participate in activities. Hand hygiene and medical masks were strongly recommended in many places. (*Rapid risk assessment: Assessing SARS-CoV-2 circulation, variants of concern, non-pharmaceutical interventions and vaccine rollout in the EU/EEA, 15th update*)

In September 2021, 61.1% of the total population in Europe was fully vaccinated. However, progress with vaccination rollout was unequal across European countries. At this point, the total number of COVID-19 cases in Europe was 37 million and 764 000 deaths had occurred. (*Assessing SARS-CoV-2 circulation, variants of concern, non-pharmaceutical interventions and vaccine rollout in the EU/EEA, 16th update*) After a period of decline in the number of COVID-19 cases in August and September, an increase was again seen in October and November in most European countries driven by the circulation of the Delta variant. A slightly increasing trend was also seen in death rates. In November, at least 70% of the total population in Europe had been vaccinated. Limiting the spread of the pandemic at this point was based on contact tracing, the testing of people with symptoms, COVID-19 quarantine and the testing of travellers. (*Assessment of the current SARS-CoV-2 epidemiological situation in the EU/EEA, projections for the end-of-year festive season and strategies for response, 17th update*)

A new SARS-CoV-2 variant, Omicron, was confirmed in December 2021 and started to spread rapidly in European countries. In most cases, omicron-related cases were asymptomatic or mild. As of the end of 2021, a total of 290 million cases of COVID-19 had been confirmed worldwide, including 5 million deaths. (*COMMUNICABLE DISEASE THREATS REPORT: Week 1, 2-8 January 2022*)

2.1.4 The COVID-19 pandemic in Finland 2020-2021

In Finland, the first case of COVID-19 was reported on 29 January 2020 in a Chinese tourist (Haveri et al., 2020). The first case in a Finnish person was confirmed in a woman arriving from Italy on 26 February (*Suomessa uusi koronavirustartunta –*

työikäinen suomalainen nainen hakeutui hoitoon). At the end of February 2020, five cases of COVID-19 had been confirmed in Finland. During March 2020, the number of COVID-19 infections increased rapidly, and the Finnish Government published recommendations concerning public gatherings, travel and social distancing measures on 12 March. (*Koronaepidemian ensimmäinen vaihe Suomessa vuonna 2020*) Thereafter, a state of emergency was declared by the Government on 16 March 2020, leading to several unprecedented measures such as schools being closed, gatherings being limited to 10 persons, travel being restricted and indoor public premises being closed. Citizens were encouraged to work from home and all persons older than 70 years were instructed to stay in quarantine and minimize social contacts. In addition, restaurants and bars were closed. (*Government Communications Department, Ministry of Education and Culture, Ministry of Social Affairs and Health. Government, in cooperation with the President of the Republic, declares a state of emergency in Finland over coronavirus outbreak*; *Koronaepidemian ensimmäinen vaihe Suomessa vuonna 2020*) The first death due to COVID-19 in Finland was reported on 20 March 2020, and the total number of reported cases on that day was 369 (*Coronavirus disease 2019 (COVID-19) Situation Report – 60*). On 28 March, the border of the Uusimaa municipality was sealed off and all movement to and from the Uusimaa region was restricted until 19 April 2020 (*Restrictions on movement to and from Uusimaa enter into force on 28 March 2020*). The total number of COVID-19 infections in Finland at the end of March 2020 had risen to 1384 and a total of 17 deaths had occurred (*Coronavirus disease 2019 (COVID-19) Situation Report – 72*). A state of emergency remained in force during April 2020 and the number of new COVID-19 cases started to decline. The total number of cases at the end of April 2020 was 4995 and a total of 211 deaths had occurred. (*Coronavirus disease (COVID-19). Situation Report – 102*) The main events during the COVID-19 pandemic in Finland are presented in Figure 2.

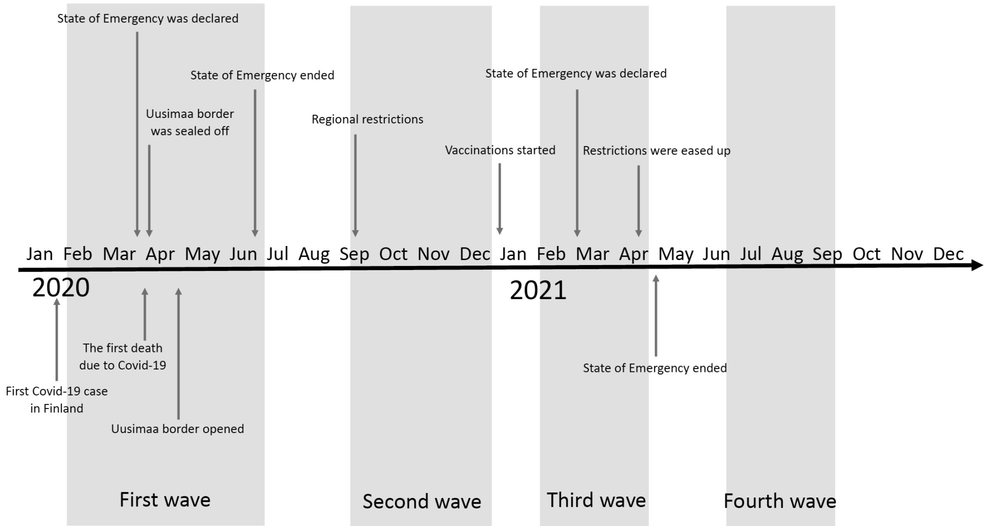

Figure 2. Main events of the COVID-19 pandemic in Finland during 2020 and 2021.

Restrictions were eased in Finland during May-June 2020, and the state of emergency was lifted on 15 June (*Hallitus päätti luopua valmiuslain käytöstä, Suomi palaa normaalioloihin – pääministeri Marin: "Epidemian uhka ei ole ohi"*). Furthermore, indoor and outdoor public events with fewer than 50 attendees were allowed, restaurants and bars were permitted to open with restricted opening hours and the recommendation to avoid visits to hospitals was lifted (*Government agrees to ease restrictions on gatherings, operations of food and beverage service businesses and visits to care institutions and hospitals*). At the end of June 2020, a total of 7209 cases and 328 deaths had been confirmed in Finland (*Coronavirus disease (COVID-19). Situation Report – 162*).

The COVID-19 situation remained stable during the summer of 2020 until a slight increase in the number of new infections was seen in July-August 2020 (*Slight increase in the number of new coronavirus infections*). The second wave of the COVID-19 pandemic began in Finland in September 2020. However, instead of a national lockdown, the Finnish government declared regional restrictions and recommendations to prevent the spread of the virus. The epidemiological situation was divided into three levels: base level, acceleration level and spreading level. (*Koronavirustartuntojen määrä on kasvanut merkittävästi*, 2020) By 30 September 2020, a total of 9992 cases and 344 deaths had been confirmed in Finland (*COVID-19 epidemic appears to continue accelerating — regional preventive measures play a key role in curbing spread of infections*)

During November and December 2020, the COVID-19 situation worsened in Finland. The number and incidence of infections rose sharply in almost all regions. On 3 December 2020, the number of COVID-19 cases in Finland had increased to 25 882 and a total of 408 deaths had occurred. (*Coronavirus situation worsening quickly across Finland*) After being stable during the Christmas period, the number of COVID-19 cases started to again increase during the first months of 2021. The first COVID-19 vaccinations began across the country. The main strategy for preventing virus spread at this point was high testing capacity, quarantine and contact tracing in addition to the fast vaccination of different population groups. (*New COVID-19 cases still reported in large numbers across Finland — contact tracing takes time but is effective*)

The number of COVID-19 cases remained high during February and the Government declared a state of emergency on 1 March 2021. At this point, the total number of COVID-19 cases in Finland was 56 407, and the total number of deaths was 742. (*COVID-19 Weekly Epidemiological Update*) However, instead of a national lockdown, regional restrictions were implemented, where necessary. In addition, travel was restricted and restaurants closed. Over 70% of cases were caused by new coronavirus variants. (*Finland declares a state of emergency*)

During April 2021, the number of new cases started to decrease, and the state of emergency was ended on 27 April. At the same time, vaccination coverage increased and the risk of serious cases of the disease decreased. (*State of emergency and use of powers under Emergency Powers Act to end on 27 April*) In May 2021, more than 90% of people aged 70 or older and more than 50% of people aged 16 or older had received the first dose of the vaccine. The number of new cases remained stable. However, regional differences in the number of COVID-19 cases were seen. (*Development of the epidemic remains stable nationally, but there are regional differences*)

New peaks of COVID-19 cases in Finland occurred during the summer and autumn of 2021. Indeed, COVID-19 was spreading, especially among unvaccinated young adults. The summer spike in cases began when Finnish football fans who had attended the UEFA Euro 2020 tournament, which should have taken place in 2020 but was postponed because of the COVID-19 epidemic, returned home from Russia (Sarvikivi et al., 2022). This resulted in a large number of people being placed in quarantine and the introduction of regional restrictions, where needed. However, the number of fully vaccinated people increased rapidly. (*Number of COVID-19 cases continues to increase— nearly 9,900 people placed in quarantine*) (*Two-dose COVID-19 vaccination rate reaches 76 per cent for people aged 12 or over – burden on specialised healthcare remains substantial*)

2.1.4.1 Societal impacts of COVID-19 in Finland

During the national lockdown in Finland, social distancing and the closure of restaurants, bars, workplaces, public buildings and schools had many consequences for people's lives and well-being. Communication with friends and relatives decreased and people spent more time at home. Undesirable emotions, such as loneliness and anxiety, increased. Behavioural changes in everyday life were seen, for example, in sleeping, dietary and exercise habits. (*Koronaepidemian vaikutukset hyvinvointiin, palveluihin ja talouteen, THL:n viikkoraportti 21/2020*)

The COVID-19 pandemic placed challenges on organisations regarding the work situations and wellbeing at work of employees in many fields. Indeed, traditional working situations changed, and social circumstances were challenged. Anxiety related to COVID-19 was more likely among women and young people under the age of 30. Furthermore, increased psychological distress, increased technostress (defined as a new disease caused by an inability to cope with technology, which results in increased distress (Brod, 1984)) and a lack of social support from the work community caused even higher anxiety. (Savolainen et al., 2021) In addition, the unemployment rate increased during the pandemic as many companies were forced to shut and adapt to the restrictions. The number of earnings-related unemployment allowance applications increased rapidly. (*Näin korona lisäsi työttömyyttä: uusia hakemuksia tulvii työttömyyskassoihin*)

Travel and global passenger traffic were strictly restricted during the COVID-19 pandemic. Constantly changing recommendations and restrictions on external border traffic, a dramatically reduced number of passengers worldwide as well as the closure of hotels and services caused a major crisis in the tourism industry. In Finland, only essential business trips and other essential travel abroad were allowed during the pandemic. The number of air passengers dropped by 56% in March 2020 and by 99% in April 2020 when compared to the same months in 2019. (*Toimialaraportit. Matkailun suuntana kestävä ja turvallinen tulevaisuus.*) When the pandemic began, domestic tourism dropped dramatically in Finland but increased rapidly during summer 2020 when national parks, cottage holidays and caravan trips attracted Finnish tourists. (*Finnish travel sector recovering, but facing staff shortages*) However, the situation in domestic tourism again worsened in autumn 2020 when the schools began and holidays ended. In Lapland, where most of the tourists come from abroad, the situation was especially difficult. (*Survey: Lapland tourism to lose over 60% of winter business*)

The national lockdown, restrictions on travel and the fear of being exposed to the coronavirus resulted in a decrease in peoples' movements and social behaviour. Moreover, opportunities to consume services and buy goods were limited during the lockdown, as restaurants, bars and other social activities were closed. This caused a large change in the consumption behaviour of households. A large decline in spending patterns and consumption was reported and more money was put into savings. GDP in Finland decreased by 2.9% in 2020 compared to the previous year. (*Forecast for the Finnish economy: Economy growing in the shadow of the virus*) However, at the same time, compensatory consumption habits increased rapidly. Restaurants started to cook and provide home delivered meals, grocery shops offered home delivery and an increase in online-shopping was seen. (*Koronan aikana suomalaisille kertyi miljardien säästöt – patoutunut kysyntä vyöryy pian talouteen, ja edessä voi olla kunnon kulutusjuhla*)

The pandemic also had an impact on the economy in Finland. The COVID-19 crisis gave rise to inflation and an increase in energy prices. In addition, an expanded level of debt was seen in Finland's public finances. (*Finnish economy's robust growth being slowed by COVID-19*) The overall consequences of the COVID-19 on Finland's economy were, however, milder than expected. A recovery started rapidly once restrictions were eased and consumption again started to rise. (*COVID-19 -kriisin yhteiskunnalliset vaikutukset Suomessa*)

2.1.4.2 The impact of the COVID-19 pandemic on healthcare in Finland

In Finland, the healthcare system is based on public healthcare services. Healthcare system in Finland covers all citizens and permanent residents and the treatment is provided either in primary health care or specialized healthcare. In addition to public sector, private companies also offer services. Until the beginning of 2023, the municipalities are responsible for organizing healthcare services in Finland. After that, the responsibility will change to wellbeing services. (*Healthcare and social welfare system and responsibilities*; *How does Finland's health sector contribute to the economy?*) The COVID-19 pandemic impacted healthcare in Finland in several ways. During the first months of the pandemic in 2020, changes in healthcare provision were already being seen in the form of the cancellation of non-urgent operations and appointments, the re-organisation of healthcare workers and increased waiting times. (*Koronaepidemialla kauaskantoiset vaikutukset ihmisten hyvinvointiin ja sosiaali- ja terveyspalveluihin*) However, the influence of the COVID-19 pandemic was felt differently by those healthcare workers working in areas most affected by the pandemic and those colleagues working in less impacted areas. For example, those professionals working on the frontline in ICU units and infection departments were heavily affected by the COVID-19 pandemic, whereas those working in less impacted areas had an even lower working load than usual. (Laukkala et al., 2020)

As the pandemic placed high demands and an increased working load on healthcare capacity, frontline healthcare professionals were especially prone to psychological distress and problems functioning and working. Indeed, the fear of being exposed to COVID-19 while providing care to patients with severe or live-threatening conditions caused insecurity and emotional stress for many. (*Korona on ajanut hoitajat jaksamisen äärirajoille, päivätyö muuttui osalla kolmivuorotyöksi: "Alanvaihtohalukkuus on lisääntynyt"*) Furthermore, healthcare professionals were relocated to new departments, and they had to manage with patients they may have had no experience of taking care of. Additionally, staff quarantine and transmission among healthcare workers limited the supply of staff in critical care. The lack of nurses and other healthcare professionals resulted in an increased work load for those who were able to work. As a result, many nurses, especially young nurses, considered leaving the profession. (*Jorvin teho-osaston "hoitaja R" kertoo valtavista paineista sairaalassa ja vetoaa suomalaisiin – "Pidä huoli. Niin mäkin teen. <3"*; *Teho-osaston hoitaja Minna ei tiedä, miten pitkään motivaatio enää pysyy – näin paljon hoitajat tienaavat*)

During the COVID-19 crisis, intensive care units were under strain throughout Finland, but the most affected hospital was Helsinki University Hospital. When the pandemic started, intensive care resources were expanded, and elective surgeries were cancelled to further secure intensive care capacity. (*Tehohoidon ylilääkäriltä pysäyttävä kuvaus: "4–5 leikkaussalia suljetaan, jotta yksi covid-potilas voidaan hoitaa – 15–20 leikkausta päivässä jää tekemättä"*) In addition, staff were relocated, and extra ICU beds, medicines and equipment were allocated. The peak prevalence in ICU admissions was seen in week 15 (6 to 12 April) when there were 83 intensive care patients at the same time. Mortality of COVID-19 patients in intensive care was low, only 15%. The number of patients admitted to ICU in Finland started to decrease after April and remained low during subsequent waves of the pandemic. (Kattainen et al., 2021)

At the beginning of the COVID-19 pandemic, elective operations were cancelled or postponed to secure healthcare capacity. The waiting times for elective surgery first decreased in March and April when the lockdown started in Finland. For example, waiting times were 10% to 16% shorter when compared to the reference years. After May 2020, waiting times for elective surgery increased and remained longer until November. (Uimonen et al., 2021) Waiting times were especially long in children, whereas the oldest adults had shortened waiting times (Uimonen, Kuitunen, et al., 2022). In April 2020, the number of elective operations decreased by 48% when compared to the previous year. The number of emergency operations decreased by 8%. (Salla Kattainen)

In Finland, a lockdown was in force in the Uusimaa region from 27 March to 15 April 2020 and all non-essential traffic was restricted to and from the region. During the lockdown, traffic volumes on the major roads were reported to have decreased by one third in Finland. However, despite the decrease in traffic volumes, the number of multiple trauma patients remained unchanged during the first wave of the pandemic. Moreover, the incidence of severely injured patients during March to May 2020 was similar to that in previous years. (Riuttanen et al., 2021)

2.1.5 World Health Organization's (WHO) initial response to the COVID-19 pandemic

The Chinese authorities alerted the WHO China Country Office to patients with atypical pneumonia on 31 December 2019. At first, the virus was named '2019 novel coronavirus' (2019-nCoV) until WHO announced the official names 'severe acute respiratory syndrome coronavirus 2' (SARS-CoV-2) and COVID-19 in February 2020 (*Naming the coronavirus disease and the virus that causes it*). Since the reporting of the first cases in 2019, WHO developed a protocol for the investigation of the early cases to inform of the development, manage cases and reduce virus spread. The main objective was to understand the key clinical, virological, and epidemiological characteristics of novel coronavirus infection. In addition, recommendations concerning the transmission of the virus from animals to humans were released. The main strategic objectives of WHO was to limit human-to-human transmission of the virus through a combination of public health measures and control in healthcare settings, guidance for travellers, raising awareness in the population and risk communication. (*Novel Coronavirus (2019-nCoV) Situation Report - 12.*) On 30 January 2020, WHO declared the coronavirus outbreak a public health emergency of international concern. However, at the time, WHO did not recommend any travel restrictions. ("Note from the editors: World Health Organization declares novel coronavirus (2019-nCoV) sixth public health emergency of international concern," 2020)

At the end of February 2020, WHO published updated recommendations for international travellers that included general recommendations for hygiene, keeping a safe distance and self-monitoring for symptoms, especially for those travellers returning from affected areas (*Updated WHO recommendations for international traffic in relation to COVID-19 outbreak*). In addition, guidance for COVID-19 patient management was released, including home care guidance for those patients treated in isolation at home and clinical care guidance for hospitalised patients (*Coronavirus disease 2019 (COVID-19) Situation Report – 41*).

On 11 March 2020, WHO declared the COVID-19 outbreak a global pandemic (Cucinotta & Vanelli, 2020). Thereafter, public health and social measures for the pandemic were released by WHO in March 2020. In addition to these measures, technical guidance publications for schools, workplaces and healthcare workers were published. The main objective was to reduce virus spread by individual and environmental measures, identifying and isolating cases, contact tracing, quarantine and safe distancing measures (mass gatherings, international travel, treatments and vaccines). While vaccines and medications were not yet available, the aim was to reduce the number of infections, prevent further international spread and to minimize the social and economic impact of the COVID-19 pandemic. (*Coronavirus disease 2019 (COVID-19) Situation Report – 72*; *Country & Technical Guidance - Coronavirus disease (COVID-19)*)

In May 2020, the COVID-19 Technology Access Pool (C-TAP) was launched to provide a global platform for sharing knowledge and data and to facilitate faster access to COVID-19 vaccines, tests, treatments and other health products for the people of all countries (*WHO COVID-19 Technology Access Pool*). However, the high expectations of C-TAP were not realised mostly because of the pharmaceutical industry and weak collaboration between private actors and governments (*C-TAP HAS NOT (YET) LIVED UP TO HIGH EXPECTATIONS*).

2.1.6 Vaccinations against coronavirus disease

In response to the COVID-19 pandemic, several vaccine candidates with different platforms were developed and tested in clinical trials during 2020 (Li et al., 2020).

In August 2020, the first reports of the phase I/II trials of two COVID-19 vaccine candidates (BNT162b1 and BNT162b2) using the RNA platform were published (Mulligan et al., 2020; Sahin et al., 2020). Subsequent trials supported the selection of BNT162b2 for later analysis and efficacy evaluation (Walsh et al., 2020). In December 2020, a two-dose regimen of BNT162b2 was proven to confer 95%

protection against COVID-19 (Polack et al., 2020). This vaccine candidate was funded by BioNTech and Pfizer.

The efficacy and safety of a similar vaccine platform, the mRNA vaccine, was demonstrated in a phase I clinical trial published in November 2020 (Jackson et al., 2020). In later trials, the mRNA-1273 vaccine showed 94.1% efficacy against COVID-19 disease, including severe disease. (Baden et al., 2021) These trials were funded by the American Biomedical Advanced Research and Development Authority and the National Institute of Allergy and Infectious Diseases.

The ChAdOx1 vaccine consisting of a chimpanzee adenoviral vector and containing the SARS-CoV-2 surface glycoprotein antigen gene showed efficacy and an acceptable safety profile in phase I and II trials (Folegatti et al., 2020; Ramasamy et al., 2021). In later trials, published in January 2021, ChAdOx1 vaccine was evaluated to have an efficacy of 70.4% after two doses (Voysey et al., 2021). This vaccine was funded by the UK Research and Innovation, National Institutes for Health Research (NIHR), the Coalition for Epidemic Preparedness Innovations, the Bill & Melinda Gates Foundation, the Lemann Foundation, Rede D'Or, the Brava and Telles Foundation, the NIHR Oxford Biomedical Research Centre, the Thames Valley and South Midland's NIHR Clinical Research Network and AstraZeneca.

The first authorized vaccines for emergency supply in the United Kingdom, the European Union and the United States were RNA vaccines called Comirnaty (BNT162b2) and Moderna/Spikevax (mRNA-1273). These vaccines and the adenovirus vaccine Vaxzevria (ChAdOx1) were approved in December 2020 and January 2021, respectively. (*Information for Healthcare Prodessionals on Pfizer/BioNTech COVID-19 vacine.*; Oliver et al., 2020; *Questions and Answers: COVID-19 vaccination in the EU.*). Two other vaccines named Jcovden/Janssen and Nuvaxovid were authorized later in 2021 (*COVID-19 vaccines: authorised*).

Starting at the end of 2020, vaccinations began according to different allocation plans, which differed by country. WHO recommended that all countries first vaccinate healthcare workers and those at high risk of developing severe disease or death, including older adults and those with chronic health conditions (*COVID-19 Weekly Epidemiological Update*). The main objective was to reduce mortality, hospitalisations and severe morbidity and to minimize the impact on healthcare systems. The next step in the vaccination strategy was to vaccinate all adults and adolescents (*Strategy to Achieve Global Covid-19 Vaccination by mid-2022*). At the end of 2021, a number of vaccines were also authorized for children (*Interim statement on COVID-19 vaccination for children and adolescents*).

The vaccines developed to fight SARS-CoV-2 showed high protection against COVID-19 related hospitalisations and the critical outcomes of the disease (Zheng et al., 2022).

2.2 Intensive care units during pandemics

2.2.1 Impact of previous pandemic outbreaks on intensive care units

The intensive care unit is a special department of a hospital that provides care for patients with severe or potentially life-threatening medical conditions (Adhikari et al., 2010). When planning a hospital's surge capacity, intensive care units are a key component, and hospitals should be able to increase ICU beds and monitors to the maximal required extent. Staff in ICUs should be properly trained and guidelines to deal with a crisis should be developed and clearly identified. (Sprung et al., 2010)

The seasonal influenza pandemic is related to an increased number of ICU admissions globally. Occurring intermittently, an influenza pandemic sets demands on ICU capacity and preparedness. During an influenza pandemic, the number of severe influenza cases in ICUs typically increases and then drops between pandemic seasons. The risk of a severe outcome and ICU admission in influenza patients is elevated among those individuals with underlying medical conditions, high age or lack of vaccination coverage. (Bonmarin et al., 2015; Menon et al., 2005)

A novel influenza A named H1N1 was first reported in Mexico in March 2009 (Dawood et al., 2009). It spread rapidly and caused a global influenza pandemic in the winter season of 2009-2010. H1N1 caused a substantial increase in demand for ICU services (Schaffer et al., 2012; Webb et al., 2009). In particular, young adults were affected by the virus, which was different than in normal seasonal influenza. (Teke et al., 2011)

In 2002-2003, the global outbreak of SARS caused pressure on healthcare systems and ICUs worldwide (Ksiazek et al., 2003). During the SARS pandemic, several healthcare units and intensive care units were closed, elective appointments and surgeries were cancelled, and healthcare systems faced numerous challenges. (Booth & Stewart, 2005; Lapinsky & Hawryluck, 2003) However, the SARS pandemic did not affect Finland.

2.2.2 Intensive care units during the COVID-19 pandemic

During the COVID-19 pandemic, ICUs around the world faced many challenges. These challenges included an increase in the number of COVID-19 patients and a high number of patients needing respiratory support. At the same time, other patients also required ICU treatment, putting a strain on ICU capacity (Phua et al., 2020). To prepare for a possible surge in COVID-19 patients, critical care resources were expanded in Finland at the start of the pandemic. The number of ICU admissions due to COVID-19 began to rise in March 2020 with a peak prevalence of 1.5 per 100 000 in April 2020. The largest number of patients needing ICU treatment in April of that year was 83 patients. During later waves of the pandemic, prevalence remained below 0.90 per 100 000 (50 patients) (*Koronatilastot*).

During the first wave of the COVID-19 pandemic, an initial reduction in the volume of surgical operations was seen. The reduction was especially seen in elective surgery but also in emergency surgical procedures. Elective operations were cancelled to secure the sufficiency of ICU beds for the emerging number of anticipated COVID patients. (Rausei et al., 2020) (Carrara et al., 2021)

In Finland, the number of severely injured patients did not markedly change during the first wave of the COVID-19 pandemic and the period of social restrictions. Indeed, a decline in traffic volumes did not lead to a reduction in the number of traffic-related severe accidents. Since the treatment of severely injured patients often requires intensive care and major resources, similar amounts of resources were needed to treat severely injured patients during the pandemic as were needed in previous years. (Riuttanen et al., 2021)

2.3 Emergency department visits and emergency surgeries during pandemics

2.3.1 Impact of previous pandemic outbreaks

Emergency departments (ED) play a crucial role in hospitals in many situations and in many types of disasters. EDs are usually the first point of contact the hospital has with patients during natural disasters, mass incidents and epidemics. As disasters can cause a rapid increase in the demand for hospital services, they can easily overwhelm the capacity and safety of the hospital. (*Hospital emergency response checklist. An all-hazards tool for hospital administrators and emergency managers.*)

Both seasonal and pandemic influenza have a remarkable effect on ED visits. During the H1N1 influenza pandemic in 2009, the number of ED visits was elevated when compared to the average annual rate for seasonal influenza. Usually, the number of ED visits increases in weeks 52 and 1. However, during the Christmas and New Year period in 2009, the number of ED visits increased to 1.3 times the usual levels at the same time of year. Interestingly, the proportion of ED visits resulting in admission to hospital was lower during the 2009 influenza pandemic than for seasonal influenza. According to a previous study, during the H1N1 pandemic, citizens were not advised to stay at home or refrain from visiting the ED unless absolutely necessary. As a result, the increased number of ED visits can be attributed primarily to a lower threshold for seeking medical care compared to normal seasonal influenza. This lower threshold may have been driven by the fear of severe illness associated with H1N1 influenza. (Schanzer & Schwartz, 2013) Admissions to EDs due to H1N1 influenza increased, especially among children. (Jain et al., 2009; Peters et al., 2016)

The outbreak of SARS occurred during 2002 and 2004. During the epidemic, the willingness to visit ED units, especially among those patients with non-severe or non-acute disease, decreased dramatically, leading to a lower number of ED admissions. The reduction in ED visits in Taiwan ranged from 40% to 52% when compared to pre-epidemic numbers. The most likely reason for this reduction was the fear of contracting the disease when visiting the hospital and changes in the behaviour of individuals during the pandemic. (Chen et al., 2004; Huang et al., 2006)

2.3.2 Impact of the COVID-19 pandemic

During the early period of the COVID-19 pandemic in 2019-2020, the total number of ED visits decreased in all age groups in the United States. The decline ranged from 31% to 45%, depending on the source and the region of the country studied. However, an increase in ED visits associated with pneumonia, difficulty in breathing or lower respiratory disease was seen. (Boserup et al., 2020; Hartnett et al., 2020)

In Finland, it was commonly thought that the fear of contracting COVID-19 resulted in decreased rates of emergency department visits during the first wave of COVID-19. Moreover, the daily number of ED admissions also decreased after the announcement of a national lockdown in Finland when compared with the same period in 2019. (Kuitunen et al., 2020; Tuominen et al., 2020).

During the COVID-19 pandemic, the recommendations to postpone or cancel elective and non-essential surgical operations caused a decrease in surgical procedure volume. Indeed, the number of all major surgical procedures decreased when compared to the same period in 2019. (Cano-Valderrama et al., 2020; Mattingly et al., 2021)

2.4 Emergency department visits due to acute abdominal pain and abdominal surgeries during pandemics

Acute abdominal pain is one of the most frequent causes of visits to the emergency department, and from 5% to 10% of all emergency department visits are due to acute abdominal pain (Cervellin et al., 2016; Fagerström et al., 2017; Hastings & Powers, 2011; Powers & Guertler, 1995). Nonspecific abdominal pain, acute appendicitis and biliary diseases are the most frequent causes of acute abdominal pain in the emergency department and nonspecific abdominal pain is the cause of 31% to 37% of all abdominal pain visits (Cervellin et al., 2016; Fagerström et al., 2017). There is, however, a lack of literature regarding the impact of previous pandemic outbreaks on emergency department visits due to acute abdominal pain and abdominal surgeries.

2.4.1 Impact of the COVID-19 pandemic

The number of emergency department visits due to acute abdominal pain decreased in the United States during the first months of the COVID-19 pandemic (Hartnett et al., 2020). Similarly, the rate of acute appendicitis cases decreased during the first wave of the COVID-19 pandemic in Israel, yet prominent changes in the rate of complicated appendicitis were not observed (Tankel et al., 2020).

Within abdominal surgeries, a clear reduction of patients admitted into emergency surgery was seen during the first months of the pandemic. In three tertiary care hospitals in Spain, the volume of acute care surgery decreased to half of the activity in the reference period. Moreover, changes in the medical conditions requiring surgery were also observed. For example, the rate of complicated appendicitis increased notably during the pandemic period (7.95% vs 42.5%).

Furthermore, a delay in the time between the onset of symptoms and the patients' admission to the ED was also observed, which may have resulted in more complicated diseases. This delay may have occurred because of the fear of being infected with COVID-19 in emergency departments and the changes in lifestyle habits of individuals during the pandemic period. (Cano-Valderrama et al., 2020; Tebala et al., 2022)

2.5 Emergency department visits due to back pain and spine surgeries during pandemics

Low back pain is a common health problem and one of the major causes of emergency department visits in the adult population. It causes a substantial personal, financial and community burden globally. The global prevalence of low back pain is estimated to be 12%, and 1-month prevalence is estimated to be 23%. Low back pain is most prevalent in individuals aged between 40 and 80 and among females. (Deyo et al., 2006; Hoy et al., 2012; Mullins et al., 2021) In Finland, the 1-month prevalence of low back pain is considered to be 17% in men and 16% in women (Heliövaara et al., 1989). However, the impacts of previous pandemic outbreaks on emergency visits due to back pain and spine surgeries have not yet been studied.

2.5.1 Impact of the COVID-19 pandemic

According to the literature, the intensity and prevalence of low back pain increased during the COVID-19 crisis when compared to the pre-pandemic period. The lockdown and isolation caused increased intensity of low back pain among patients suffering from chronic back pain. This may have been because the rate of physical activity decreased and the length of time sitting increased during the lockdown, as well as other changes in lifestyle that occurred during the lockdown. (Hoy et al., 2012) During the first wave of the COVID-19 pandemic, however, a considerable reduction in the number of emergency department visits due to lower back pain was reported. (Borsa et al., 2020; Cofano et al., 2020)

In addition, the volume of spine surgeries also decreased during the COVID-19 pandemic. This decrease was especially seen in non-trauma related elective operations, which was expected due to the reduction in the volume of elective operations performed during the pandemic. However, the number of trauma-related spinal operations remained unchanged. (Meyer et al., 2020; Patel et al., 2020). An earlier study in the UK revealed that the number of surgical decompressions performed for cauda equina syndrome did not decrease during the first wave of the COVID-19 pandemic. Indeed, patients with critical conditions were still admitted to the ED and treated appropriately during the restrictions. (Jayakumar, Ferguson, et al., 2020)

2.6 Emergency department visits due to traumatic brain injury and acute neurosurgeries during pandemics

Traumatic brain injury (TBI) is a common reason for visiting the emergency department. It is one of the most severe types of injury since many of the survivors suffer long-term implications and case fatality is high. (Marin et al., 2014) In Europe, the mean incidence of TBI is reported to be 258 per 100 000 population per year (Brazinova et al., 2021). In Finland, the incidence of TBI-related hospital admission in the adult population is evaluated to be 69 per 100 000 persons (Posti et al., 2022). In addition, the incidence of TBI-related craniotomies is decreasing in all procedure subgroups. In Finland, a 33% decrease was reported between 1997 and 2018. (Nevalainen et al., 2022) There is, however, a lack of previous studies concerning the impacts of previous pandemic outbreaks on emergency department visits due to TBI and acute neurosurgeries.

2.6.1 Impact of the COVID-19 pandemic

During the first wave of the COVID-19 pandemic, some studies found a decrease in the number of emergency referrals due to TBI (Figueroa et al., 2021; Horan et al., 2021; Karthigeyan et al., 2021; Rault et al., 2021; Santing et al., 2020). However, a previous study from Finland reported that the number of TBI and SAH patients remained the same during the first wave of the pandemic (Luostarinen et al., 2020).

In the field of neurosurgery, the number of operations decreased worldwide during the first wave of the COVID-19 pandemic. A reduction was especially seen in elective practises, which was expected due to the cancellation of elective operations during the pandemic. In addition, a decrease in road traffic volumes during the travel restrictions and recommendations to work from home may also have led to a decrease in the number of traumatic brain injuries. One explanation might also be that changes in alcohol sales during the pandemic resulted in a decrease in alcohol-related falls and violence. (ElGhamry et al., 2021; Jayakumar, Kennion, et al., 2020; Patel et al., 2020; Sharma et al., 2021).

3 AIMS OF THE STUDY

The main aim of this study was to evaluate the consequences of the nationwide COVID-19 pandemic on Emergency Department visits and emergency surgeries in Finland.

The specific aims of studies I-V were as follows:

1. To assess the impact of the COVID-19 pandemic on acute abdominal pain visits and abdominal surgeries.
2. To assess acute appendicitis presentations and appendicectomies during the COVID-19 pandemic.
3. To assess trends in back pain visits and spine surgeries during the pandemic.
4. To assess the impact of the COVID-19 pandemic on emergency department visits due to traumatic brain injury.
5. To assess trends in intensive care unit treatment periods before and during the COVID-19 pandemic.

4 METHODS AND PATIENTS

4.1 Study design

This retrospective register study was conducted at three large Finnish hospitals. Tampere University Hospital (tertiary level unit), Mikkeli Central Hospital (secondary level) and Central Finland Hospital (secondary level unit) cover a catchment area of approximately 700 000 adult inhabitants. The information and number of emergency department visits and emergency surgeries in adult patients (aged 18 or older) was collected from the patient information systems of the participating hospitals using the International Classification of Diseases 10th Revision (ICD-10) (*World Health Organization. ICD-10 Classifications*) diagnostic codes and NOMESCO Classification of Surgical Procedures (NCSP) (*NOMESCO, N. (2011). NOMESCO Classification of Surgical Procedures (NCSP), version 1.16.*) procedure codes (Finnish version).

4.2 Patients

4.2.1 Study I

In study I, data on emergency department visits for abdominal pain in adult patients were collected from patient information systems using the ICD-10 (*World Health Organization. ICD-10 Classifications*) diagnostic codes for abdominal pain. The included groups, according to diagnostic codes, are presented in Table 1.

Table 1. Emergency Department visits due to abdominal pain according to diagnostic (ICD-10) codes.

ICD-10 code	Explanation
K223	Perforation of oesophagus
K25*	Gastric ulcer
K26*	Duodenal ulcer
K27*	Peptic ulcer
K35*	Acute appendicitis
K38*	Other disease of appendix
K40*	Inguinal hernia
K55*	Vascular disorders of intestine
K56*	Paralytic ileus and intestinal obstruction without hernia
K57*	Diverticular disease
K58*	Irritable bowel syndrome
K59*	Other functional disorders
K61*	Abscess
K63*	Other disease of intestine
K65*	Peritonitis
K80*	Cholelithiasis
K81*	Cholecystitis
K85*	Acute pancreatitis
K86*	Other disease of pancreas
R10*	Abdominal and pelvic pain

The data cover the years 2017 to 2019 (reference years) and 2020 (study period), and all patients admitted to the study hospitals with abdominal pain during these periods were included. The most common diagnostic groups were appendicitis, cholelithiasis, hernia, nonspecific abdominal pain and pancreatitis.

In the present study, the data on acute abdominal surgeries were retrospectively collected from the hospitals' electronic medical record systems using NOMESCO Classification of Surgical Procedures (NCSP) (*NOMESCO, N. (2011). NOMESCO Classification of Surgical Procedures (NCSP), version 1.16.*) procedure codes (Finnish version). The procedure codes starting with J (digestive system and spleen) were collected for the study period and the reference years, with the most common codes being JEA01 (laparoscopic appendectomy), JAH00 (laparotomy) and JKA21 (laparoscopic cholecystectomy). The data included patients' age, gender, operation date, in-hospital delay before operation and a specific diagnostic and procedure code for each patient.

4.2.2 Study II

In study II, data on emergency department visits due to abdominal pain were collected from the hospital records using the most common ICD-10 diagnostic codes for abdominal pain, including abdominal and pelvic pain (R10), acute appendicitis (K35-38) and diverticulitis (K57). All patients living within the catchment area with a clinical suspicion of acute appendicitis are referred to the three hospitals.

Typical symptoms of acute appendicitis include right lower abdominal pain, abdominal rigidity and migration of pain to the right lower quadrant. Patients with these typical symptoms are diagnosed through a clinical examination and laboratory tests (CRP and leucocytosis). In most cases, the diagnosis is confirmed with a CT scan of the abdomen. Patients with clinically and radiologically suspected acute appendicitis usually undergo emergency surgery in the days following hospitalisation. Perforation or abscess verified by a CT scan or during surgery is defined as complicated appendicitis. An appendicolith on a CT scan without perforation or abscess of the appendix is defined as uncomplicated appendicitis.

Data on the patients in this study were retrospectively collected and confirmed from the electronic medical record systems of the three participating hospitals using ICD-10 (*World Health Organization. ICD-10 Classifications*) diagnostic codes. The codes included were K35.0 (acute appendicitis with generalized peritonitis), K35.1 (acute appendicitis with peritoneal abscess), and K35.9 (acute appendicitis, other and unspecified) and the NOMESCO Classification of Surgical Procedures (NCSP)(*NOMESCO, N. (2011). NOMESCO Classification of Surgical Procedures (NCSP), version 1.16.*) procedure codes JEA00 (appendectomy and JEA01 (laparoscopic appendectomy). The data include patients' age, gender, length of hospital stay, day of operation, type of appendicitis (complicated/uncomplicated), time between onset of symptoms and visit to the emergency department, time spent in the hospital before the operation, laboratory findings and postoperative complications. The data also include the comorbid diseases of the patients, according to the Charlson Comorbidity Index(Charlson et al., 1987). The Clavien-Dindo Classification of surgical complications(Clavien et al., 2009) was used to record and define adverse surgical events.

4.2.3 Study III

This study collected data on emergency department visits, hospitalisations due to back pain and emergency spine surgeries in the adult population (aged 18 or older) using ICD-10 (*World Health Organization. ICD-10 Classifications*) diagnostic codes for back pain. The aim of the study was to evaluate the incidence of emergency department visits and operations due to back pain. All patients with spine specific ICD-10 diagnostic codes (Table 2) were collected from patient information systems of the participating hospitals.

Table 2. The classification of ED visits due to back pain and spine surgeries according to diagnostic and procedure codes

ED visits due to back pain		Spine surgeries	
Non-specific back pain		Disc surgery	
M47.2	Spondylosis with radiculopathy	ABC16	Excision of lumbar intervertebral disc displacement
M53.8	Other specified dorsopathies	ABC23	Open discectomy of thoracic spine
M53.9	Dorsopathy, unspecified	ABC26	Open discectomy of lumbar spine
M54.0	Panniculitis of back	Decompression	
M54.3	Ischias	ABC33	Decompression of thoracic nerve roots
M54.4	Lumbago with sciatica	ABC36	Decompression of lumbar nerve roots
M54.5	Low back pain	ABC53	Decompression of thoracic spinal canal and nerve roots
M54.6	Pain in thoracic spine	ABC56	Decompression of lumbar spinal canal and nerve roots
M54.8	Other dorsalgia	Fracture	
M54.9	Dorsalgia, unspecified	NAJ22	External fixation of fracture of thoracic spine
Lumbar disc herniation		NAJ30	Internal fixation of fracture of cervical spine
M51.0	Intervertebral disc disorders with myelopathy	NAJ32	Internal fixation of fracture of thoracic spine
M51.1	Disc disorders with radiculopathy	Fusion	
M51.9	Unspecified intervertebral disc disorder	NAG52	Interbody fusion of thoracic spine with external fixation
Back contusion		NAG53	Interbody fusion of thoraco-lumbar spine with external fixation
S23.0	Traumatic rupture of thoracic intervertebral disc	NAG57	Interbody fusion of spine with external fixation
S23.3	Sprain of ligaments of thoracic spine	NAG62	Interlaminary fusion of thoracic spine without fixation
S30.0	Contusion of lower back and pelvis	NAG63	Interlaminary fusion of thoraco-lumbar spine without fixation

ED visits due to back pain		Spine surgeries	
Lumbar spine fracture		NAG66	Interlaminary fusion of lumbo-sacral spine without fixation
S32.0	Fracture of lumbar vertebra	NAG99	Other excision, reconstruction, or fusion
S32.7	Multiple fracture of lumbar vertebra	Other	
Spinal stenosis		NAR00	Incomplete excision of soft tissue tumor of spine
M48.0	Spinal stenosis	NAR99	Other operation for tumor of spine
Thoracic spine fracture		NAK10	Partial or total excision of vertebra
S22.0	Fracture of thoracic vertebra	NAK99	Other operation of vertebra
S22.1	Multiple fracture of thoracic vertebra	NAS99	Other operation for infection of tendon, joint, disk or bone of spine
		NAW00	Reoperations on spine and neck
		NAW10	Reoperations on spine and neck
		NAW99	Reoperations on spine and neck

Patient visits to the ED were classified into the following groups: non-specific back pain, back contusion, lumbar disc herniation, spinal stenosis, lumbar spine fracture and thoracic spine fracture (Table 2). The data of all patients who were admitted to the participating hospitals with back pain during the years 2017 through 2019 (reference years) and the year 2020 (study period) were included.

The data on urgent spine surgeries (delay of less than 14 days) during the same time periods were retrospectively collected from the medical records of the participating hospitals using NOMESCO Classification of Surgical Procedures (NCSP) (*NOMESCO, N. (2011). NOMESCO Classification of Surgical Procedures (NCSP), version 1.16.*) procedure codes (Finnish version). The groups of spine surgeries were classified as follows: decompression, disc surgery, fracture, fusion and other (Table 2).

Hospitalisations were divided into two categories: patients with non-specific back pain and patients with other causes of back pain.

4.2.4 Study IV

In study IV, data on ED visits due to traumatic brain injury (TBI) in the adult population (aged 18 or older) was retrieved from the patient information system of the participating hospitals using the International Classification of Diseases 10th

Revision (ICD-10) (*World Health Organization. ICD-10 Classifications*) diagnostic codes for TBI. The included codes are presented in Table 3.

Table 3. Emergency Department visits due to traumatic brain injury according to diagnostic (ICD-10) codes.

ICD code	Explanation
S06.0	Concussion
S06.1	Traumatic cerebral edema
S06.2	Diffuse traumatic brain injury
S06.3	Focal traumatic brain injury
S06.4	Epidural hemorrhage
S06.5	Traumatic subdural hemorrhage
S06.6	Traumatic subarachnoid hemorrhage
S06.7	Intracranial injury with prolonged coma
S06.8	Other specified intracranial injuries
S06.9	Unspecified intracranial injury

Data of all adult patients who were admitted to the study hospitals with TBI in 2020 (study period) and the years 2017 through 2019 (reference years) were collected.

NOMESCO Classification of Surgical Procedures (NCSP) (*NOMESCO, N. (2011). NOMESCO Classification of Surgical Procedures (NCSP), version 1.16.*) procedure codes (Finnish version) were used to collect information on trauma craniotomies and craniectomies (delay less than 14 days) from the electronic medical record systems of the three participating hospitals. The following codes were included: AAD00 (evacuation of epidural haematoma), AAD05 (evacuation of acute subdural haematoma), AAD15 (evacuation of traumatic intracerebral haematoma) and AAK80 (partial excision of skull cap) combined with the diagnostic code S06*. Only craniotomies and craniectomies related to trauma were collected, as we only wanted to evaluate acute neurosurgeries. We were, however, unable to combine all trauma-related diagnostic codes with procedure codes due to the register-based data.

4.2.5 Study V

Data on intensive care unit (ICU) admissions were collected from the ICU patient information systems of the participating hospitals. The study included adult patients (aged 18 or older) who were admitted to the ICUs of the three hospitals during the years 2020 and 2021. The reference years included ICU admissions from 2017 to

2019. ICD-10 diagnostic codes (*World Health Organization. ICD-10 Classifications*) were used for the classification of patients. The first diagnosis of a patient was used for the collection of ICU admissions. Only one treatment period per patient was collected. The changes in the number of ICU admissions were collected and analysed in groups based on ICD-10 diagnostic codes (Table 4).

Table 4. Classification of Intensive Care Unit admissions according to diagnostic (ICD-10 main classes) codes.

ICD-10 main class	Explanation
A00-B99	Infectious and parasitic diseases
C00-D89	Neoplasms. diseases of the blood
E00-E89	Endocrine. nutritional and metabolic diseases
F01-F99	Mental. Behavioral and Neurodevelopmental disorders
G00-G99	Diseases of the nervous system
I00-I99	Diseases of the circulatory system
J00-J99	Diseases of the respiratory system
K00-K95	Diseases of the digestive system
M00-M99	Diseases of the musculoskeletal system and connective tissue
N00-N99	Diseases of the genitourinary system
O00-O9A	Pregnancy. childbirth and the puerperium
S00-T88	Injury. poisoning and other external causes
U07.1	COVID-19, confirmed by laboratory testing

The number of patients who tested positive for COVID-19 and were admitted to the ICU in the years 2020 and 2021 was collected using the ICD-10 diagnostic code U07.1 COVID-19 (confirmed by laboratory testing).

4.3 Statistical Methods

The analyses and figures were performed using R version 3.6.2 (R Foundation for Statistical Computing, Vienna, Austria) and SPSS Statistics version 26. Monthly and yearly incidences for the pre-pandemic and pandemic periods with 95% confidence intervals (CI) were counted per 100 000 person-years by Poisson exact method and compared by incidence rate ratios (IRR). The incidence for each study month per 100 000 person-years was counted using the total number of admitted patients in three participating hospitals. The mean adult population in Pirkanmaa, South Savo and Central Finland hospital districts for the study years was collected from the

Official Statistics of Finland website (Finland, 2020). For the reference years, the mean population between 2017 and 2019 was used. The mean population was the average of the populations of two consecutive years. Median and interquartile range (IQR) was calculated for ICU stay duration. In Study II, the difference between weeks in preoperative CRP, preoperative leucocytosis, pre-hospital symptom duration, hospital stay, and Clavien-Dindo Classification was tested using Mann-Whitney U test. Chi-square test ($\chi 2$) without Yates' correction was used to evaluate complication, abscess and appendicolith rates, and postoperative complications.

4.4 Ethics

4.4.1 Ethics of the study

Since this study is a retrospective register study, ethical approval was not required. According to the Finnish research law, ethical committee evaluation is not required when data is analysed retrospectively, and the participants are not contacted. However, this study was conducted according to relevant guidelines and Finnish regulations.

4.4.2 Study permissions

All methods were carried out in accordance with relevant guidelines and Finnish regulations. According to Finnish research law and the law on the secondary use of routinely collected healthcare data, informed consent to participate is not required when institutional or national register data is analysed retrospectively. Therefore, the need for informed consent was waived by the institutional review boards of the participating hospitals (Tampere University Hospital, Central Finland Hospital Nova, and Mikkeli Central Hospital) and the ethical committee of Tampere University Hospital. This study received research permissions from each of the participating hospitals' institutional research boards.

4.4.3 Secondary use of routinely collected healthcare data in Finland

When this study started and study permissions were granted, informed consent was only needed from the institutional review boards of the participating hospitals since the law on the secondary use of routinely collected healthcare data was not in force.

5 SUMMARY OF THE RESULTS

5.1 Abdominal pain and abdominal surgeries (Study I)

A total of 14 576 emergency department visits due to abdominal pain were recorded in the participating hospitals during the year 2020. However, after the declaration of a national lockdown in spring 2020, the incidence of ED visits due to abdominal pain decreased in all three hospitals (Figure 3), being the lowest between March and May (during the lockdown period).

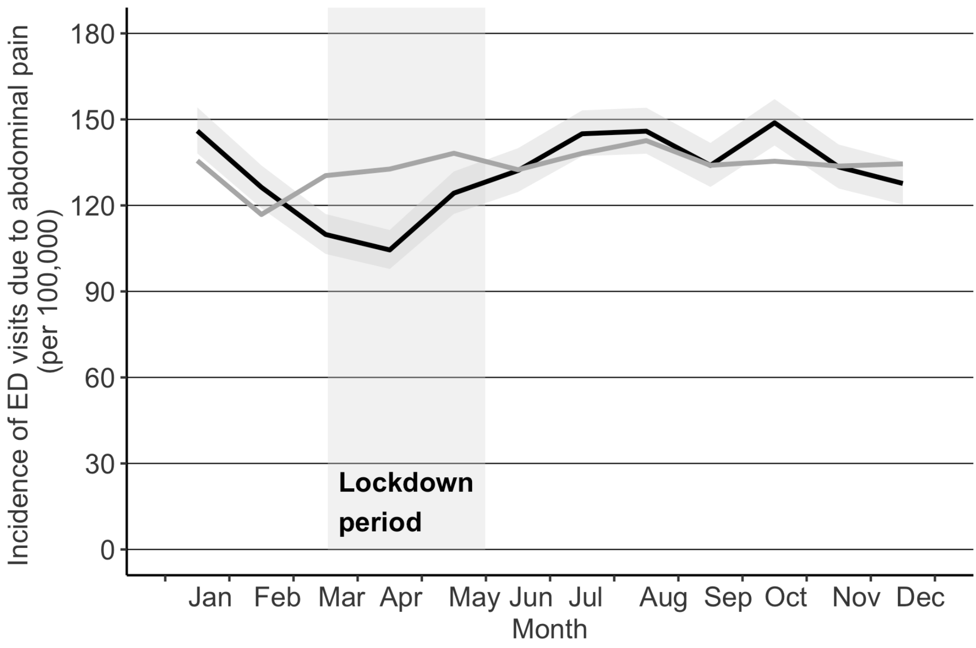

Figure 3. The incidence of ED visits due to abdominal pain during the COVID-19 pandemic. The grey line illustrates the mean incidences in the reference years (2017–2019) and the black line illustrates the incidence during the study period (2020) with confidence intervals.

The incidence rebounded towards its previous level when the lockdown ended in June. Although the incidence of abdominal pain visits during the study period compared to the reference years was similar in February (IRR 1.09, CI: 1.00-1.18) before the national lockdown, a decrease in the incidence of ED visits was seen in March (IRR 0.83, CI: 0.76 to 0.90) when the lockdown was first declared. The second decrease in the incidence of ED visits was seen in December during the second wave of the pandemic (IRR 0.93, CI: 0.86 to 1.01).

Nonspecific abdominal pain (58.2%), appendicitis (6.4%), cholelithiasis (5.3%), hernia (3.6%) and pancreatitis (3.2%) were the most common reasons for visiting the ED due to abdominal pain. The IRR of nonspecific abdominal pain decreased during the national lockdown, being similar in comparison to previous years in February (IRR 1.08, CI 0.97 to 1.20). In April 2020, the IRR decreased (IRR 0.67, CI 0.59 to 0.75) and remained lower until June (IRR 0.91, CI: 0.82 to 1.01). (Figure 4)

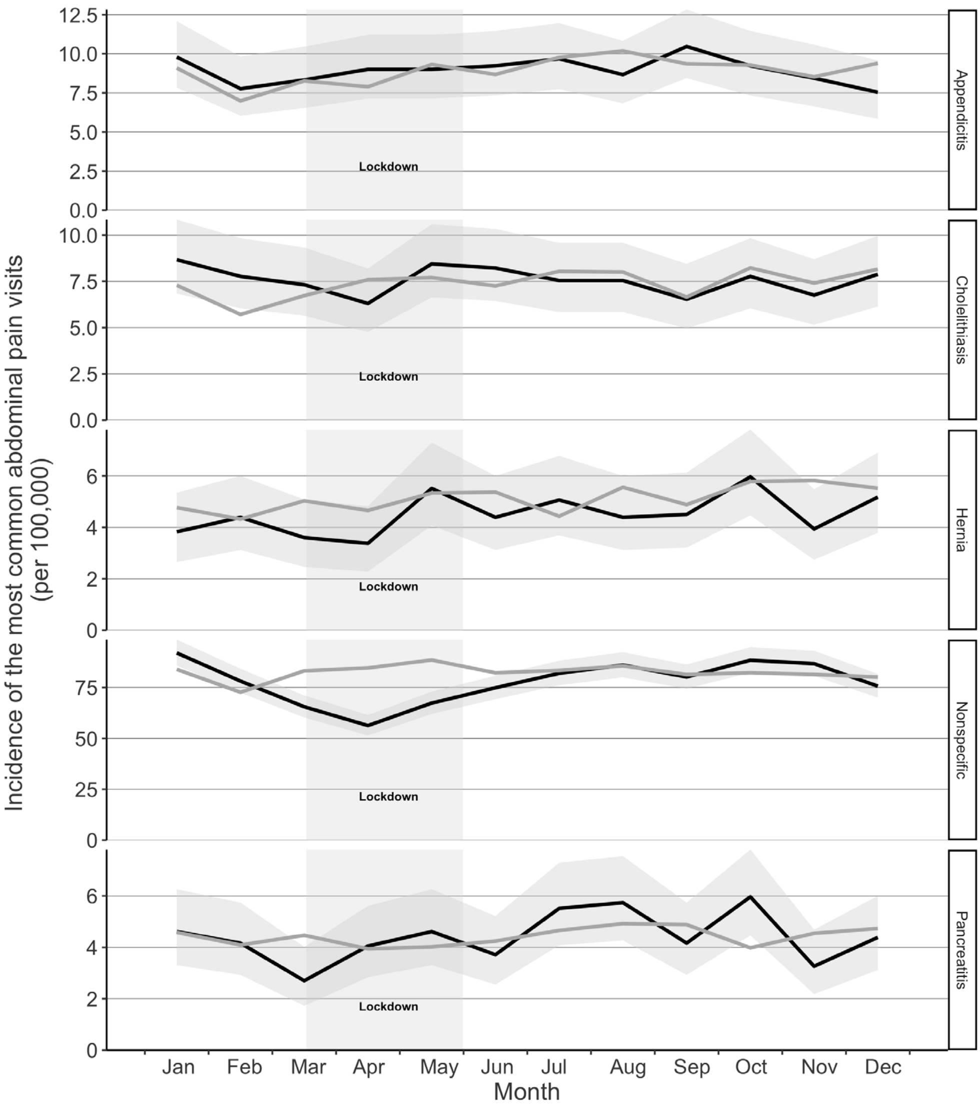

Figure 4. Incidence of the most common visits to ED due to abdominal pain during the COVID-19 pandemic. The grey line illustrates the mean incidences in the reference years (2017–2019) and the black line illustrates the incidence during the study period (2020) with confidence intervals.

During the second wave of the pandemic, the incidence of abdominal pain for nonspecific reasons remained at the same level as in previous years. Among other diagnostic groups (appendicitis, cholelithiasis, hernia and pancreatitis), the incidence remained at a similar level during both the study period and the reference years.

A total of 12 920 acute abdominal surgeries were performed during the years 2017 through 2020. The mean number of operations during the reference years (2017 through 2019) was 3212. The number of operations in 2020 was 3283. After the start of the national lockdown, the IRR of all acute abdominal surgeries remained at the same level in comparison to the reference years, and in March the IRR was 0.90 (CI 0.76 to 1.08). (Figure 5)

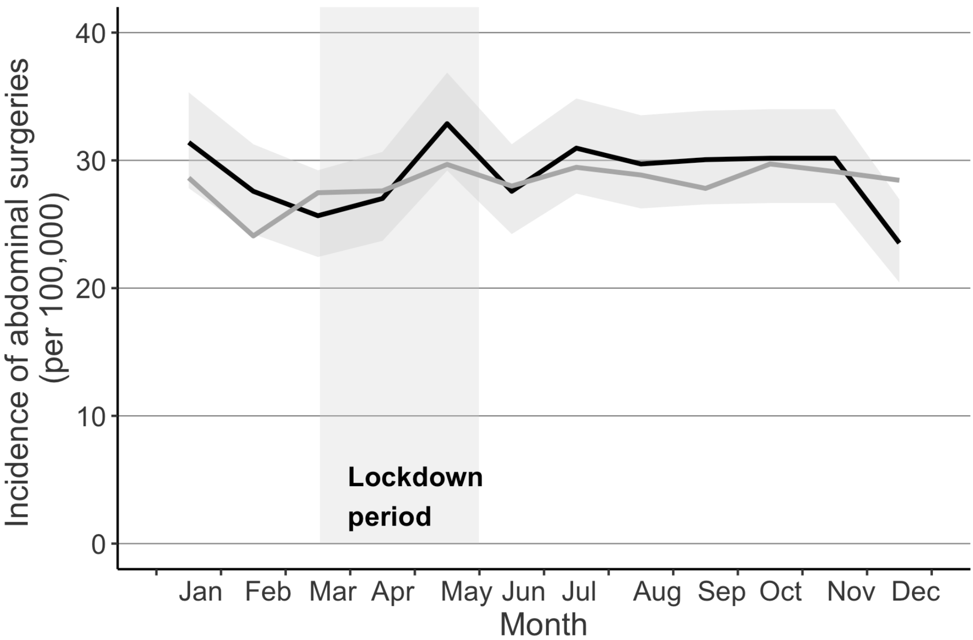

Figure 5. The incidence of abdominal surgeries during the COVID-19 pandemic. The grey line illustrates the mean incidences in the reference years (2017–2019) and the black line illustrates the incidence during the study period (2020) with confidence intervals.

When the study period and the reference years are compared, the incidence of acute abdominal surgeries remains similar until December when a decrease is seen (IRR 0.84, CI: 0.71 to 1.00).

Laparotomy (JAH00), laparoscopic appendectomy (JEA01) and laparoscopic cholecystectomy (JKA21) were the most common acute abdominal surgeries performed during the study period. The incidence of laparoscopic appendectomy and laparotomy remain at the same level when the first wave of the pandemic in 2020 and the reference years are compared. (Figure 6)

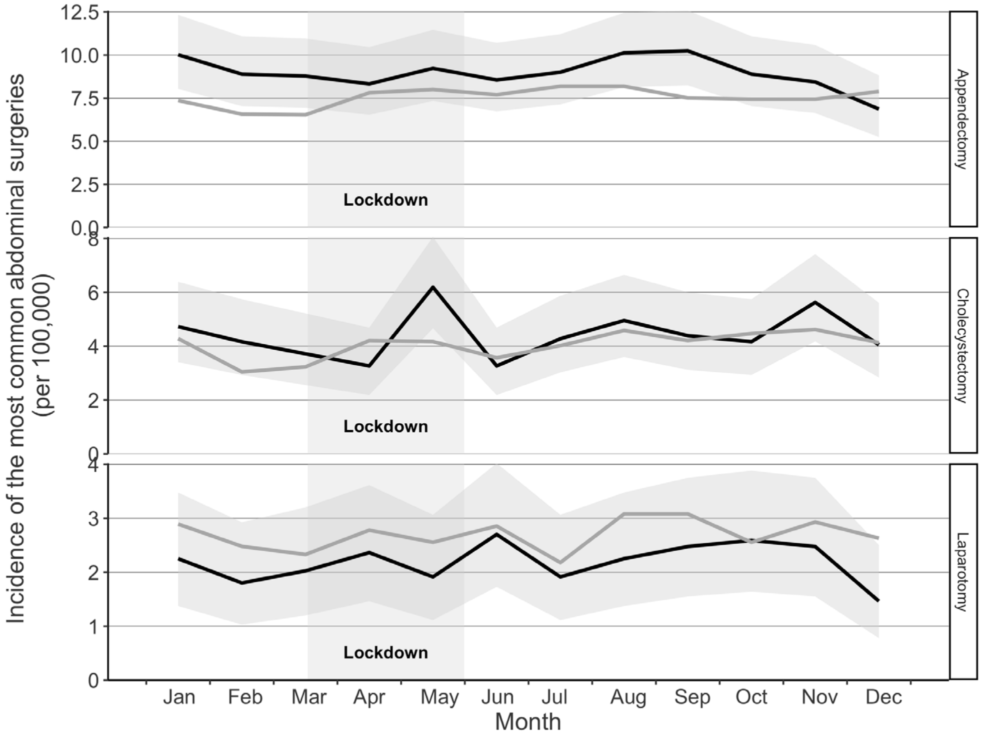

Figure 6. Incidence of the most common abdominal surgeries during the COVID-19 pandemic. The grey line illustrates the mean incidences during the reference years (2017–2019) and the black line illustrates the incidence during the study period (2020) with confidence intervals.

When the lockdown was declared, however, the incidence of laparoscopic cholecystectomies was at the same level (IRR in March 1.15, CI: 0.70 to 1.90) as in previous years. A decrease was seen in April (IRR 0.77, CI: 0.47 to 1.25), and the incidence started to increase thereafter. The incidence of laparoscopic cholecystectomies was at the highest level in comparison to previous years in May, which was in the middle of the lockdown (IRR 1.48, CI 0.98 to 2.25). In December, during the second wave of the pandemic, the incidence of appendectomies, cholecystectomies and laparotomies remained at the same level in comparison to the reference years.

5.2 Acute appendicitis (Study II)

During the 13-week study period (February 1st to April 30th), a total of 2198 patients visited the emergency departments of the three participating hospitals due to abdominal pain. Of these, 257 (12%) patients had a clinical diagnosis of acute appendicitis. The weekly mean number of ED visits due to abdominal pain was 169 visits during the whole study period, 190 visits in weeks -6 to -1 and 145 visits in weeks 1 to 6. After the declaration of the national lockdown, the number of visits in week 0 decreased by 30% and remained lower in week 1. In week 2, however, the number of visits rebounded towards the level seen previously.

All patients diagnosed with acute appendicitis underwent emergency surgery, except for one patient who underwent antibiotic treatment. Patients' age, Charlson Comorbidity Index distribution and gender ratio all followed a similar trend after the lockdown. In weeks -6 to -1, 140 patients were diagnosed with acute appendicitis and 117 patients in weeks 1 to 6. The proportion of complicated appendicitis in the whole study population was 21% (55/257), ranging from 9% (week -4) to 30% (week -3). The highest perforation rates were observed in weeks -3 (30%), 3 (29%) and 5 (29%). In the whole study population, an appendicolith was present in 31% (79/257) of cases. The distribution of complicated appendicitis cases per week is shown in Figure 7.

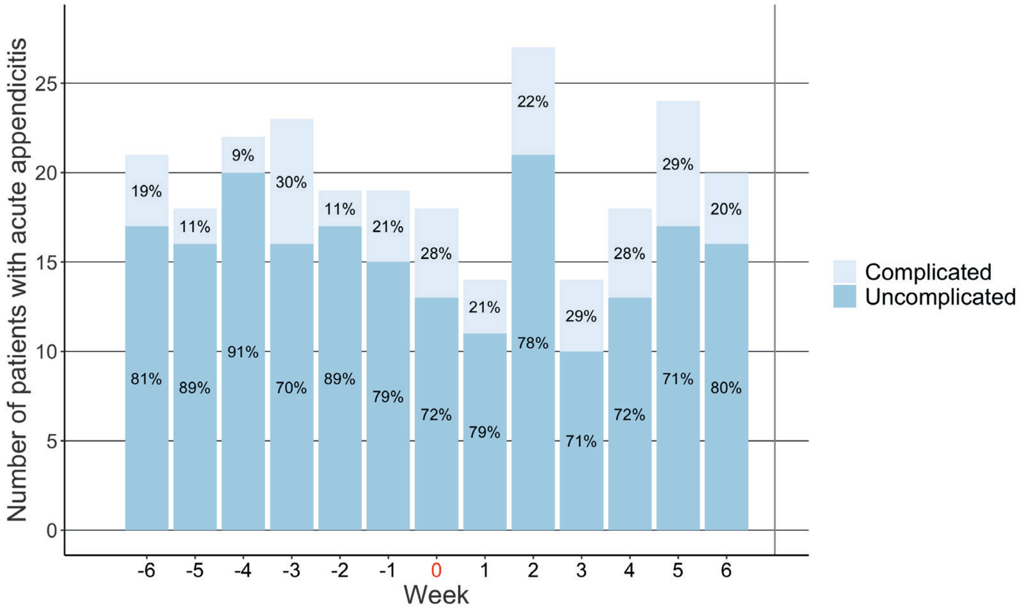

Figure 7. Number of patients with appendicectomy and the proportion of patients with complicated appendicitis.

In patients with acute appendicitis, the median pre-hospital symptom duration remained at 1 day (IQR: 0 and 1) both before and in the beginning of the lockdown (weeks -1 and 1). However, between weeks 1 and 2, the pre-hospital symptom duration median increased from 1 to 2 days (IQR: 2 and 3). The median length of hospital stay remained at 2 days (IQR: 1 and 2) during weeks -1 to 2. The median preoperative CRP was 40 mg/L (range, 0 to 406 mg/L) during the study period. The preoperative leucocytosis mean was 12.8 E9/L (range, 2.5 to 25.8 E9/L). There was no change in preoperative laboratory findings after the lockdown and societal restrictions were lifted. Prominent changes in the incidence of postoperative complications were not observed. Complications based on the Clavien-Dindo Classification followed a similar trend before and after the lockdown.

5.3 Back pain and spine surgeries (Study III)

During the year 2020, a total of 4310 patients visited ED due to back pain, and 376 urgent spine surgeries were performed. For ED visits due to back pain, the mean age of the patients was 54 years, and the proportion of women patients was 55%. The mean age of patients who underwent spine surgery was 56 years, and 57% of them were men. The mean number of ED visits due to back pain was 4884 during the reference years (2017-2019). The same number for urgent spine surgeries was 307.

A decrease in the incidence of ED visits due to back pain was seen during the first and second waves of the COVID-19 pandemic (Figure 8).

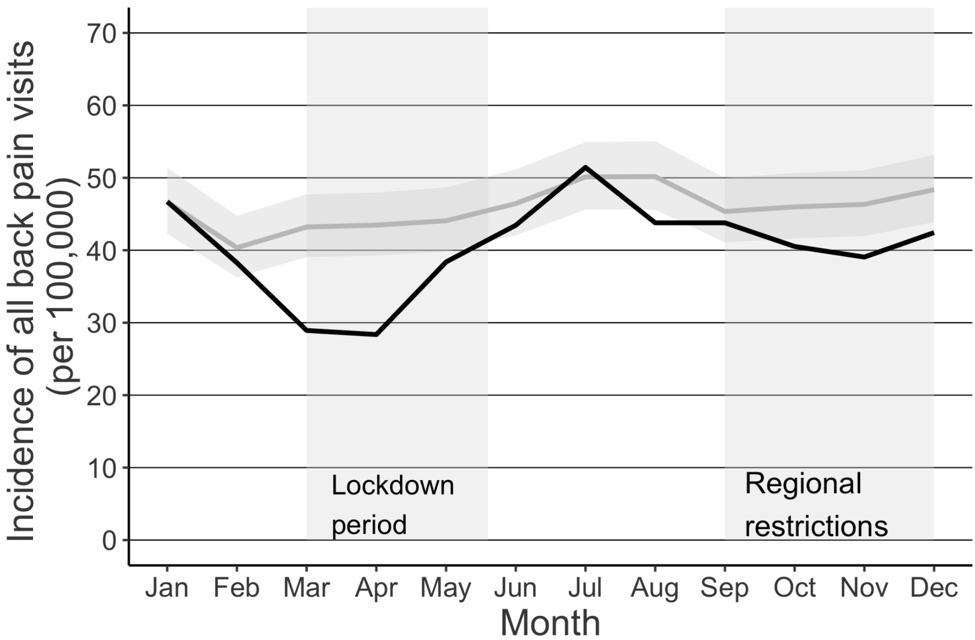

Figure 8. Incidence of all visits due to back pain during the COVID-19 pandemic. The black line illustrates the incidence during the study period (2020) and the grey line illustrates the mean of incidences in the reference years (2017–2019) with confidence intervals.

The incidence of ED visits due to back pain in February 2020 was similar to previous years (IRR 0.95, CI: 0.82 to 1.10) when compared to the reference years. However, a notable decrease in the incidence of back pain visits was seen in March

(IRR 0.67, CI: 0.57 to 0.78), but the incidence rebounded to its previous level when the lockdown period ended in June. A slight decrease in the incidence of back pain visits was seen in October (IRR 0.88, CI: 0.76 to 1.02) when regional restrictions were implemented. The largest decrease in incidence was seen in November (IRR 0.84, CI: 0.73 to 0.97).

Non-specific back pain, lumbar disk herniation, back contusion and lumbar spine fracture (Figure 9) were the most common reasons for admissions to ED due to back pain.

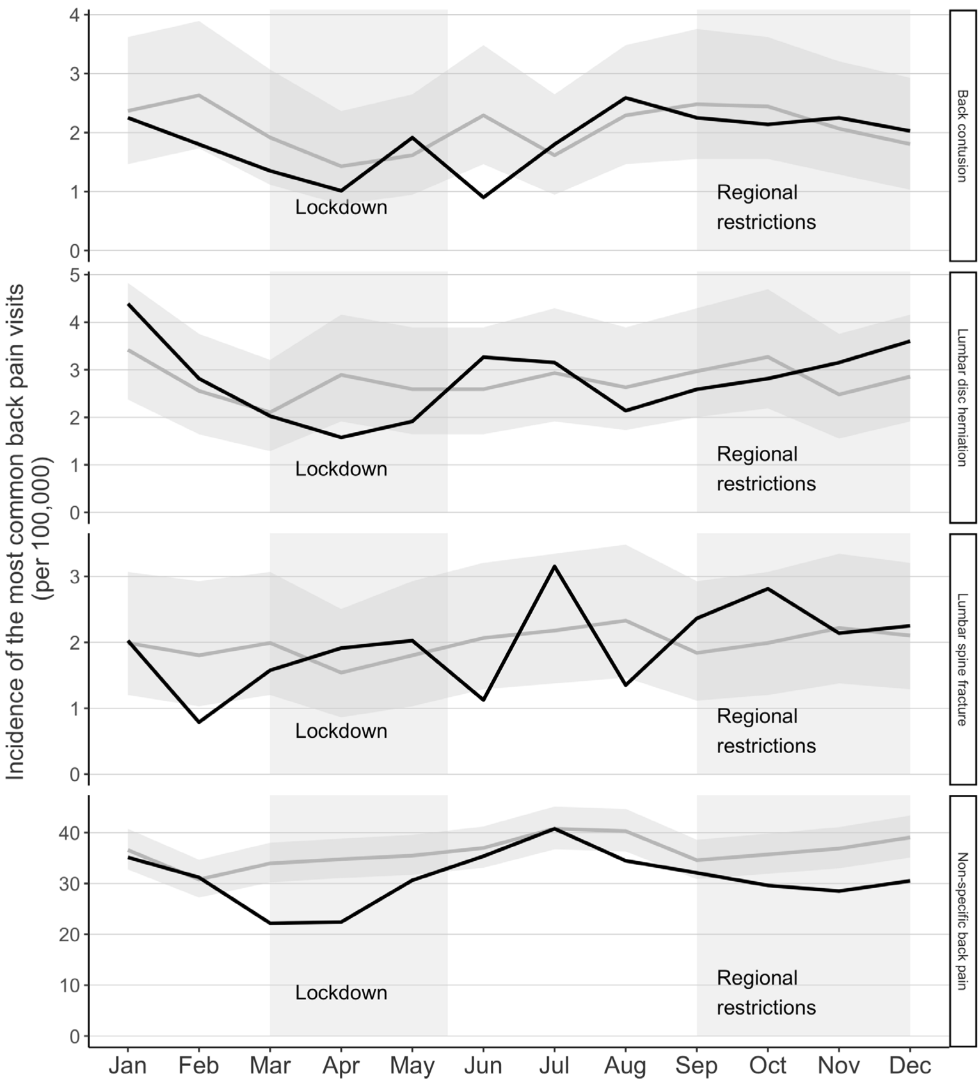

Figure 9. Incidence of the most common visits due to back pain during the COVID-19 pandemic. The black line illustrates the incidence during the study period (2020) and the grey line illustrates the mean of incidences in the reference years (2017–2019) with confidence intervals.

During the national lockdown and regional restrictions, the incidence of ED visits due to non-specific back pain decreased. Moreover, a decrease was first seen from February (IRR 1.01, CI: 0.86 to 1.20) to March (IRR 0.65, CI: 0.55 to 0.78). From May to September, the incidence of non-specific back pain remained at the same level as in the reference years, but a second decrease was seen in October (IRR 0.83, CI: 0.70 to 0.98). However, the incidence of back contusions, lumbar disc herniations and lumbar spine fractures was at the same level when compared to the reference years.

The incidence of hospitalisations remained at the same level during the COVID-19 pandemic. During the lockdown in April, the IRR of hospitalisations in patients with non-specific back pain was 0.68 (CI: 0.42 to 1.11). During the regional restrictions in October, the IRR of hospitalisations was 0.83 (CI: 0.53 to 1.32). In patients with other reasons for back pain, the IRR of hospitalisations was 0.89 (CI: 0.55 to 1.43) in May and 1.23 (CI: 0.80 to 1.89) in October.

When all urgent spine surgeries were compared, the incidence remained at the same level during the study period as in the reference years (Figure 10).

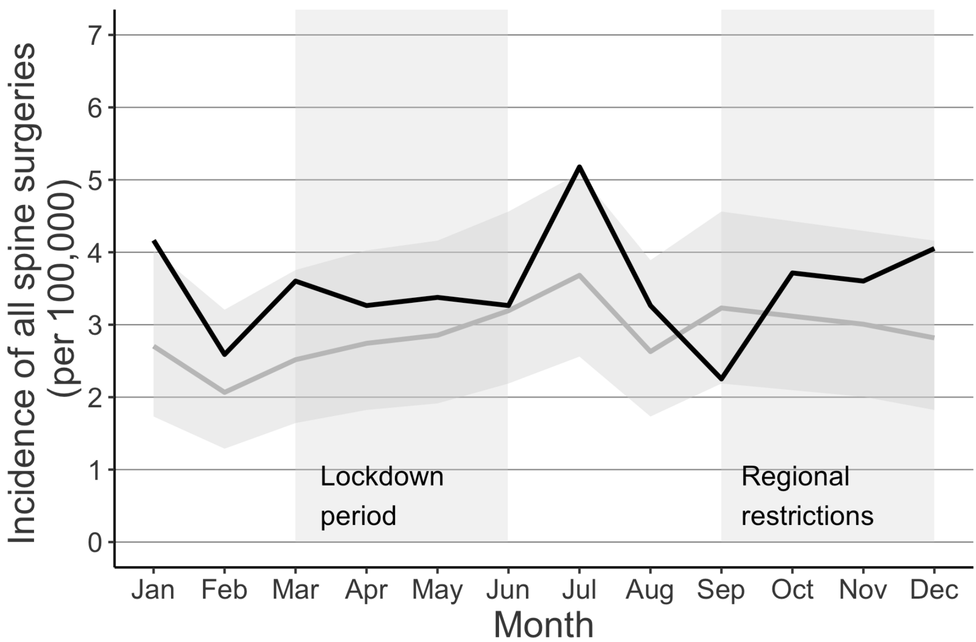

Figure 10. Incidence of all spine surgeries during the COVID-19 pandemic. The black line illustrates the incidence during the study period (2020) and the grey line illustrates the mean of incidences in the reference years (2017–2019) with confidence intervals.

The IRR of all spine surgeries was 1.18 (CI: 0.70 to 2.01) during the lockdown in May and 1.19 (CI: 0.72 to 1.97) during the regional restrictions in October. The incidence of the most common spine surgeries (disc surgery, decompression, fusion, and fracture) (Figure 11) remained at the same level during the first and second waves of the COVID-19 pandemic.

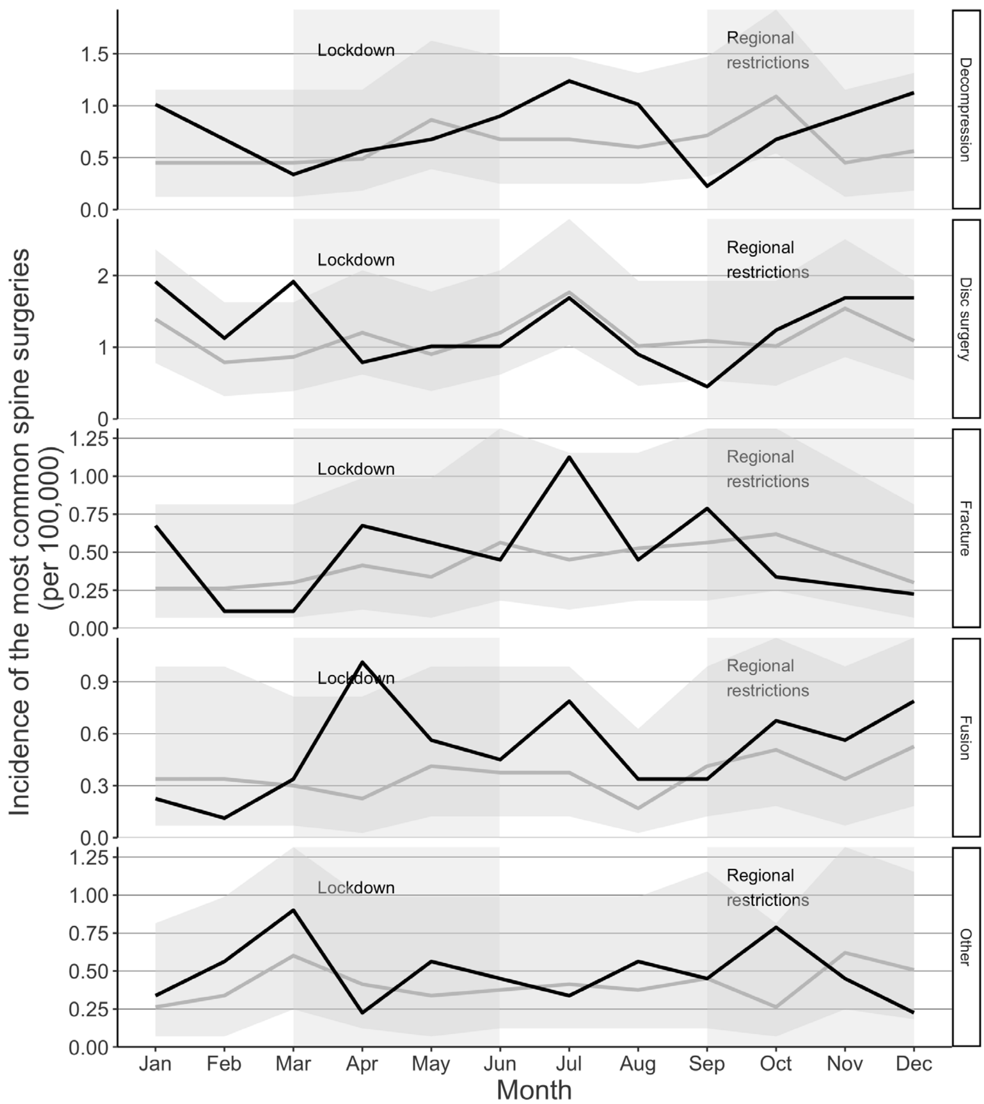

Figure 11. Incidence of the most common spine surgeries during the COVID-19 pandemic. The black line illustrates the incidence during the study period (2020) and the grey line illustrates the mean of incidences in the reference years (2017–2019) with confidence intervals.

The most common spine surgery was disc surgery. The IRR for disc surgery was 1.12 (CI: 0.43 to 2.91) in May and 1.22 (CI: 0.51 to 2.95) in October.

5.4 Traumatic brain injury, trauma craniotomies and craniectomies (Study IV)

A total of 11 982 ED visits due to TBI were made between the years 2017 through 2020. During the year 2020, 2981 visits occurred in the participating hospitals. The mean number of ED visits due to TBI was 3000 during the reference years (2017-2019).

When the national lockdown was declared in spring 2020, the incidence of ED admissions due to TBI decreased (Figure 12).

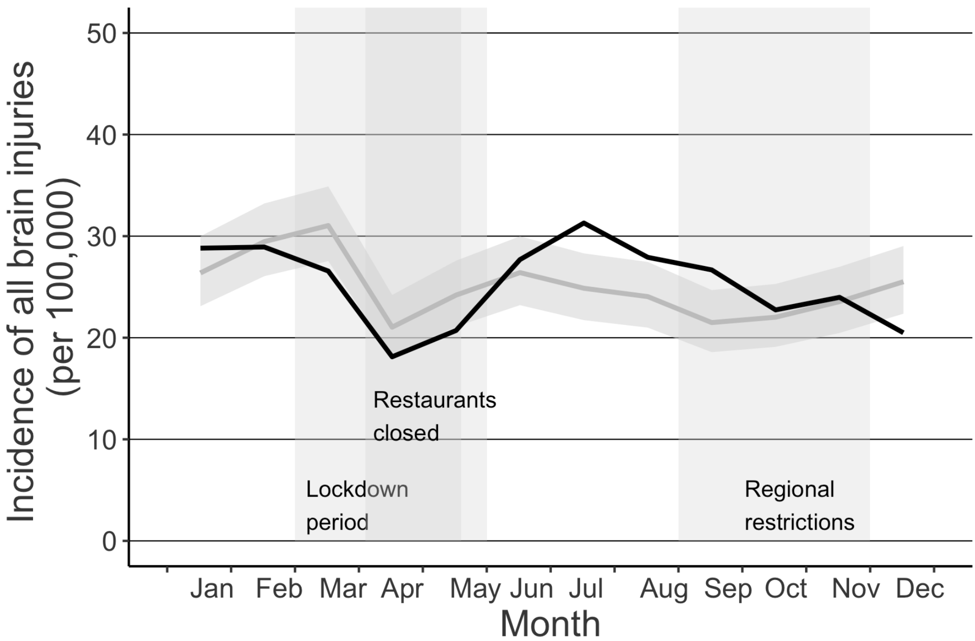

Figure 12. Incidence of all visits due to TBI during the COVID-19 pandemic. The black line illustrates the incidence during the study period (2020) and the grey line illustrates the mean of the incidences in the reference years (2017–2019) with confidence intervals.

A decrease in the incidence of ED visits compared to the reference years was first seen during the study period in March 2020 (IRR 0.86, CI: 0.73 to 1.02), and the incidence was lowest in April 2020 (IRR 0.83, CI: 0.68 to 1.01). In June, when the lockdown ended, the incidence of ED visits rebounded to its previous level until a second decrease occurred in December after targeted regional restrictions were implemented (IRR 0.80, CI: 0.67 to 0.96).

Concussion (S06.0) and traumatic subdural hemorrhage (S06.5) were the most common ICD-10 coded reasons for visits to ED due to TBI. Between the years 2017 and 2020, the total number of concussions was 9468. For traumatic subdural hemorrhage, the same number was 1713. Concussion was the most common reason for ED admission due to TBI. Before the national lockdown in February, the IRR of concussion was 0.97 (CI 0.81 to 1.17), and a decrease in incidence was seen in March (IRR 0.80, CI 0.66 to 0.97). After that, the incidence of concussion remained lower until May. During the second wave of the pandemic, the incidence of concussion remained at the same level as in the reference years, until a decrease was seen in December (IRR 0.80, CI 0.65 to 0.98). Furthermore, the incidence of the other ICD-10 coded reasons for ED visits remained at the same level as in previous years.

A total of 182 trauma craniotomies and craniectomies were performed during the years 2017 through 2020 in the participating hospitals. The mean number of operations during the reference years (2017 through 2019) was 46, and the number of operations in 2020 was 45. Trauma craniotomies and craniectomies remained at the same level as in previous years during the first wave of the COVID-19 pandemic until April (IRR 1.90, CI: 0.54 to 6.75) when the restaurants were closed (Figure 13).

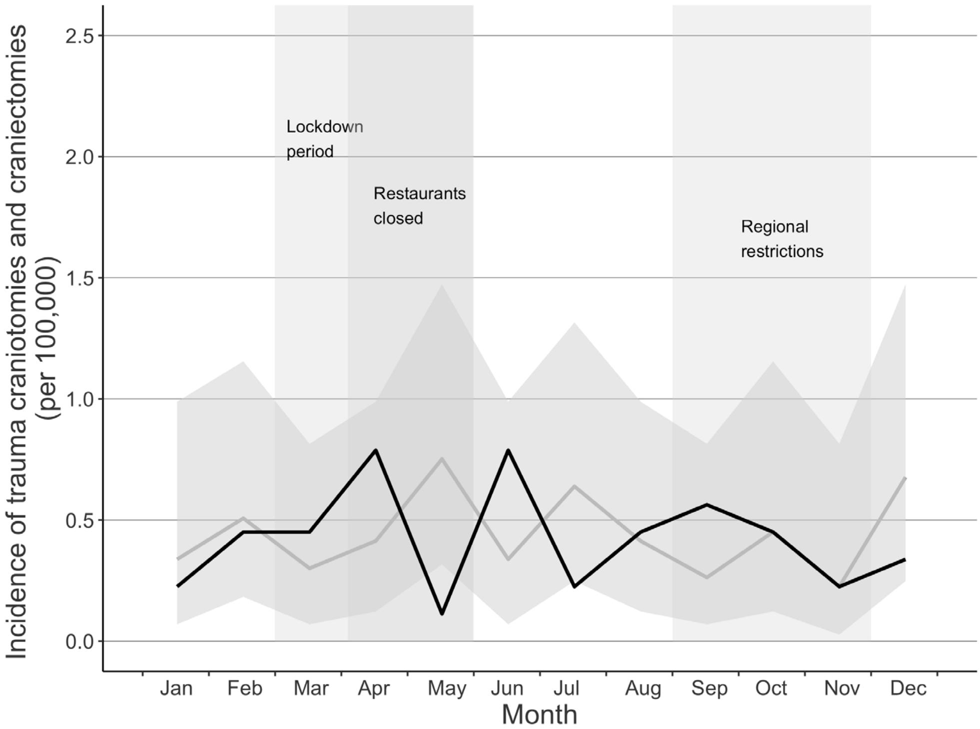

Figure 13. Incidence of trauma craniotomies and craniectomies during the COVID-19 pandemic. The black line illustrates the incidence during the study period (2020) and the grey line illustrates the mean of incidences in the reference years (2017-2019) with confidence intervals.

The incidence of trauma craniotomies and craniectomies decreased, being the lowest in May during restaurant restrictions (IRR 0.15, CI: 0.02 to 1.23). The incidence remained low until the restaurants reopened in June when the incidence rebounded to its previous level. During the second wave of the pandemic, the incidence remained at the same level as in the reference years, IRR being 0.50 (CI 0.12 to 2.00) in December.

5.5 Intensive care unit admissions (Study V)

During the year 2020, the number of ICU admissions was 4407. In 2021, the number of ICU admissions was 4931. Between the years 2017 through 2019 (reference years), the mean number of admissions to ICU was 4781. In 2017, a total of 4864 admissions occurred. The number of admissions in 2018 was 4856 and 4624 in 2019. During the year 2020 (study year), a total of 110 (2.5% of all ICU admissions) COVID-positive patients were admitted to the ICUs in the participating hospitals. The number of COVID-positive patients admitted to the ICUs during 2021 was 141 (2.9% of all ICU admissions). Three distinctive peaks of COVID patients being admitted to ICU were identified: 27 patients in April 2020, 23 patients in December 2020 and 27 patients in December 2021 (Figure 14).

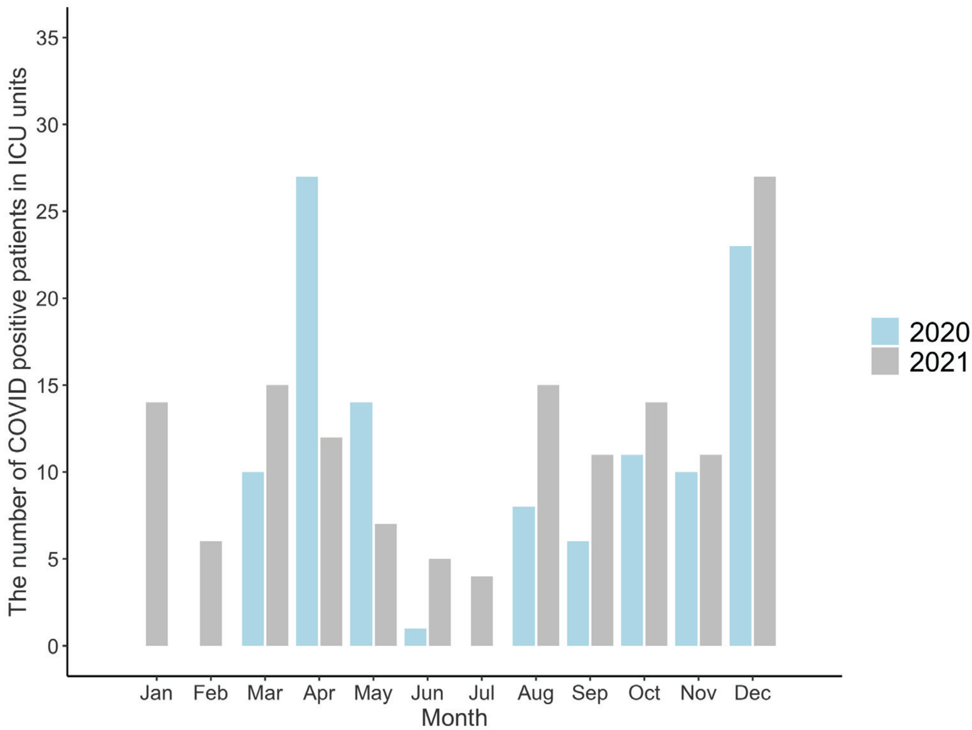

Figure 14. The number of COVID-positive patients in the three ICUs during the COVID-19 pandemic.

The incidence of ICU admissions for all reasons decreased during the lockdown period in 2020 when compared to previous years (Figure 15).

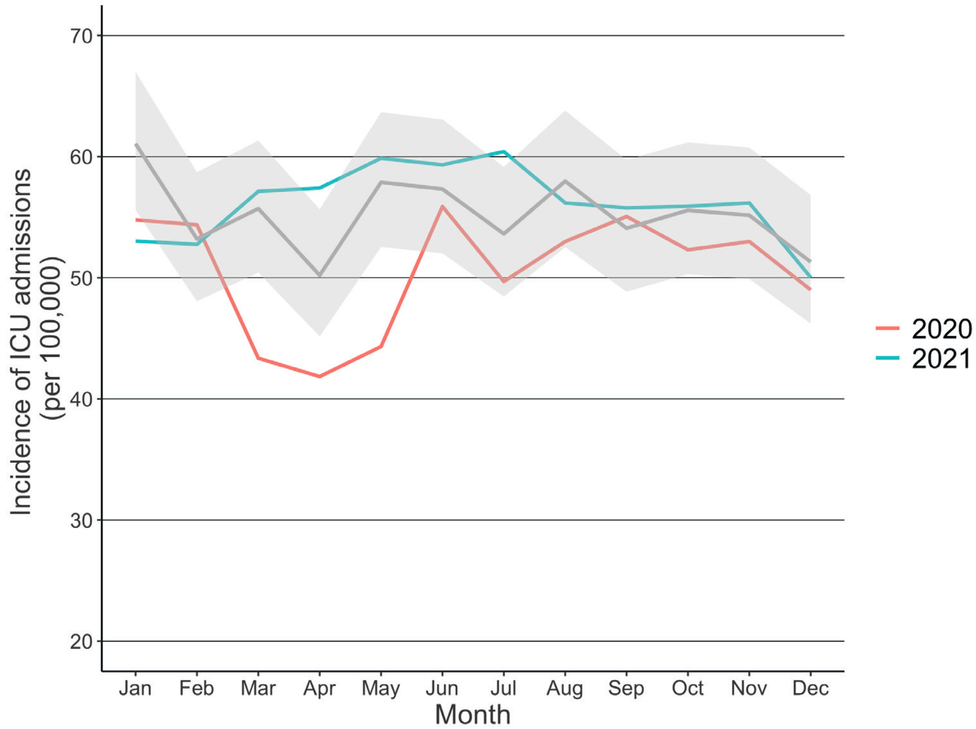

Figure 15. Incidence of ICU admissions for any cause during the COVID-19 pandemic and the reference years (2017-2019). The grey line illustrates the mean of incidences in the reference years (2017–2019) with confidence intervals.

Before the lockdown in February 2020, the IRR of all-cause ICU admissions was 1.02 (CI: 0.89 to 1.18). However, it decreased during the lockdown period to 0.78 (CI: 0.67 to 0.90) in March. After the lockdown, the incidence rebounded to its previous level and remained there until the end of that year. During 2021, the incidence of all-cause ICU admissions was at the same level as in previous years. The most prominent change in ICU admissions was seen in the incidence of diseases of the nervous system (G), the incidence of diseases of the respiratory system (J) and the incidence of neoplasms (C and D) (Table 5).

Table 5. The yearly number of ICU admissions and incidence in 2020 and 2021 compared to the mean yearly incidence of the reference years (2017-2019) by incidence rate ratios (IRR) with 95% confidence intervals.

		2017–2019		2020			2021		
ICD code	Explanation	N	Inc	N	Inc	IRR (95 % CI)	N	Inc	IRR (95 % CI)
A. B	Infectious and parasitic diseases	273	37.8	266	36.6	0.97 (0.82–1.14)	250	34.2	0.90 (0.76–1.07)
C. D	Neoplasms. diseases of the blood	608	84.4	534	73.5	0.87 (0.78–0.98)	555	75.8	0.90 (0.80–1.01)
E	Endocrine. nutritional and metabolic diseases	647	89.7	591	81.3	0.91 (0.81–1.01)	602	82.3	0.92 (0.82–1.02)
F	Mental. Behavioral and Neurodevelopmental disorders	212	29.4	202	27.8	0.95 (0.78–1.15)	221	30.2	1.03 (0.85–1.24)
G	Diseases of the nervous system	219	30.4	194	26.7	0.88 (0.72–1.06)	352	48.1	1.58 (1.34–1.87)
I	Diseases of the circulatory system	1542	213.8	1429	196.7	0.92 (0.86–0.99)	1711	233.8	1.09 (1.02–1.17)
J	Diseases of the respiratory system	163	22.6	125	17.2	0.76 (0.60–0.96)	116	15.9	0.70 (0.55–0.89)
K	Diseases of the digestive system	81	11.2	114	15.7	1.40 (1.05–1.86)	74	10.1	0.90 (0.66–1.23)
M	Diseases of the musculoskeletal system and connective tissue	21	3.0	13	1.8	0.60 (0.30–1.21)	16	2.2	0.74 (0.39–1.41)
N	Diseases of the genitourinary system	17	2.4	20	2.8	1.17 (0.61–2.23)	22	3.0	1.28 (0.68–2.40)
O	Pregnancy. childbirth and the puerperium	19	2.6	18	2.5	0.94 (0.49–1.79)	18	2.5	0.93 (0.49–1.78)
S	Injury. poisoning and other external causes	221	30.7	238	32.8	1.07 (0.89–1.28)	196	26.8	0.87 (0.72–1.06)
T	Injury. poisoning and other external causes	174	24.2	168	23.1	0.96 (0.77–1.18)	220	30.1	1.24 (1.02–1.52)
U0*	Covid patients	0		110	15.1		141	19.3	
W	External causes of morbidity	437	60.6	372	51.2	0.84 (0.74–0.97)	390	53.3	0.88 (0.77–1.01)
R. H. L. Z	Other and unspecified	572	79.3	486	66.9	0.84 (0.75–0.95)	569	77.8	0.98 (0.87–1.10)

The incidence of diseases of the nervous system decreased from 30.4 per 100 000 person-years in 2017 to 2019 to 26.7 per 100 000 person-years (IRR: 0.88 CI: 0.72 to 1.06) in 2020. During the year 2021, however, the incidence increased to 48.1 per 100 000 person-years (IRR: 1.58, CI: 1.34 to 1.87) when compared to the reference years. During the study period, the incidence of diseases of the respiratory system decreased from 22.6 per 100 000 person-years during the reference years to 17.2 per 100 000 person-years (IRR 0.76, CI:0.60 to 0.96) in 2020. During 2021, the incidence was 15.9 per 100 000 person-years (IRR 0.70, CI: 0.55 to 0.89) when compared to previous years. In diseases of the blood and neoplasms, the incidence decreased to its lowest (73.5) in 2020 (IRR: 0.87, CI: 0.78 to 0.98). During the reference years, incidence was 84.4 per 100 000 person-years. In 2021, the incidence increased to 75.8 per 100 000 person-years (IRR: 0.90, CI: 0.80 to 1.01).

No changes were seen in the length of ICU stay during the years 2020 and 2021 when compared to previous years (Table 6).

Table 6. Mean and standard deviation for ICU stay duration during the COVID-19 pandemic and pre-pandemic period (2017-2019).

	Pre-pandemic 2017-2019		Pandemic 2020-2021	
	Mean	SD	Mean	SD
Jan	1.5	3.3	1.4	2.6
Feb	1.5	3.2	1.5	2.8
Mar	1.6	3.4	1.7	3.7
Apr	1.7	3.3	1.9	4.4
May	1.4	2.8	1.4	2.7
Jun	1.4	2.9	1.4	2.9
Jul	1.5	3.0	1.5	3.1
Aug	1.4	2.8	1.4	2.9
Sep	1.6	3.4	1.4	2.9
Oct	1.5	2.9	1.5	3.0
Nov	1.4	3.0	1.5	3.3
Dec	1.7	4.0	1.7	3.1

6 DISCUSSION

6.1 Emergency department visits due to abdominal pain and abdominal surgeries

The main finding of this study was that the incidence of ED visits related to abdominal pain decreased when the national lockdown was declared and remained lower until the end of the lockdown. When the national lockdown ended, the number of ED visits rebounded to the same level as in previous years. In December 2020, during the second wave of the COVID-19 pandemic, a second decrease was seen in the incidence of ED visits. The most prominent change occurred in visits related to nonspecific abdominal pain, which was also the most common reason for visiting the ED (58%). In particular, patients with milder symptoms may have avoided or postponed ED visits due to their concerns about contracting COVID-19. A decline in the number of ED visits was also reported in the literature for the early pandemic period (Boserup et al., 2020; Hartnett et al., 2020; Kuitunen et al., 2020).

In the United States, the largest declines were seen in ED visits due to abdominal pain and other abdomen or digestive symptoms and signs, which are the most common reasons for admittance to the ED (Hartnett et al., 2020). Those individuals who use the ED because of a lack of access to primary healthcare may have avoided seeking care during the pandemic due to the infection risk and recommendations to avoid unnecessary visits. Some patients may have even ignored the signs or symptoms of diseases that would normally have resulted in them seeking medical care.

In this study, prominent changes in the incidence of acute abdominal surgeries were not observed during the first wave of the COVID-19 pandemic. The incidence of laparoscopic cholecystectomies, which was the most common abdominal surgery, first decreased at the beginning of the lockdown and then started to increase. In a previous study, a 45% decrease was reported in the number of emergency cholecystectomies during the pandemic period when compared to a previous year. In that study, the number of cholecystitis and perforation decreased, whereas an increase was seen in the number of patients with gallstone pancreatitis. (Isherwood et al., 2020) This change may have been the result of the monthly changes in the prevalence of the disease. The incidence of laparoscopic cholecystectomies was highest in May during the middle of the lockdown. Thereafter, the incidence returned to its previous level. The incidence of two other common abdominal surgeries, exploratory laparotomies and laparoscopic appendectomies, remained stable throughout the study period. These results suggests that even if the number of ED visits due to abdominal pain decreased during the pandemic, patients still sought medical treatment in cases of severe abdominal pain. Since abdominal pain is one of the most common reasons for ED visits, further research is required to evaluate the number of patients who need medical care for abdominal pain and the number of patients with milder abdominal pain who may experience spontaneous resolution. This may help to better allocate resources in ED units for future pandemics.

6.2 Acute appendicitis and appendicectomy

In this study, we reported that the number of acute appendicitis decreased after the declaration of a national lockdown. Indeed, the weekly number of ED visits due to abdominal pain and the proportion of patients with acute appendicitis decreased slightly after the national lockdown began. Two weeks after the declaration of the lockdown, the number of ED visits increased slightly but remained lower than usual. While the number of patients with acute appendicitis decreased, prominent changes in the rate of complicated appendicitis were not observed. The highest perforation rates were observed 3 to 5 weeks after the start of the lockdown, yet the same level of perforation rates was seen in weeks -3 and 0. The perforation rate remained higher than usual until the end of the study period.

There is evidence that suggests that cases of uncomplicated appendicitis may perforate when pre-hospital time exceeds 24 hours (Li et al., 2019). The findings of our current study do not, however, support this evidence. However, there was an increase in pre-hospital symptom duration in weeks 1 and 2, which may have been the result of the restrictions and citizens avoiding unnecessary ED visits. In addition, the number of acute appendicitis first decreased in week 1 and then increased in week 2. This finding might be due to patients waiting longer before visiting the hospital. This trend did not result in higher rates of complicated appendicitis. During the COVID-19 pandemic, patients with less symptomatic appendicitis and mild abdominal pain might not have wanted to visit the emergency department to avoid non-essential hospital visits. The pathophysiology of appendicitis is multifarious. Therefore, it is possible that patients with milder forms of appendicitis may experience spontaneous resolution (Salminen et al., 2015; Salminen et al., 2018). Further, some patients with milder forms of appendicitis may have postponed the ED visit and eventually recovered spontaneously. However, this remains speculative and cannot be addressed by our data.

6.3 Emergency department visits due to back pain and spine surgeries

The results of this study reveal that a decrease occurred in the incidence of ED visits due to back pain during the first and second waves of the COVID-19 pandemic. Similar findings have been reported in previous studies investigating the first wave of the COVID-19 pandemic (Borsa et al., 2020; Cofano et al., 2020; Zahra et al., 2020). In Italy, the decrease in the number of ED visits due to acute low back pain was more than 80% (Borsa et al., 2020; Cofano et al., 2020).

In the first months of the pandemic, citizens were advised to avoid all non-necessary healthcare visits and ICU personnel were redeployed because COVID-19 led to fewer visits to EDs due to nonspecific back pain. One reason for changes in the number of ED visits due to nonspecific back pain may be the changes to daily routines during lockdown. As sport activities were banned and social contacts restricted, citizens spent more time at home. Furthermore, people were encouraged to stay at home and remote work was recommended. These changes in daily life led to decreased physical activity, which is known to have a negative effect on patients with chronic diseases (Lee et al., 2012). A low level of physical activity is also known to be a risk factor for low back pain (Salminen et al., 1999). A previous study revealed that the intensity and prevalence of low back pain increased during the pandemic when compared to the pre-pandemic period. Moreover, the intensity of pain in patients with chronic low back pain increased during the COVID-19 pandemic, especially during periods of lockdown. In addition, a higher prevalence of low back pain was reported in the adult population. (Papalia et al., 2022) This may also have been due to changes in daily activities caused by the pandemic and lockdown. In patients with degenerative spine diseases, reduced physical activity is known to be a predisposing factor for the onset of back pain (Heneweer et al., 2011).

The incidence of lumbar disc herniations, back contusions and lumbar spine fractures remained at the same level when compared to the reference years, indicating that patients with severe back pain still visited the ED at a similar rate than before the pandemic.

Consequently, the incidence of hospitalisations and spine surgeries remained stable during the study period in comparison to previous years. This supports the finding that the same numbers of patients with severe pain and prominent symptoms visited the ED unit despite the pandemic and social restrictions. A similar finding was reported in a previous study from the UK that reported the number of surgical decompressions performed for cauda equina syndrome did not change during the first months of the COVID-19 pandemic. However, according to the findings of that study, a considerable decrease was seen in the number of electronic referrals due to cauda equina syndrome and degenerative spinal conditions. (Jayakumar, Ferguson, et al., 2020) This indicates that during the pandemic, patients with critical neurological symptoms and severe reasons for back pain were treated appropriately despite the pandemic and lockdown restrictions. Our findings support this evidence.

Increased surgical cancellation rates and a decline in the number of operations, especially elective operations, have been reported during the COVID-19 pandemic (Bajunaid et al., 2020; Giorgi et al., 2020; Jean et al., 2020). The stable number of urgent spine surgeries suggests that the cancellation of elective spine surgeries did not lead to patients on surgery waiting lists shifting to emergency cases. Increased waiting times did not cause a worsening of the patients' spine disease. However, it is possible that some of the scheduled elective operations were reorganized and performed as emergency surgeries.

Further research should be undertaken to identify those acute low back pain patients in EDs who really need urgent hospital evaluation. Diagnostic pathways and guidelines are important for identifying patients with serious conditions who need early evaluation in hospital settings.

6.4 Emergency department visits due to TBI and acute neurosurgeries

In this study, the main finding was that a decrease was seen in the incidence of ED visits due to traumatic brain injury (TBI) after the declaration of a national lockdown in March 2020, with the lowest incidence being observed in April. Thereafter, the incidence rebounded back to the same level as in previous years. This rebound may have been seen the result of various changes that happened in peoples' behaviour. First, the actual incidence of TBI may have decreased. However, a previous study reported that the incidence of TBI and SAH patients remained the same during the first wave of the pandemic at Helsinki University Hospital. In Finland, the Helsinki area was the most affected by the COVID-19 pandemic since the borders were closed, moving was restricted and schools and restaurants were closed. (Luostarinen et al., 2020)

The other reason may be that during the lockdown most sport and leisure activities were banned, and citizens were encouraged to work from home. Since people spent more time at home, commuting and traffic volumes decreased, and the number of road traffic accidents decreased. Second, some patients with mild TBI/concussion may have avoided seeking medical intervention since people were told to avoid unnecessary ED visits. These changes may have been some of the main factors causing the changes in incidence rates. Moreover, other studies from the first wave of the pandemic have reported similar findings (Figueroa et al., 2021; Horan et al., 2021; Karthigeyan et al., 2021; Rault et al., 2021; Santing et al., 2020). For example, a recent study from Ireland reported a 17% decrease in trauma referrals during the pandemic when compared to a previous year (Horan et al., 2021). In Normandy, France, the incidence of severe TBI admissions to ICU decreased by 33% during the first COVID-19 lockdown. Furthermore, according to a previous study, a remarkable change was seen in the aetiology of TBI with fewer road traffic accidents but more alcohol-related TBIs. (Rault et al., 2021) A similar 36% decrease in TBI referrals was reported in the Netherlands. (Santing et al., 2020) However, in India and the United States, a 60% decrease in the incidence of head injuries during lockdown was reported. (Figueroa et al., 2021; Karthigeyan et al., 2021)

In Finland, a second decrease in the incidence of ED visits due to TBI was seen during the second wave of the COVID-19 pandemic in December. During the national lockdown, the opening hours of restaurants and bars were restricted, which may have resulted in individuals consuming less alcohol. Moreover, the place of alcohol consumption may have shifted from bars to the home. Consequently, this may have led to a decreased incidence of TBIs, as alcohol is a risk factor for TBI (Weil et al., 2018).

In our current study, we found that the incidence of trauma craniotomies and craniectomies decreased during the period of restaurant restrictions. The lowest incidence was seen in May. However, when the restaurants reopened in June, the incidence of trauma craniotomies and craniectomies rebounded back to the same level as in the reference years. A reduction in the number of TBIs may have led to fewer emergency neurosurgeries. Therefore, a decreasing trend in the incidence of trauma craniotomies and craniectomies may be linked to the decrease in the number of TBIs. Previous research has reported a reduction in elective neurosurgery during the COVID-19 pandemic (ElGhamry et al., 2021; Grassner et al., 2021; Jayakumar, Kennion, et al., 2020; Patel et al., 2020). Elective operations were postponed or cancelled to prioritise healthcare resources and to reduce non-urgent operations. Similar findings have been reported in the field of emergency neurosurgery (Sharma et al., 2021). However, according to previous research from Helsinki, Finland, nationwide restrictions did not lead to a decrease in the number of patients with TBI who were treated neurosurgically. The total number of emergency and non-emergency neurosurgical operations was lower during the pandemic than in previous years. (Luostarinen et al., 2020)

6.5 Intensive care units

According to the findings of this study, the incidence of all-cause ICU admissions decreased during the first wave of the COVID-19 pandemic in 2020. The number of COVID-positive patients admitted to ICU units was only 3% in 2020 and 2021, being highest in April 2020. During the period of social distancing measures and restrictions, the spread of other respiratory infections decreased. As respiratory infections are one of the most common reasons for admission to ICU units, a reduction in their spread may have resulted in a decrease in ICU admissions. Similar findings have been reported in previous studies. (Chen et al., 2022; Chu et al., 2020)

The results of our current study show that the most remarkable change in all-cause ICU admissions during the lockdown in 2020 was reported at Mikkeli Central Hospital. During 2021, the incidence of ICU admissions remained lower than in previous years, whereas an increase was seen in Central Finland Central Hospital, which is a larger hospital. Based on the results of this study, the incidence of ICU admissions due to severe diseases of the respiratory system decreased during the pandemic. Furthermore, during the national lockdown in Finland in 2020, a decrease was reported in the number of emergency department visits and hospital inpatient admissions, which may also have had an effect on the number of ICU admissions (Kuitunen et al., 2020; Tuominen et al., 2020).

During the COVID-19 pandemic, the number of patients requiring intensive care due to coronavirus infection remained low in Finland (*Koronatilastot*). This may have been the result of the measures and restrictions implemented in Finland. Moreover, the incidence of coronavirus was lower in Finland in 2020 and 2021 than in the majority of other European countries.

In this study, the most remarkable change in ICU admissions was seen in diseases of the nervous system, diseases of the respiratory system and neoplasms. The incidence of ICU admissions due to diseases of the nervous system was lowest in 2020 but increased notably in 2021. However, the incidence of ICU admissions due to neoplasms decreased in 2020 when compared to the reference years even though a slight increase was seen in 2021. Admissions to ICU due to neoplasm included patients who have malignant tumours and have undergone oncological surgery. Based on the findings of a previous study, the incidence of oncological surgery decreased slightly when the lockdown started in Finland but remained at the level of previous years (Kuitunen et al., 2021). Because of the need for isolation and more equipment, caring for COVID-positive patients requires more ICU capacity than for other patients. Therefore, the total number of patients treated at the same time in ICUs may have been limited.

Based on the findings of previous studies, a decrease was seen in the number of ED visits due to acute coronary syndrome during the first wave of the COVID-19 pandemic (Olié et al., 2021; Pines et al., 2021; Uimonen, Ponkilainen, et al., 2022). A reduced willingness to visit ED units because of the fear of infection and delayed medical intervention may have resulted in a worsening of the patients' cardiac disease. During the second wave of the pandemic, this may have been reflected in an increased number of ICU admissions.

The incidence of trauma-related ICU admissions remained at the same level during the pandemic as in previous years. Based on a previous Finnish study, however, a 16% decrease was seen in the number of emergency department visits due to injury during the national lockdown in 2020 (Nygren et al., 2022). Nevertheless, during the first wave of COVID-19 in Finland, the incidence of severely injured trauma patients remained at the same level as in previous years (Riuttanen et al., 2021). The number of minor injuries may have decreased because peoples' behaviour changed as a result of social restrictions and recommendations to stay at home. However, the findings of Study V indicate that the number of severe traumas and patients requiring ICU treatment because of serious injury remained stable. In the literature, similar findings of the rate of severe traumas decreasing or remaining stable during the COVID-19 pandemic have been reported globally (Giudici et al., 2021; van Aert et al., 2021; Walline et al., 2021).

6.6 Strengths and limitations

6.6.1 Strengths of the study

The main strengths of our study are the following.

All the studies of this dissertation aimed to evaluate the impact of the COVID-19 pandemic on emergency departments during an extraordinary global situation. When the study began, there was a lack of literature investigating this currently topical issue. Our first publications were released during the early pandemic period when knowledge regarding the consequences of the new pandemic was still limited. We included the broad patient material from three large Finnish hospitals. The data were comprehensive, and all adult patients who were admitted to the three hospitals with certain symptoms during the study period were collected. In general, Finnish hospital register data demonstrate a high level of quality.

Furthermore, we had specific information on the national pandemic restrictions in Finland, which were similar in all the study hospitals during the first wave of the COVID-19 pandemic.

In later studies, we were able to evaluate the impact of re-opening and the lifting of restrictions during the second wave.

6.6.2 Limitations of the study

The studies included in this dissertation have several limitations. In Studies I-IV, we aimed to collect all emergency department visits due to abdominal pain (Study I-II), back pain (Study III) and traumatic brain injury (Study IV) from three large hospitals. Although most patients who live in the catchment area of the study hospitals visit the ED unit of these hospitals in cases of acute pain or injury, the data from those patients who received treatment in primary healthcare and were not admitted to hospital are possibly lacking. Since abdominal pain, back pain and traumatic brain injury are also common reasons for admission to an ED in primary healthcare, the risk of information bias should be considered.

In Studies I and II, one source of uncertainty is the assumption that milder forms of acute appendicitis may undergo spontaneous resolution and these patients may not seek medical intervention.

In Study II, the ICD-10 diagnostic codes for back pain only include specific codes and do not accurately define symptoms. Therefore, non-specific back pain includes a variety of symptoms and information bias should be considered.

Owing to the retrospective register-based study design, we were unable to separately study the different severities of TBI in Study IV. Moreover, due to uncertainty related to the reliability of ICD-10 and NOMESCO coding and the register-based design, we only included craniotomies and craniectomies and excluded all other neurosurgical traumas.

In Study V, we only analysed treatment periods according to the patient's primary diagnosis. Therefore, some patients may have had more than one diagnosis and reason for ICU stay, and this information is lacking. Since we only collected patients according to their primary diagnosis, this may have affected the number of patients in the ICD coded groups and may have caused information bias.

7 SUMMARY AND CONCLUSIONS

Study I

In conclusion, the findings of Study I show that the incidence of ED visits due to abdominal pain decreased after the declaration of national lockdown in all participating hospitals, being the lowest in March and May (during the lockdown). The incidence rebounded towards its previous level when the lockdown ended in June. The second decrease in the incidence of ED visits was seen in December during the second wave of the pandemic. The change in the number of ED visits due to abdominal pain was mostly described by a decreased incidence of nonspecific abdominal pain. According to the findings of this study, the incidence of abdominal surgeries remained stable during the COVID-19 pandemic.

Study II

In this study, we provided a more detailed information of the impact of the COVID-19 pandemic on abdominal pain, specifically focusing on acute appendicitis. According to our findings, 12% of patients with abdominal pain had a clinical diagnosis of acute appendicitis. After the declaration of the national lockdown, the number of abdominal pain visits decreased by 30% and remained lower in week 1. In week 2, however, the number of visits rebounded towards previous levels. The incidence of complicated appendicitis did not change during the COVID-19 pandemic. All patients diagnosed with acute appendicitis underwent emergency surgery, except for one patient who underwent antibiotic treatment. Patients' age, Charlson Comorbidity Index distribution, gender ratio and pre-hospital symptom duration all followed a similar trend after the lockdown. Moreover, there was no change in preoperative laboratory findings. Complications based on the Clavien-Dindo Classification followed a similar trend before and after the lockdown.

Study III

In Study III, we found that a decrease was seen in the incidence of ED visits due to back pain during the first wave of the COVID-19 pandemic. The incidence was lowest in March and then rebounded back to its previous level in June. Thereafter, a further decrease was seen during the second wave of the pandemic in November. The decrease was mostly described in the incidence of nonspecific back pain. However, the incidence of urgent spine surgeries and hospitalisations did not change during the COVID-19 pandemic. Moreover, the incidence of the most common spine surgery, disc surgery, followed a similar trend both during the study period and the reference years.

Study IV

After the declaration of the national lockdown in spring 2020, the incidence of ED visits due to TBI decreased, being lowest in April. When the lockdown ended, the incidence of ED visits rebounded back to its previous level. However, a second decrease was reported after the declaration of regional restrictions in December. Concussion and traumatic subdural haemorrhage were the most common reasons for ED visits due to TBI. In the field of neurosurgery, the incidence of trauma craniotomies and craniectomies decreased in April during the restrictions on restaurants and was lowest in May. When the restaurants reopened in June, the incidence rebounded back to the same level as in previous years. During the second wave of the pandemic, the incidence remained at the same level when compared to the reference years.

Study V

According to the findings of Study V, the incidence of ICU admissions for all causes decreased during the national lockdown in response to the COVID-19 pandemic. The most prominent change in ICU admissions was seen in the incidence of diseases of the nervous system, the incidence of diseases of the respiratory system and the incidence of neoplasms. Only 3% of COVID-19 patients required intensive care during the years 2020 and 2021. When the lockdown measures began in Finland, a slight reduction was reported in the incidence of oncological surgery and the incidence of ICU admissions due to neoplasms. However, the incidence of ICU admissions related to traumatic events remained at the same level during the pandemic compared to previous years. Furthermore, no changes were seen in the length of ICU stay during 2020 and 2021 when compared to previous years.

Indications for future studies

The results of this study suggest that ED visits due to minor conditions, such as nonspecific abdominal pain and nonspecific back pain, decreased during the pandemic period. A decrease was also seen in the incidence of minor head traumas. ED visits due to severe conditions remained at a similar level during the pandemic. Therefore, further research could evaluate the number of patients who really need urgent medical evaluation and hospital care to better allocate hospital and ED resources during future pandemics. To the best of our knowledge, the consequences of earlier pandemic outbreaks have not previously been evaluated in Finland and it would, therefore, be useful to investigate the results of these outbreaks on ED units.

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PUBLICATION
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Trends in acute abdominal pain visits to EDs and rate of abdominal surgeries during the COVID-19 pandemic in Finland: A retrospective register study

Jäntti Saara, Ponkilainen Ville, Kuitunen Ilari, Hevonkorpi Teemu, Paloneva Juha, Ukkonen Mika, Mattila Ville

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Trends in acute abdominal pain visits to EDs and rate of abdominal surgeries during the COVID-19 pandemic in Finland: A retrospective register study

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COVID-19, abdominal pain, abdominal surgery, emergency, lockdown

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As the COVID-19 pandemic led to restrictions in Finland, the emergency department (ED) visits decreased and during the first 6 weeks, a 12%-decrease was observed in gastrointestinal diseases.[1,2] Previously, we have reported that the rate of acute appendicitis decreased during the first wave of the pandemic, yet prominent changes in the rate of complicated appendicitis were not observed.[3] A recent study in Finland showed that the incidence of emergency surgery remained stable both before and after the declaration of national lockdown.[4] The aim of this study was to evaluate the rate of ED visits due to acute abdominal pain and abdominal surgeries during the first and second waves of the COVID-19 pandemic.

Three large Finnish hospitals (Tampere University Hospital, Mikkeli Central Hospital, and Central Finland Hospital) covering a catchment area of 900,000 inhabitants participated in this study. We collected the number of ED visits due to abdominal pain in adult patients from hospital registers. Inclusion was based on the International Classification of Diseases—10th Revision (ICD-10) and the list of included diagnosis codes is in Supplemental Appendix 1. Acute abdominal surgeries were retrospectively collected from hospital registers and classified by using NOMESCO Classification of Surgical Procedures (NCSP) procedure codes (Finnish version). All procedure codes in the J group (digestive system and spleen) were included. The monthly incidences with 95% confidence intervals (CIs) were calculated, and 2020 (study period) was compared to reference period (2017–2019) by incidence rate ratios (IRRs). Analyses were performed using *R* version 3.6.2 (*R* Foundation for Statistical Computing, Vienna, Austria).

The incidence of ED visits due to abdominal pain in all the participating hospitals decreased after the declaration of the national lockdown in spring 2020 (Fig. 1A). The incidence of ED visits during the study period compared to the reference years was similar in February (IRR: 1.08, CI: 0.99–1.18), but a decrease in the ED visit rate was seen in March (IRR: 0.84, CI: 0.77-0.92) when the lockdown was first declared. The incidence of ED visits was similar compared to the reference years in December during the second wave of the pandemic (IRR: 0.95, CI: 0.88–1.03). Nonspecific abdominal pain, the most common reason for admission to ED unit, decreased in April (IRR: 0.67, CI: 0.59–0.75) but were similar compared to the reference years in June (IRR: 0.91, CI: 0.82–1.01). Moreover, the incidence of the other diagnostic groups (appendicitis, cholelithiasis,

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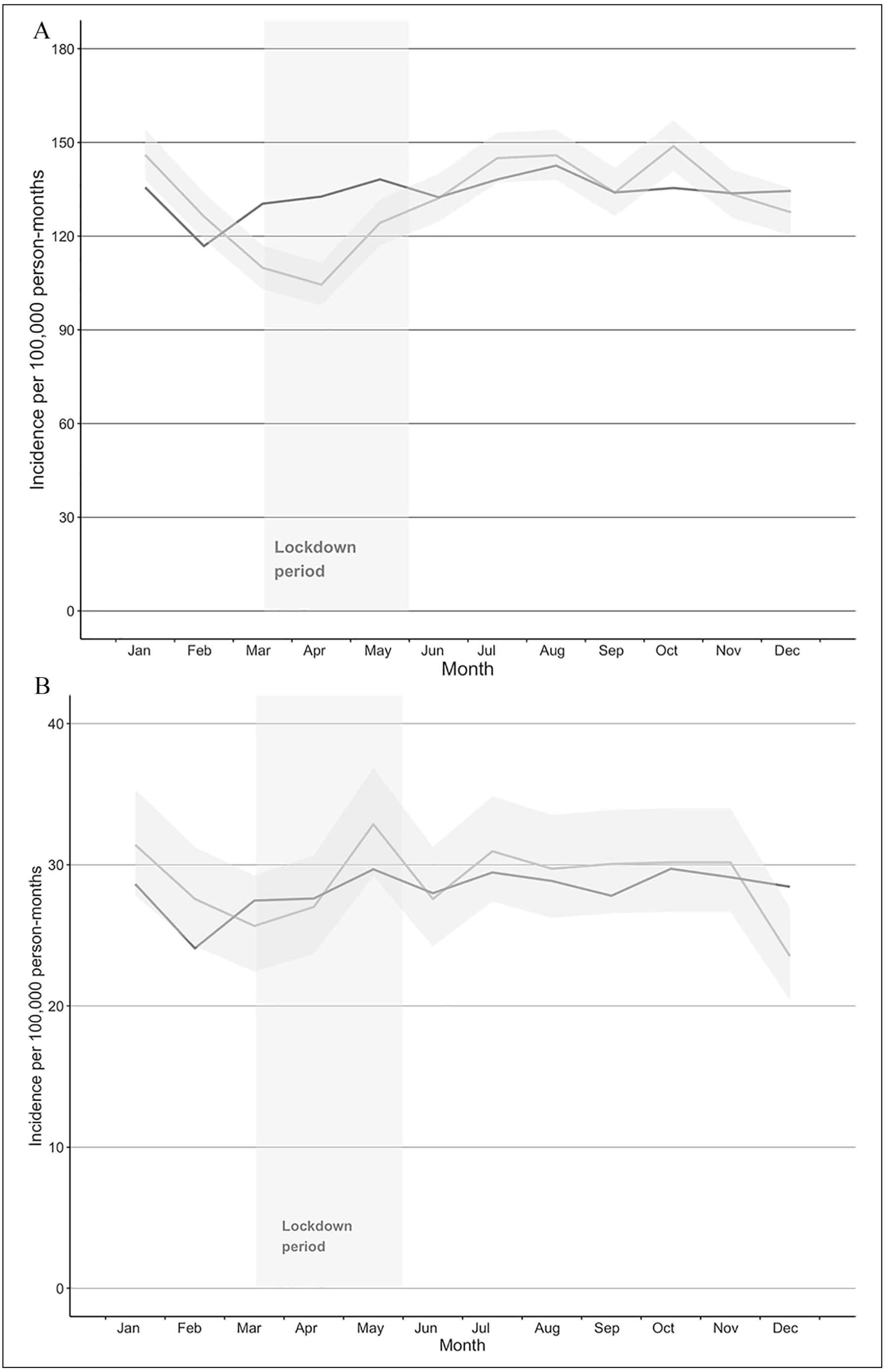

Fig. 1. Incidence of all visits (A) and surgeries (B) to the ED unit due to acute abdominal pain. The light line illustrates the study period (2020) with confidence intervals and the dark line illustrates mean of incidences in the reference years (2017–2019).

hernia, and pancreatitis) remained at a similar level both during the study period and the reference years. The IRR of acute abdominal surgeries remained at the same level in comparison to the reference years after the announcement of the national lockdown, being 0.93 (CI: 0.78–1.12) in March (Fig. 1B). The incidence of acute abdominal surgeries was similar during the study period in comparison to previous years until December, when a decrease occurred (IRR: 0.83, CI: 0.69–0.99). During the first wave of the pandemic, the incidence of laparotomy, laparoscopic cholecystectomy and laparoscopic appendectomy stayed at the same level when comparing 2020 and the reference years.

Previous studies have shown that the number of ED visits decreased during the early stage of the COVID-19 pandemic.[1,5,6] However, most studies have only investigated the impact of the early pandemic period and knowledge of ED visits due to acute abdominal pain, and the impact of the second wave of the pandemic is lacking. In this study, the change was seen in visits due to nonspecific abdominal pain, which was the most common reason for admission to the ED units. The fear of contracting COVID-19 seems to have resulted in citizens avoiding or postponing ED visits, especially those patients with milder symptoms. When comparing the most common abdominal surgeries, no major conclusions can be drawn.

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Author contribution

V.M., M.U., and V.P. conceived of the presented idea. S.J. and V.P. designed and performed the data analysis and analyzed the data. S.J. wrote the manuscript with input from all authors. V.M., V.P., I.K., M.U., T.P.H., and J.P. provided critical feedback, discussed the results, and helped shape the research and manuscript. V.M. and V.P. supervised the project.

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Supplemental material

Supplemental material for this article is available online.

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PUBLICATION
II

Trends in appendicectomy during the COVID-19 pandemic

Jäntti Saara, Ponkilainen Ville, Kuitunen Ilari, Hevonkorpi Teemu, Paloneva Juha, Ukkonen Mika, Mattila Ville

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Research Letter

Trends in appendicectomy during the COVID-19 pandemic

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Dear Editor

It has commonly been thought that fear of contracting COVID-19 has led patients to postpone seeking emergency care, although according to a previous study[1], the rates of acute surgery remained stable during the lockdown. One of the most common reasons for seeking emergency care is acute abdominal pain, and acute appendicitis is one of the most common causes of such pain[2,3]. The effect of the national lockdown, social restrictions and fear of COVID-19 on the rate of appendicectomy remains unclear.

This study was conducted in three large Finnish hospitals (Tampere University Hospital, Mikkeli Central Hospital and Central Finland Hospital) between 1 February 2020 and 30 April 2020. These hospitals provide healthcare services in a catchment area of approximately 900 000 inhabitants. Patient data were collected from the electronic medical record systems of the participating hospitals using ICD-10 diagnostic codes (K35.0, acute appendicitis with generalized peritonitis; K35.1, acute appendicitis with peritoneal abscess; and K35.9, acute appendicitis, other and unspecified) and the (Nordic Medico-Statistical Committee (NOMESCO) Classification of Surgical Procedures[4] procedure codes (JEA00, appendicectomy; and JEA01, laparoscopic appendicectomy). Complicated appendicitis was defined as perforation or abscess verified in surgery or by CT. The presence of an appendicolith on CT without abscess or perforation of the appendix was defined as uncomplicated appendicitis. Patient visits and rate of perforated appendicitis were analysed in 1-week time periods. In statistical analysis, the Mann–Whitney *U* test and the χ^2 without Yates' correction were used. Analyses were performed using SPSS® Statistics version 26 (IBM, Armonk, NY, USA) and R version 3.6.2 (The R Foundation for Statistical Computing, Vienna, Austria).

During the 13-week study period, a total of 257 patients had a clinical diagnosis of acute appendicitis. The proportion of complicated appendicitis in the whole study population was 21.4 per cent (55 patients), and the range was from 9 per cent (in week −4) to 30 per cent (in week −3) (*Fig. 1*). The median prehospital duration of symptoms in patients with acute appendicitis remained at 1 (i.q.r. 0–1) day both before and during the beginning of the lockdown (weeks −1 and 0). However, between weeks 1 and 2, the median prehospital symptom duration increased from 1 to 2 (IQR: 2–3) days. The median length of hospital stay remained at 2 (IQR: 1–2) days during weeks −1 to 2. There was no increase in preoperative laboratory findings (C-reactive protein level and leucocytosis) after the lockdown when societal restrictions were lifted. Postoperative complications based on the Clavien–Dindo classification followed a similar trend before and after the lockdown.

During the study period, the number of patients with acute appendicitis decreased. However, prominent changes in the rate of complicated appendicitis were not observed. The highest rates of complicated appendicitis were observed 3–5 weeks (28–29 per cent) after the start of the lockdown, yet a similar rate was seen in weeks −3 (30 per cent) and 0 (28 per cent). The rate of complicated appendicitis remained higher than usual until the end of the follow-up. Prehospital symptom duration increased slightly in weeks 1 and 2, which may have been the result of social restrictions and citizens avoiding unnecessary emergency department (ED) visits. At the same time, the proportion of acute appendicitis first decreased in week 1 and then rebounded in week 2. This finding might be due to patients waiting longer at home before being admitted to the ED unit. However, this trend was not seen in the rates of complicated appendicitis. In this study,

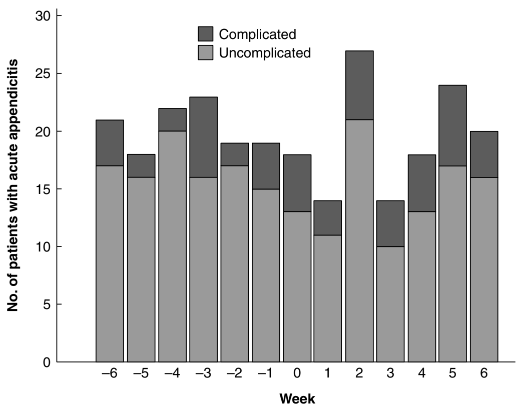

Fig. 1 **Number of patients who had appendicectomy and the proportion with complicated appendicitis over the study period**

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prominent changes in the rate of postoperative complications or laboratory findings were not observed.

In conclusion, the incidence of complicated appendicitis did not change during the COVID-19 pandemic. Although the number of patients with acute appendicitis decreased, prominent changes in the rate of complicated appendicitis were not observed, indicating that patients sought ED help when they had abdominal pain.

Disclosure. The authors declare no conflict of interest.

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PUBLICATION
III

Trends in emergency department visits due to back pain and spine surgeries during the COVID-19 pandemic in Finland

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Observational Study

Medicine

OPEN

Trends in emergency department visits due to back pain and spine surgeries during the COVID-19 pandemic in Finland

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Abstract

We aim to report the incidences of ED visits due to back pain, hospitalizations, and urgent spine surgeries during the first and second waves of COVID-19 in Finland. The number of emergency department visits and hospitalizations due to back pain as well as urgent spine surgeries in the adult population was collected from hospital discharge registers for the years 2017 through 2019 (reference years) and 2020.

This study was conducted at three large Finnish hospitals. The monthly incidence with 95% confidence intervals (CI) of emergency department visits and hospitalizations due to back pain and spine surgeries in the three participating hospitals were calculated and compared by incidence rate ratios (IRR).

Visits to ED due to back pain decreased during the pandemic. The incidence of ED visits due to back pain was similar in February (IRR 0.95, CI: 0.82-1.10), but a decrease was seen after lockdown began (March IRR 0.67, CI: 0.57-0.78; April IRR 0.65, CI: 0.56-0.76) compared to the reference years. A second decrease in visits was seen after regional restrictions were implemented in October (IRR 0.88, CI: 0.76-1.02). The most common diagnoses were non-specific back pain, lumbar disk herniation, and back contusion. Incidence of non-specific back pain decreased during the lockdown (March IRR 0.65, CI: 0.55-0.78) and regional restrictions (October IRR 0.83, CI: 0.70-0.98), whereas the rates of other diagnoses remained unchanged, and incidences of hospitalizations and urgent spine surgeries remained stable.

A clear decrease in ED visits due to back pain was seen during the first and second waves of the pandemic. This decrease was mainly the result of patients with non-specific back pain avoiding visits to the ED. The incidence of specific back pain, hospitalizations, and urgent spine surgeries remained unchanged during the pandemic.

Abbreviations: CI = confidence interval, ED = emergency department, ICU = intensive care unit, IRR = incidence rate ratio, SARS-CoV-2 = severe acute respiratory syndrome coronavirus-2.

Keywords: back pain, COVID-19, emergency, spine surgery, urgent surgery

1. Introduction

The rapid spread of the Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2), more commonly known as COVID-19, has impacted health care across the world.[1] In Finland, the Government declared a state of emergency and national lockdown in March 2020 due to the coronavirus outbreak. Thereafter, guidelines emphasizing social distancing as a necessary strategy to reduce viral spread resulted in a rapid decrease in the number of COVID-19 cases. At the time of the lockdown in March, schools were closed, gatherings were limited to up to 10 persons, and public indoor premises were closed. In addition, traveling was restricted from March to June. Schools were reopened in mid-May.[2]

The second wave of COVID-19 infections began in Finland in the fall of 2020. However, no state of emergency was declared. Instead, targeted regional restrictions were implemented, where

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to the privacy of research patients.

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necessary. Furthermore, the Finnish Institute for Health and Welfare (THL) recommended the wearing of facial masks for individuals 15 years and older in situations where keeping a safe distance was not possible. The epidemiologic situation was divided into three levels: base level, acceleration level, and spreading level.

Back pain is a common complaint in the adult population and also a major cause of emergency department (ED) visits.[3–5] During the first wave of the COVID-19 pandemic, however, a clear reduction in the number of ED visits due to lower back pain was reported.[6,7]

The COVID-19 pandemic also decreased the volume of spine surgeries performed,[8,9] with the exception of the number of surgical decompressions performed for cauda equina syndrome, which did not decrease during the first wave of the COVID-19 pandemic.[10]

The aim of this study is to evaluate the incidence of ED visits and hospitalizations due to back pain and the rates of urgent spine surgery during the first and second waves of the COVID-19 pandemic in Finland.

2. Methods

This study was conducted at three large Finnish public hospitals. Tampere University Hospital (tertiary level unit), Mikkeli Central Hospital (secondary level unit with integrated primary care ED), and Central Finland Hospital (secondary level unit with integrated primary care ED) cover a catchment area of approximately 900,00 inhabitants.[11] The number of emergency department visits and hospitalizations due to back pain as well as emergency spine surgery in the adult population (age 18 or older) was collected from patient information systems using the International Classification of Diseases 10th Revision (ICD-10)[12] diagnostic codes for back pain. As our aim was to include all emergency department visits and operations due to back pain, we gathered all patients with spine specific ICD-10 codes (Table 1). The visits due to back pain were classified into the following groups: non-specific back pain, lumbar disk herniation, back contusion, lumbar spine fracture, spinal stenosis, and thoracic spine fracture. All patients who were admitted to the participating hospitals with back pain in the year 2020 and the years 2017 through 2019 (reference years) were included. Ethical committee approval was not necessary for this study since this is a retrospective study.

Information on and the number of urgent spine surgeries (delay less than 14 days) during the year 2020 and the reference years were retrospectively collected and confirmed from the electronic medical record systems of the participating hospitals using NOMESCO Classification of Surgical Procedures (NCSP)[13] procedure codes (Finnish version). Spine surgeries were classified into the following groups: disk surgery, decompression, fracture, fusion, and other (Table 1).

Hospitalizations were classified into two groups: patients with non-specific back pain and patients with other back pain

Table 1

The classification of ED visits due to back pain and spine surgeries according to diagnostic and procedure codes.

ED visits due to back pain		Spine surgeries	
Non-specific back pain		**Disc surgery**	
M51.9	Unspecified intervertebral disc disorder	ABC16	Excision of lumbar intervertebral disc displacement
M53.8	Other specified dorsopathies	ABC23	Open discectomy of thoracic spine
M53.9	Dorsopathy, unspecified	ABC26	Open discectomy of lumbar spine
M54.0	Panniculitis of back	**Decompression**	
M54.3	Ischias	ABC33	Decompression of thoracic nerve roots
M54.4	Lumbago with sciatica	ABC36	Decompression of lumbar nerve roots
M54.5	Low back pain	ABC53	Decompression of thoracic spinal canal and nerve roots
M54.6	Pain in thoracic spine	ABC56	Decompression of lumbar spinal canal and nerve roots
M54.8	Other dorsalgia	**Fracture**	
M54.9	Dorsalgia, unspecified	NAJ22	External fixation of fracture of thoracic spine
		NAJ30	Internal fixation of fracture of cervical spine
Lumbar disc herniation		NAJ32	Internal fixation of fracture of thoracic spine
M51.0	Intervertebral disc disorders with myelopathy	**Fusion**	
M51.1	Disc disorders with radiculopathy	NAG52	Interbody fusion of thoracic spine with external fixation
		NAG53	Interbody fusion of thoraco-lumbar spine with external fixation
Back contusion		NAG57	Interbody fusion of spine with external fixation
S23.0	Traumatic rupture of thoracic intervertebral disc	NAG62	Interlaminary fusion of thoracic spine without fixation
S23.3	Sprain of ligaments of thoracic spine	NAG63	Interlaminary fusion of thoraco-lumbar spine without fixation
S30.0	Contusion of lower back and pelvis	NAG66	Interlaminary fusion of lumbo-sacral spine without fixation
Lumbar spine fracture		NAG99	Other excision, reconstruction, or fusion
S32.0	Fracture of lumbar vertebra	**Other**	
S32.7	Multiple fracture of lumbar vertebra	NAR00	Incomplete excision of soft tissue tumor of spine
Spinal stenosis		NAR99	Other operation for tumor of spine
M48.0	Spinal stenosis	NAK10	Partial or total excision of vertebra
M47.2	Spondylosis with radiculopathy	NAK99	Other operation of vertebra
Thoracic spine fracture		NAS99	Other operation for infection of tendon, joint, disk or bone of spine
S22.0	Fracture of thoracic vertebra	NAW00	Reoperations on spine and neck
S22.1	Multiple fracture of thoracic vertebra	NAW10	Reoperations on spine and neck
		NAW99	Reoperations on spine and neck

ED = emergency department.

including all other reasons. Monthly incidences with 95% CI were counted per 100,00 person-months by Poisson exact method and compared by incidence rate ratios (IRR). The analyses and figures were performed using R version 3.6.2 (R Foundation for Statistical Computing, Vienna, Austria).

3. Results

A total of 4310 visits due to back pain occurred during the year 2020, and 376 urgent spine surgeries were performed during the same period. The mean age of patients visiting ED unit due to back pain was 54 years and 55% of them were women. For urgent spine surgeries, the mean age of patients was 56 years and 57% of them were men. During the reference years (2017–2019), the mean number of visits due to back pain was 4884 and 307 for urgent spine surgeries.

The incidence of ED visits due to back pain decreased during the first and second waves of COVID-19 pandemic (Fig. 1A). When compared to the reference years, the incidence of visits due to back pain in February 2020 was similar to previous years

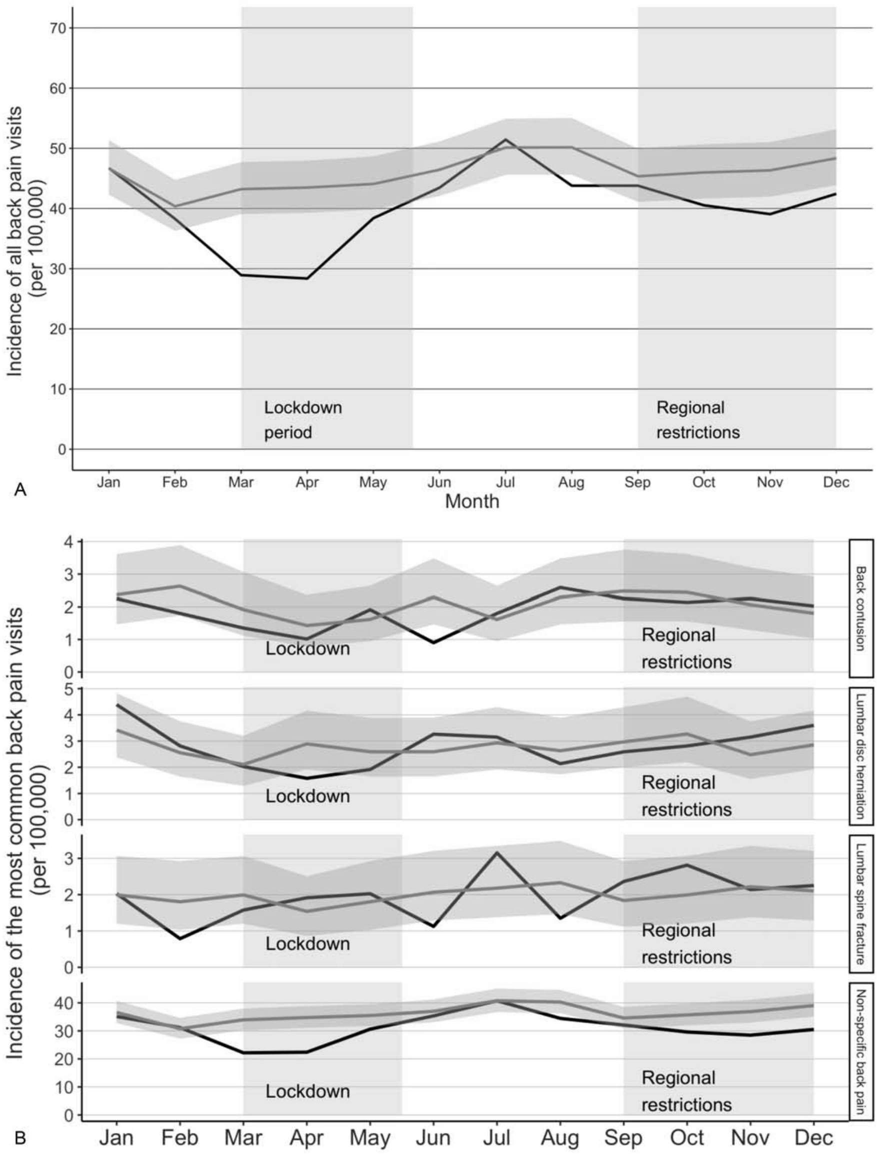

Figure 1. Incidence of all visits due to back pain (A) and the most common visits due to back pain (B) during the COVID-19 pandemic. The dark line illustrates the incidence during the study period (2020) and the lighter line illustrates the mean of incidences in the reference years (2017–2019) with confidence intervals.

(IRR 0.95, CI: 0.82–1.10), but a notable decrease was seen in March (IRR 0.67, CI: 0.57–0.78). The incidence of back pain visits rebounded to its previous level after the lockdown period ended in June, but again showed a slight decrease when regional restrictions were implemented in October (IRR 0.88, CI: 0.76–1.02), with the largest decrease in November (IRR 0.84, CI: 0.73–0.97).

The most common reasons for visits to the ED due to back pain were non-specific back pain, lumbar disk herniation, back contusion, and lumbar spine fracture (Fig. 1B). The incidence of non-specific back pain decreased both during the lockdown and during the regional restrictions. A decrease was first seen from February (IRR 1.01, CI: 0.86–1.20) to March (IRR 0.65, CI: 0.55–0.78). The incidence of non-specific back pain remained at the same level as in the reference years between May and September, but a further decrease was seen in October (IRR 0.83, CI: 0.70–0.98). However, the incidence of lumbar disk herniations, back contusions, and lumbar spine fractures was similar when compared to the reference years.

The incidence of hospitalizations remained stable during the COVID-19 pandemic (Fig. 2). The IRR of hospitalizations in patients with non-specific back pain was 0.68 (CI: 0.42–1.11) during the lockdown in April and 0.83 (CI: 0.53–1.32) during the regional restrictions in October. The IRR of hospitalizations in patients with other back pain was 0.89 (CI: 0.55–1.43) in May and 1.23 (CI: 0.80–1.89) in October.

The incidence of all urgent spine surgeries remained at the same level in comparison to the reference years (Fig. 3A). In the middle of the lockdown in May, the IRR of all spine surgeries was 1.18 (CI: 0.70–2.01). During the regional restrictions, the IRR was at the same level, being 1.19 in October (CI: 0.72–1.97). The most common spine surgeries were disk surgery, decompression, fusion, and fracture (Fig. 3B). The incidence of the most common spine surgeries remained stable during the first and second waves of the COVID-19 pandemic. The IRR of the most common spine surgery, disk surgery, was 1.12 (CI: 0.43–2.91) in May and 1.22 (CI: 0.51–2.95) in October.

4. Discussion

The results of this study show that the incidence of visits to the ED due to back pain decreased during the first and second waves of the pandemic. Previous studies investigating the first wave of the COVID-19 pandemic have reported similar findings.[6,7,14] In February and March, ED and ICU personnel were redeployed due to COVID-19, and citizens were advised to avoid all non-necessary health care visits. These steps likely led to a decreased number of visits to EDs due to nonspecific back pain, which may reflect the decreased willingness of patients with minor conditions to visit the ED. Further, the incidence of lumbar disk herniations, back contusions, and lumbar spine fractures were similar when compared to the reference years, indicating that patients with severe back pain visited the ED at a rate similar to that before the pandemic.

Consequently, during the study period, the incidence of hospitalizations and spine surgeries remained stable in comparison to the reference years. This also supports the finding that similar numbers of patients with severe pain and prominent symptoms were admitted to EDs in spite of the COVID-19 pandemic. A similar finding was reported in a previous study that showed that the volume of surgical decompressions performed for cauda equina syndrome did not decrease during

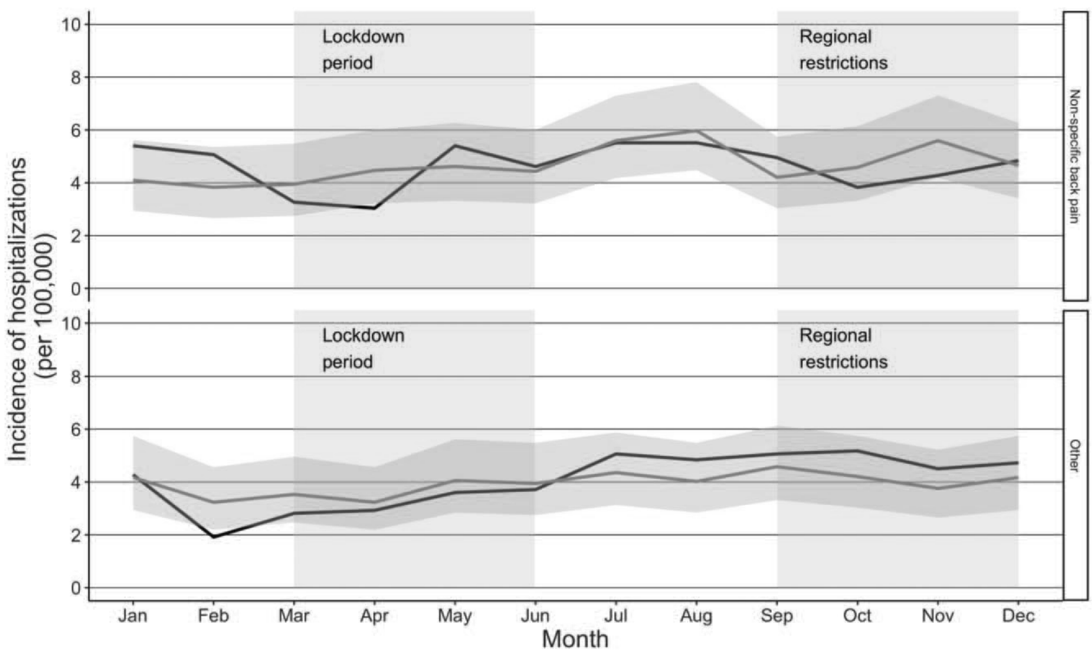

Figure 2. Incidence of hospitalizations during the COVID-19 pandemic. The dark line illustrates the incidence during the study period (2020) and the lighter line illustrates the mean of incidences in the reference years (2017–2019) with confidence intervals.

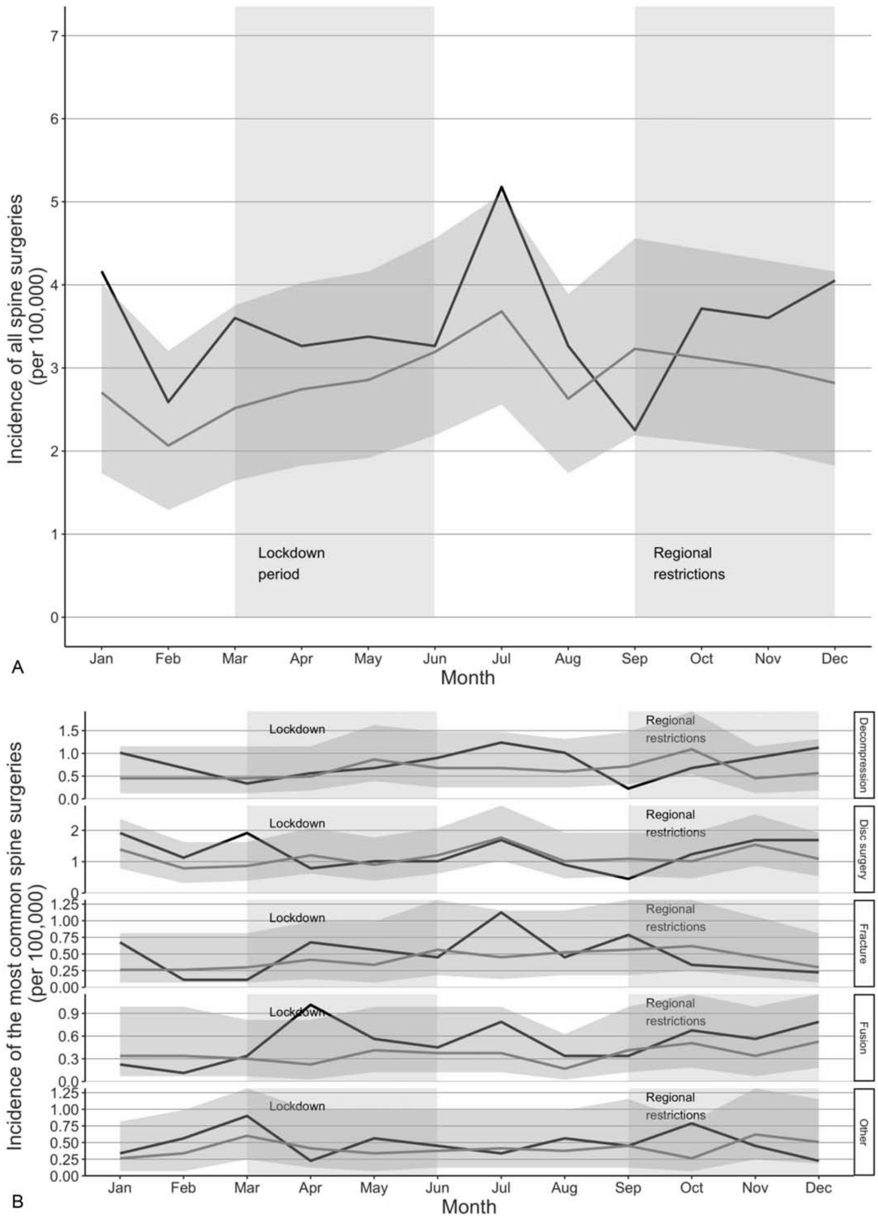

Figure 3. Incidence of all spine surgeries (A) and the most common spine surgeries (B) during the COVID-19 pandemic. The dark line illustrates the incidence during the study period (2020) and the lighter line illustrates the mean of incidences in the reference years (2017–2019) with confidence intervals.

the first wave of the COVID-19 pandemic.[10] However, the literature describing the changes in neurosurgical procedures during the COVID-19 pandemic has reported increased surgical cancellation rates and a decline in the number of operations, especially elective operations.[15–17] The stable number of urgent spine surgeries may indicate that cancellations of elective spine surgery have not caused patients on waiting lists for surgery to shift to become emergency patients. It may also be the case that a some of the elective operations may have been reorganized to emergency operations. However, we did not address this issue in our study.

The strengths of our study include the broad data that included all visits and surgeries due to back pain in three large Finnish hospitals during the years 2017–2020. The data were comprehensive, and all patients within the study hospital districts were admitted to the study hospitals. Furthermore, we were able to collect follow-up data from all patients during the first and second waves of the COVID-19 pandemic. Our current study also has some limitations. The ICD-10 diagnostic codes for back pain only include specific codes and do not accurately define symptoms. Therefore, non-specific back pain includes a variety of symptoms. We were not able to use imaging to categorize the patients since we did not have access to imaging data. Even though we collected all the ED visits due to back pain and all spine surgeries from the three large study hospitals, data from those patients who received treatment only in primary health care and were not admitted to hospital are lacking. However, as all patients with severe symptoms are referred to our study hospitals, the missing data might only concern the number of patients with unspecific, non-severe back pain.

In conclusion, the incidence of ED visits due to back pain decreased during the first wave of COVID-19 pandemic. A decrease was also seen during the second wave of pandemic. The decrease in incidence can be explained by patients with non-specific back pain avoiding visits to the ED. The incidence of hospitalizations and urgent spine surgeries did not, however, change during the pandemic. The results of this study can be used when preparing for future pandemics and additionally when planning ED triage for patients with back pain, as severe cases were still treated during the pandemic.

Author contributions

Data curation: Saara Jäntti, Ville Ponkilainen
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Resources: Saara Jäntti
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Writing – review & editing: Heikki Mäntymäki, Ilari Kuitunen, Mikko Uimonen, Ville Mattila, Ville Ponkilainen

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PUBLICATION
IV

Trends in Emergency Department Visits and Surgeries due to Traumatic Brain Injury During the COVID-19 Pandemic in Finland

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ORIGINAL PAPER

Trends in Emergency Department Visits and Surgeries due to Traumatic Brain Injury During the COVID-19 Pandemic in Finland

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Abstract

We aim to evaluate the changes in the incidence of TBI, trauma craniotomies, and craniectomies during the COVID-19 pandemic in Finland. This retrospective register study was conducted at three Finnish hospitals. We retrieved the numbers of emergency department (ED) visits, inpatient admissions, and trauma craniotomies and craniectomies due to TBI in the adult population from 2017 to 2020.We calculated the incidences per 100 000 inhabitants and compared the year 2020 to the reference years (2017–2019) by incidence rate ratios (IRR) with 95% confidence intervals. The incidence of TBI-related ED visits during the study period compared to the reference years started to decrease in March 2020 (IRR 0.86, CI: 0.73–1.02), and the lowest incidence was seen in April 2020 (IRR 0.83, CI: 0.68–1.01). The incidence of ED visits showed a second decrease in December (IRR 0.80, CI: 0.67–0.96). The incidence of concussion decreased during the national lockdown in March (IRR 0.80, CI 0.66–0.97). The incidence of ED visits due to TBI decreased after the declaration of national lockdown in spring 2020 and showed a second decrease during regional restrictions in December. In addition, the incidence of neurosurgically treated TBI decreased during restaurant restrictions in the spring.

Keywords Traumatic brain injury · COVID-19 · Neurosurgery · Craniotomy

Introduction

Since the first outbreak of COVID-19 in 2020, elective operations have been regularly postponed and healthcare staff relocated to emergency units in preparation for a possible surge in COVID-19 cases. Following a rapid decrease in the number of COVID-19 cases in May 2020, lockdown restrictions in Finland were lifted at the beginning of June.

Subsequently, a second wave of COVID-19 infections began in the fall of 2020. Although the weekly number of COVID-19 cases during the second wave was higher than in the first, a national lockdown was not initiated, and targeted regional restrictions were implemented instead. The epidemiologic situation was divided into three levels: base level, accelerating level, and spreading level. During the first wave of the COVID-19 pandemic in Finland, restaurants were ordered to close from April to the end of the May 2020. However, restrictions on opening hours and the number of customers allowed in restaurants were still in force during the second wave of the pandemic [1]. During the restrictions, the consumption of alcohol shifted from bars and restaurants to the home, and the volumes of alcohol sold in bars and restaurants decreased. Thus, when compared to alcohol consumption in 2019, a decrease in total alcohol consumption was observed in 2020 [2].

This article is part of the Topical Collection on *Covid-19*

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Traumatic brain injury (TBI) is one of the most common causes for emergency department (ED) admissions [3]. Because an individual is more likely to suffer a head trauma during acute alcohol intoxication, alcohol misuse is a major risk factor for TBI [4]. During the first wave of the COVID-19 pandemic, a decrease in the number of emergency referrals due to TBI was reported by several studies. Travel restrictions, social distancing, cancellation of sport activities, and recommendations to work from home caused a decrease in the rate of accidents since people spent more time at home and, for example, traffic road accidents decreased. These types of accidents are usually at high energy and likely to cause head trauma. Citizens may have also avoided unnecessary ED visits, and patients with mild TBI or concussion may have stayed at home instead of seeking medical care [5–9]. However, some studies also reported that the number of TBI patients admitted to ED units remained the same during the pandemic [10]. Within neurosurgery, however, operating volumes decreased worldwide during the first wave of the COVID-19 pandemic [11–13]. A similar trend was also seen in the number of emergency neurosurgeries [14].

Globally, the COVID-19 pandemic, together with the restrictive measures enacted to prevent the spread of the virus, has had an immense impact on the way of life of many people, resulting in numerous changes in social behavior. For example, many people may now be reluctant to seek medical care due to fear of being exposed to the COVID-19 virus. Moreover, these behavioral changes could fundamentally alter the dynamics of emergency care and further increase the overall risk for sustaining injuries such as TBI. In this study, we evaluate the incidences of TBI, trauma craniotomies, and craniectomies during the first and second waves of the COVID-19 pandemic in Finland.

Material and Methods

This study was conducted at three large Finnish public hospitals. The three hospitals—Tampere University Hospital (tertiary level unit), Mikkeli Central Hospital (secondary level unit with integrated primary care ED), and Central Finland Hospital (secondary level unit with integrated primary care ED)—cover a catchment population of approximately 900,000 inhabitants [15]. The number of ED visits due to TBI in the adult population (18 years or older) was retrieved from the patient information system of the participating hospitals using the International Classification of Diseases 10th Revision (ICD-10) [16] diagnostic codes for TBI: S06.0, S06.1, S06.2, S06.3, S06.4, S06.5, S06.6, S06.7, S06.8, and S06.9. All adult patients who were admitted to the participating hospitals with TBI in 2020, and the years 2017 through 2019 (reference years) were included.

Information on the number of trauma craniotomies and craniectomies (delay of less than 14 days) during 2020, and the reference years were retrospectively retrieved and confirmed from the electronic medical record systems of the participating hospitals using NOMESCO Classification of Surgical Procedures (NCSP) [17] procedure codes (Finnish version). The codes included were AAD00, AAD05, AAD15, and AAK80 combined with the diagnostic code S06*. Only craniotomies and craniectomies due to trauma were included.

Incidences with 95% confidence intervals (CI) were calculated per 100 000 inhabitants by Poisson exact method [18]. The reference population for incidences was calculated using the mean of annual incidence during the years 2017–2019. The crude incidences were compared by incidence rate ratios (IRR) with 95% CI. The statistical analyses were performed using R version 3.6.2 (R Foundation for Statistical Computing, Vienna, Austria).

Results

The total number of ED visits due to TBI during the years 2017 through 2020 was 11 982, and during the reference years (2017–2019), the mean number of visits due to TBI was 3000. In the participating hospitals, a total of 2981 visits due to TBI occurred during 2020. However, after the declaration of a national lockdown in spring 2020, the incidence of ED visits due to TBI decreased (shown in Fig. 1). The incidence of ED visits during the study period compared to the reference years started to decrease in March 2020 (IRR 0.86, CI: 0.73–1.02), and the lowest incidence was seen in April 2020 (IRR 0.83, CI: 0.68–1.01). Once the lockdown ended in June, however, the incidence of ED visits rebounded to its previous level. A second decrease in the incidence of ED visits occurred in December after targeted regional restrictions were implemented (IRR 0.80, CI: 0.67–0.96). Percentual change between the highest IRR in July (IRR 1.26, CI: 1.05–1.50) and the lowest IRR in December (IRR 0.80, CI: 0.66–0.98) was 36% (shown in Table 1).

The most common ICD-10 coded reasons for admission to ED units due to TBI were S06.0 (concussion) and S065 (traumatic subdural hemorrhage). During the years 2017 through 2020, the total number of concussions was 9468, and the total number of traumatic subdural hemorrhage was 1713. During the national lockdown, the incidence of concussion, the most common reason for admission to an ED unit due to TBI, decreased, being at the same level as previous years in February (IRR 0.97, CI: 0.81–1.17). Subsequently, the incidence decreased in March (IRR 0.80, CI: 0.66–0.97) and remained lower until May. During the second wave of the pandemic, the incidence of concussion remained at the same level as in the previous years until December (IRR 0.80, CI: 0.65–0.98). Furthermore, the incidence of the other ICD-10 coded reasons for admission to an ED unit did not change notably.

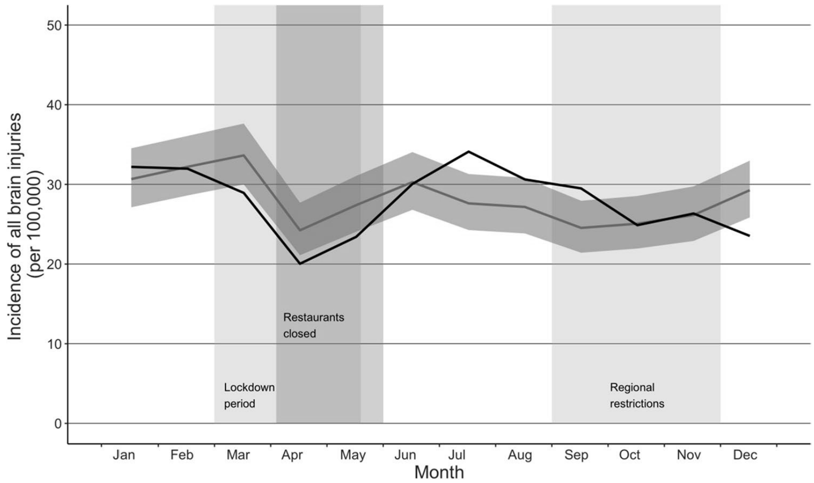


Fig. 1 Incidence of all visits due to TBI during the COVID-19 pandemic. The dark line illustrates the incidence during the study period (2020), and the lighter line illustrates the mean of incidences in the reference years (2017–2019) with confidence intervals

Table 1 Incidence of ED visits due to TBI during the study period (2020) and reference years (2017–2019)

	Study period (2020)		Reference years (2017–2019)				
Month	*N*	Incidence	*N*	Incidence	IRR	Confidence interval	
Jan	256	28.8	234	26.4	1.09	0.92	1.30
Feb	257	28.9	261	29.5	0.98	0.83	1.17
Mar	236	26.6	275	31.0	0.86	0.72	1.02
Apr	161	18.1	187	21.0	0.86	0.70	1.06
May	184	20.7	215	24.2	0.86	0.70	1.04
Jun	246	27.7	234	26.4	1.05	0.88	1.25
Jul	278	31.3	221	24.9	1.26	1.05	1.50
Aug	248	27.9	213	24.0	1.16	0.97	1.39
Sep	237	26.7	191	21.5	1.24	1.03	1.50
Oct	202	22.7	195	22.0	1.03	0.85	1.26
Nov	213	24.0	209	23.6	1.02	0.84	1.23
Dec	182	20.5	226	25.5	0.80	0.66	0.98

When comparing the incidence of ED visits due to TBI in different age groups, a decrease was seen in age group 17 to 40 years old during the lockdown in April (IRR 0.53, CI: 0.33–0.87) when comparing to previous years (shown in Fig. 2). After the first wave of the pandemic, incidence remained to its previous level being 0.85 (CI: 0.58–1.24) in October. In the age group 40 to 60 years, incidence of ED visits due to TBI remained at the same level as previous years during the year 2020. In elderly (60 years or older), incidence was similar to that in previous years until July when an increase was seen (IRR 1.42, CI: 1.12–1.81). Incidence of ED visits due to TBI remained at higher level than in previous years until December, when it set down to the same level as previous years (IRR 0.96, CI: 0.75–1.24). When comparing ED visits by gender, the incidence did not change notably to that in previous years in men, being 0.87 (CI: 0.65–1.15) in May and 1.08 (CI: 0.81–1.43) in October (shown in Fig. 3). In women, incidence was similar to that in previous years until an increase was seen in July (IRR 1.41, CI: 1.10–1.82). After that, incidence remained the same level than previous years, being 0.98 (CI: 0.75–1.29) in October.

The total number of trauma craniotomies and craniectomies during the years 2017 through 2020 was 182. The mean number of operations in the years 2017 through 2019 (reference years) was 46, and the number of operations in 2020 was 45. During the first wave of the COVID-19 pandemic, the incidence of trauma craniotomies and craniectomies was similar to that in previous years until April (IRR 1.90, CI: 0.54–6.75) (shown in Fig. 4). The incidence of trauma craniotomies and craniectomies was lowest in May (IRR 0.15, CI: 0.02–1.23) and rebounded to its previous level in June. During the second wave of the pandemic, the incidence remained at the same level as previous years, being 0.50 (CI 0.12–2.00) in December.

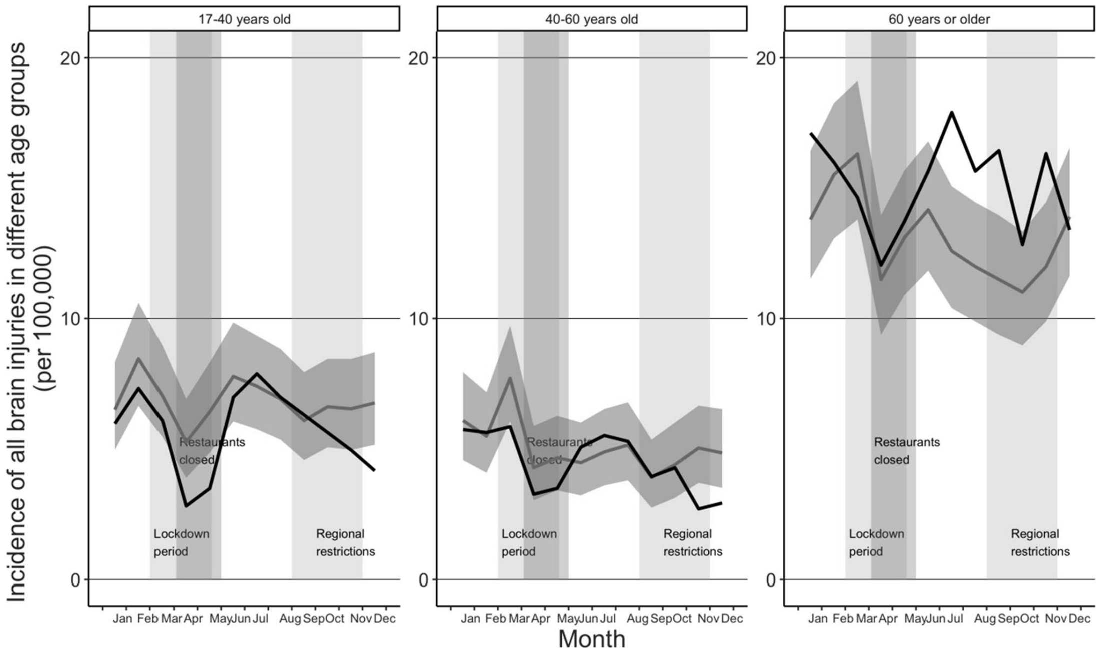


Fig. 2 Incidence of ED visits due to TBI in different age groups during the COVID-19 pandemic. The dark line illustrates the incidence during the study period (2020), and the lighter line illustrates the mean of incidences in the reference years (2017–2019) with confidence intervals

Discussion

According to the findings of this study, the incidence of ED visits due to TBI decreased after the declaration of a national lockdown in March 2020, with the lowest incidence being observed in April. Thereafter, the incidence rebounded to the same level as in the reference years. This rebound may have been the result of various changes in peoples' behavior. First, the actual incidence of TBI may have decreased. In addition, most sport and leisure activities were banned during the lockdown, and people were encouraged to work from home. As a result, commuting and traffic volumes decreased, and fewer traffic accidents occurred. Second, citizens were told to avoid unnecessary ED visits, and thus some of the patients with mild TBI/concussion may have avoided seeking medical treatment. These changes may therefore have been some of the main factors behind the changes in incidence rates. Previous studies concerning the first wave of the pandemic have reported similar findings [5–9].

During the second wave of the COVID-19 pandemic in December, the incidence of ED visits due to TBI showed a second decrease. Restaurant and bar restrictions during the national lockdown may have resulted in individuals consuming less alcohol or shifting the place of alcohol consumption from bars to their home. This may, in turn, have led to a decreased incidence of TBIs, as alcohol is a major risk factor for TBI [4].

In the present study, we found that the incidence of trauma craniotomies and craniectomies decreased during the period of restaurant restrictions, being the lowest in May. When the restaurants reopened in June, the incidence of trauma craniotomies and craniectomies rebounded to the same level as in previous years. A decreasing trend in the incidence of trauma craniotomies and craniectomies may be linked to the decrease in the number of TBIs, since fewer TBIs may have led to a reduction in emergency neurosurgery. Indeed, reductions in elective neurosurgery during the COVID-19 pandemic have been reported [11–13, 19], with elective operations canceled or rescheduled to prioritize health care resources and to reduce non-urgent treatment. Similar findings have been reported in emergency neurosurgery [14]. However, according to a previous study from Finland, the nationwide restrictions did not result in a decrease in the number of patients with TBI neurosurgically treated [10].

The strengths of our study include the broad data from three large Finnish hospitals. Furthermore, many previous studies have only evaluated the impact of the first wave of the COVID-19 pandemic. In this study, we were able to collect follow-up data from all patients during the first and second waves of the COVID-19 pandemic and to evaluate the impact of re-opening and restrictions during the second wave. Our current study also has some limitations. Since we aimed to evaluate only trauma patients, we only included specific ICD-10 diagnostic codes. Owing to

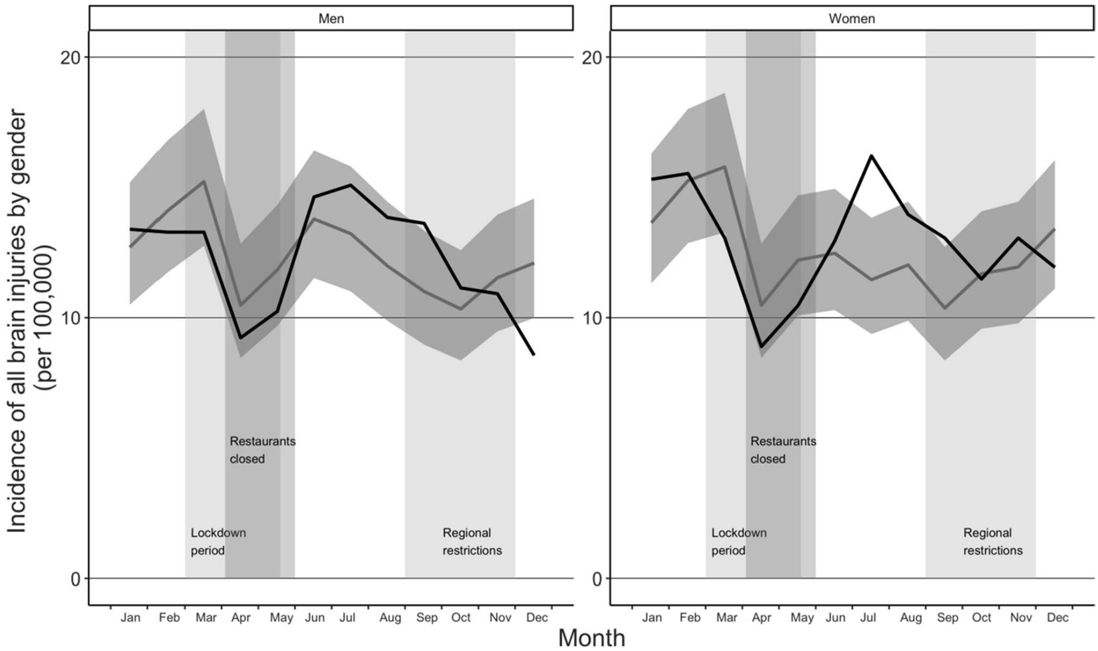
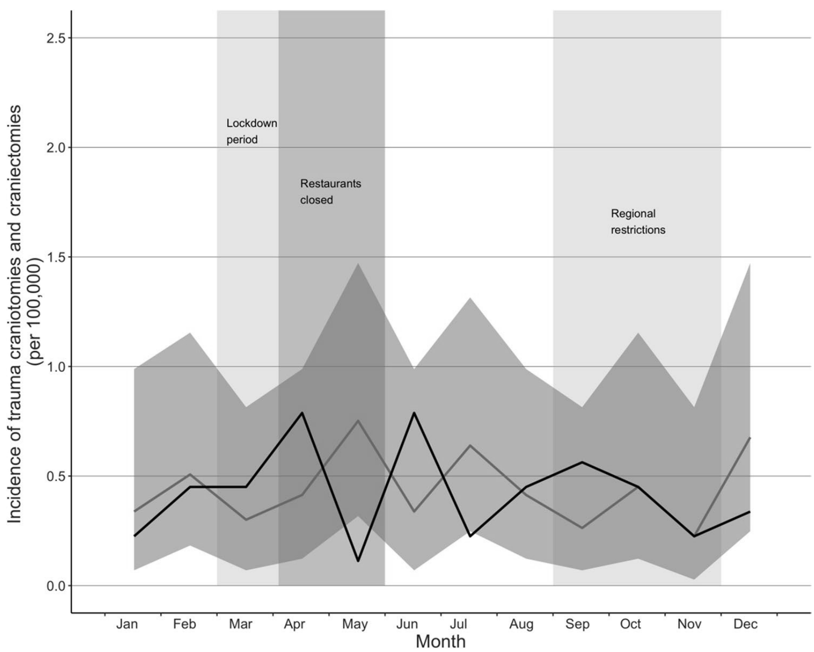


Fig. 3 Incidence of ED visits due to TBI by gender during the COVID-19 pandemic. The dark line illustrates the incidence during the study period (2020), and the lighter line illustrates the mean of incidences in the reference years (2017–2019) with confidence intervals

Fig. 4 Incidence of trauma craniotomies and craniectomies during the COVID-19 pandemic. The dark line illustrates the incidence during the study period (2020), and the lighter line illustrates the mean of incidences in the reference years (2017–2019) with confidence intervals



the retrospective and administrative nature of the present study, we were unable to separately study the different severities of TBI. Moreover, due to the register-based design and uncertainty related to the reliability of ICD-10 and NOMESCO coding, we were only able to evaluate trauma craniotomies and craniectomies, and other neurosurgical traumas were excluded.

In conclusion, the incidence of ED visits due to TBI decreased after the declaration of national lockdown in spring 2020, and a second decrease was observed after the implementation of regional restrictions in December. In addition, the incidence of trauma craniotomies and craniectomies decreased during the restaurant restrictions implemented in the spring. As expected, the COVID-19 pandemic and nationwide restrictions resulted in a decreasing trend in the incidence of ED visits due to TBI and neurosurgically treated TBI.

Author Contribution V.M., T.L., and V.P. conceived of the presented idea. S.J. and V.P. designed and performed the data analysis and analyzed the data. S.J. wrote the manuscript with input from all authors. All authors provided critical feedback, discussed the results, and helped shape the research and manuscript. V.M. and V.P. supervised the project.

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Data Availability Research data are not publicly available due to Finnish research legislation as the Law on the secondary use of routinely collected healthcare data prohibits to share data.

Declarations

Ethics Approval According to Finnish research legislation, ethical approval was not needed due to the register-based study design, as the participants were not contacted. This study has the research permission of each participating hospital (Tampere University Hospital, Mikkeli Central Hospital and Central Finland Hospital).

Consent to Participate Not required due to the register-based study design.

Consent for Publication Not required due to the register-based study design.

Competing Interests The authors declare no competing interests.

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PUBLICATION
V

Intensive care unit admissions with and without COVID-19 in Finland from 2017 to 2021: a retrospective register-based study

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RESEARCH

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Intensive care unit admissions with and without COVID-19 in Finland from 2017 to 2021: a retrospective register-based study

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Abstract

Background After the COVID-19 pandemic started, critical care resources were expanded in Finland to manage a possible surge in patients requiring intensive care. The aim of this study was to evaluate the incidence of overall ICU admissions, patient diagnoses, characteristics, and length of stay during the pandemic.

Methods This retrospective hospital register-based study was conducted in two large and one mid-size Finnish public hospitals. The required data were collected from ICU patient information systems and all adult patients were included. Monthly and yearly incidences with 95% confidence intervals (CI) were counted per 100 000 persons-years by Poisson exact method and compared by incidence rate ratios (IRR).

Results A total of 4407 admissions to ICUs for any cause occurred during 2020. In 2021, this figure was 4931. During the reference years (2017–2019), the mean number of admissions to ICU was 4781. In 2020 and 2021, the proportion of patients requiring intensive care due to COVID-19 was only 3%. The incidence of all-cause ICU admissions decreased during the lockdown in 2020 when compared to the reference years. Before the start of the lockdown in February 2020, the IRR of all-cause ICU admissions was 1.02 (CI: 0.89 to 1.18). During the lockdown period, however, the IRR of all-cause ICU admissions decreased to 0.78 (CI: 0.67 to 0.90) in March. When the lockdown ended, the incidence rebounded to the same level as before the lockdown. However, in 2021, the incidence of ICU admissions remained at the same level when compared to the reference years. The most prominent changes occurred in the incidence of diseases of the nervous system, which includes epilepsy and seizures and transient cerebral ischemic attacks, in diseases of the respiratory system, and neoplasms.

Conclusions According to the findings of this study, the incidence of all-cause ICU admissions decreased after the lockdown was implemented in 2020. Furthermore, the percentage of patients requiring intensive care due to COVID-19 in Finland was only 3% in 2020 and 2021. These findings may serve to help in the planning and allocating of ICU resources during future pandemics.

Keywords COVID-19, Intensive care unit, Critical care

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Background

During the COVID-19 pandemic, ICUs worldwide have faced numerous challenges. The increasing number of COVID-19 patients and a high number of patients requiring respiratory support, in addition to other patients requiring ICU treatment, have placed high demands on ICU capacity [1]. At the start of the pandemic in Finland, critical care resources were expanded to deal with a possible surge in COVID-19 patients requiring intensive care. The number of ICU admissions due to COVID-19 began to increase in March 2020. In Finland, the peak prevalence in ICU admissions in patients who tested positive for COVID-19 was 1.5 per 100 000 in April 2020. The largest number of patients needing ICU treatment was 83 patients on April 7, 2020. Thereafter, the prevalence remained below 0.90 per 100 000 (50 patients) during subsequent waves of the pandemic [2].

During the global outbreaks of SARS in 2002–2003 and a novel influenza H1N1 in 2009, a substantial increase in demand of ICU services was reported. According to previous research from New Zealand and Australia, during the H1N1 pandemic in winter 2009 the number of ICU admissions was 15 times the number of admissions due to viral pneumonitis in reference years. In 2002–2003, SARS pandemic created a strain on healthcare systems in Toronto. The supply of critical care staff was limited, and ICU beds were closed which caused limitation of beds for all critical ill patients [3, 4].

To our knowledge, the extent of the changes in overall ICU admissions and the length of ICU stay during the pandemic remains unclear. As the number of patients requiring intensive care due to COVID-19 has remained low during the pandemic in Finland, this is an important issue that needs to be addressed.

Previous literature has yielded conflicting results, as both increases and decreases in non-COVID-19 ICU admissions have been reported [5–7].

Therefore, the aim of this study was to evaluate the incidence of overall ICU admissions, patient demographics, and length of stay during the pandemic. Also, the number of confirmed COVID-19 patients in Finland requiring intensive care during the years 2020 and 2021 was assessed.

Methods

This retrospective hospital register-based study was conducted in two large - Tampere University Hospital (tertiary level unit), and Central Finland Hospital (secondary level unit) and one mid-size - Mikkeli Central Hospital (secondary level) Finnish public hospitals. In total, these hospitals cover a catchment area of approximately 700 000 adult inhabitants (remained unchanged during the study years). During the study period, the mean age in Finnish population was 43 years. In the catchment area of Tampere University Hospital, the mean age of population was 43 years, in Mikkeli Central Hospital catchment area 49 years and in Central Finland Hospital catchment area 43 years. The distribution by gender was similar in all areas, 50% were men and 50% women [8]. The required data were collected from the ICU patient information systems of the three hospitals. All adult patients (aged 18 or older) who were admitted to the ICUs of the participating hospitals in 2020 and 2021 were included. As a reference, we used ICU admissions from 2017 to 2019. The classification of patients was done using International Classification of Diseases 10th Revision (ICD-10) diagnostic codes [9]. Data regarding ICU admission was collected using the first diagnosis of a patient and each treatment period was collected only once. The changes in the number of ICU admissions were collected and analyzed in categories based on the ICD-10 diagnostic codes (Table 1). The number of patients who were admitted to ICU and had tested positive for COVID-19 in the years 2020 and 2021 was collected using ICD-10 diagnostic codes starting with U07.1.

Statistical analysis

Monthly and yearly incidences with 95% confidence intervals (CI) were counted per 100 000 person-years by Poisson exact method and compared by incidence rate ratios (IRR). Median and interquartile range (IQR) was calculated for ICU stay duration. The analyses and figures were performed using R version 3.6.2 (R Foundation for Statistical Computing, Vienna, Austria).

Ethics.

Due to the register-based study design, we did not obtain ethical committee evaluation. As the law on the secondary use of routinely collected health care data is rather strict, we did not combine the patient data from the participating hospitals. Instead, we analyzed the data from each hospital separately and then combined the data anonymously.

Results

A total of 4407 admissions to ICU occurred in 2020 and 4931 in 2021. During the reference years (2017–2019), the mean number of admissions to ICU was 4781. A total of 4864 admissions occurred in 2017, 4856 in 2018, and 4624 in 2019. In addition, a total of 110 (2.5% of all ICU admissions) COVID-positive patients were admitted to ICU units in the participating hospitals in 2020. During the year 2021, the number of COVID patients admitted was 141 (2.9% of all ICU admissions). We found three distinctive peaks of COVID patients being admitted to ICU: 27 patients in April 2020, 23 patients in December 2020, and 27 patients in December 2021 (Fig. 1).

When compared to the reference years, the incidence of all-cause ICU admissions decreased during the

Table 1 The yearly number of ICU admissions and incidence in 2020 and 2021 compared to the mean yearly incidence of the reference years (2017–2019) by incidence rate ratios (IRR) with 95% confidence intervals

		2017–2019		**2020**				**2021**		
ICD code	Explanation	N	Inc	N	Inc	IRR (95% CI)		N	Inc	IRR (95% CI)
A. B	Infectious and parasitic diseases	273	37.8	266	36.6	0.97	(0.82–1.14)	250	34.2	0.90 (0.76–1.07)
C. D	Neoplasms. diseases of the blood	608	84.4	534	73.5	0.87	(0.78–0.98)	555	75.8	0.90 (0.80–1.01)
E	Endocrine. nutritional and metabolic diseases	647	89.7	591	81.3	0.91	(0.81–1.01)	602	82.3	0.92 (0.82–1.02)
F	Mental. Behavioral and Neurodevelopmental disorders	212	29.4	202	27.8	0.95	(0.78–1.15)	221	30.2	1.03 (0.85–1.24)
G	Diseases of the nervous system	219	30.4	194	26.7	0.88	(0.72–1.06)	352	48.1	1.58 (1.34–1.87)
I	Diseases of the circulatory system	1542	213.8	1429	196.7	0.92	(0.86–0.99)	1711	233.8	1.09 (1.02–1.17)
J	Diseases of the respiratory system	163	22.6	125	17.2	0.76	(0.60–0.96)	116	15.9	0.70 (0.55–0.89)
K	Diseases of the digestive system	81	11.2	114	15.7	1.40	(1.05–1.86)	74	10.1	0.90 (0.66–1.23)
M	Diseases of the musculoskeletal system and connective tissue	21	3.0	13	1.8	0.60	(0.30–1.21)	16	2.2	0.74 (0.39–1.41)
N	Diseases of the genitourinary system	17	2.4	20	2.8	1.17	(0.61–2.23)	22	3.0	1.28 (0.68–2.40)
O	Pregnancy. childbirth and the puerperium	19	2.6	18	2.5	0.94	(0.49–1.79)	18	2.5	0.93 (0.49–1.78)
S	Injury. poisoning and other external causes	221	30.7	238	32.8	1.07	(0.89–1.28)	196	26.8	0.87 (0.72–1.06)
T	Injury. poisoning and other external causes	174	24.2	168	23.1	0.96	(0.77–1.18)	220	30.1	1.24 (1.02–1.52)
U0*	Covid patients	0		110	15.1			141	19.3	
W	External causes of morbidity	437	60.6	372	51.2	0.84	(0.74–0.97)	390	53.3	0.88 (0.77–1.01)
R. H. L. Z	Other and unspecified	572	79.3	486	66.9	0.84	(0.75–0.95)	569	77.8	0.98 (0.87–1.10)

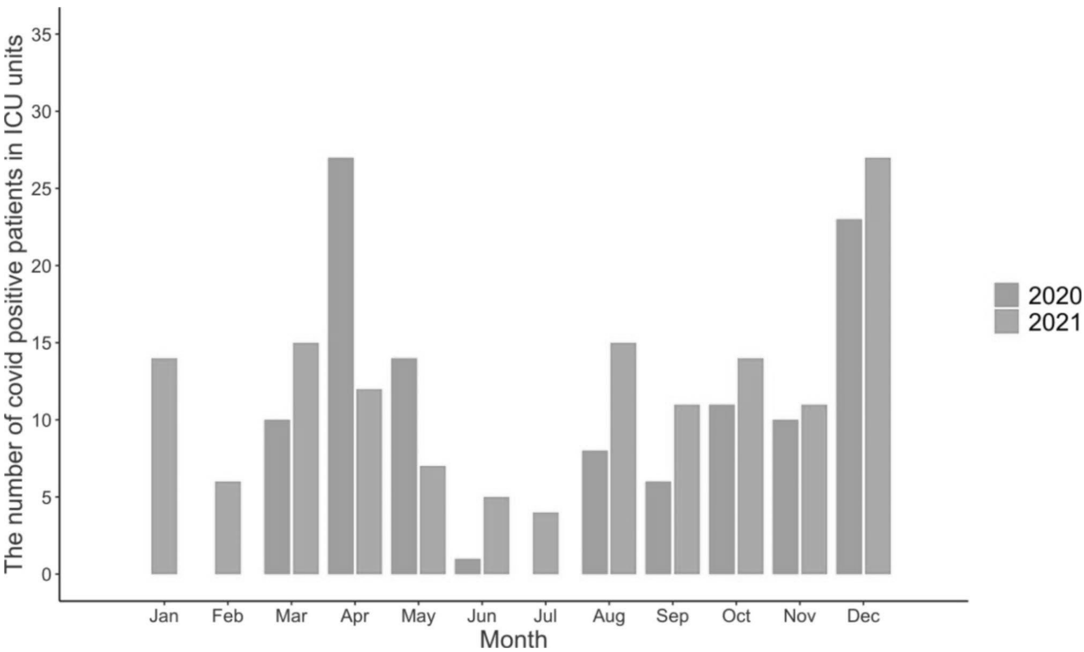

Fig. 1 The number of COVID-positive patients in three ICU units during the COVID-19 pandemic

lockdown period in 2020 (Fig. 2). The IRR of all-cause ICU admissions was 1.02 (CI: 0.89 to 1.18) before the lockdown in February 2020 when compared to reference years. During the lockdown period in 2020, the IRR of all-cause ICU admissions decreased, falling to 0.78 (CI: 0.67 to 0.90) in March. When the lockdown ended, the incidence rebounded to pre-pandemic levels and remained there until the end of that year. In 2021, the

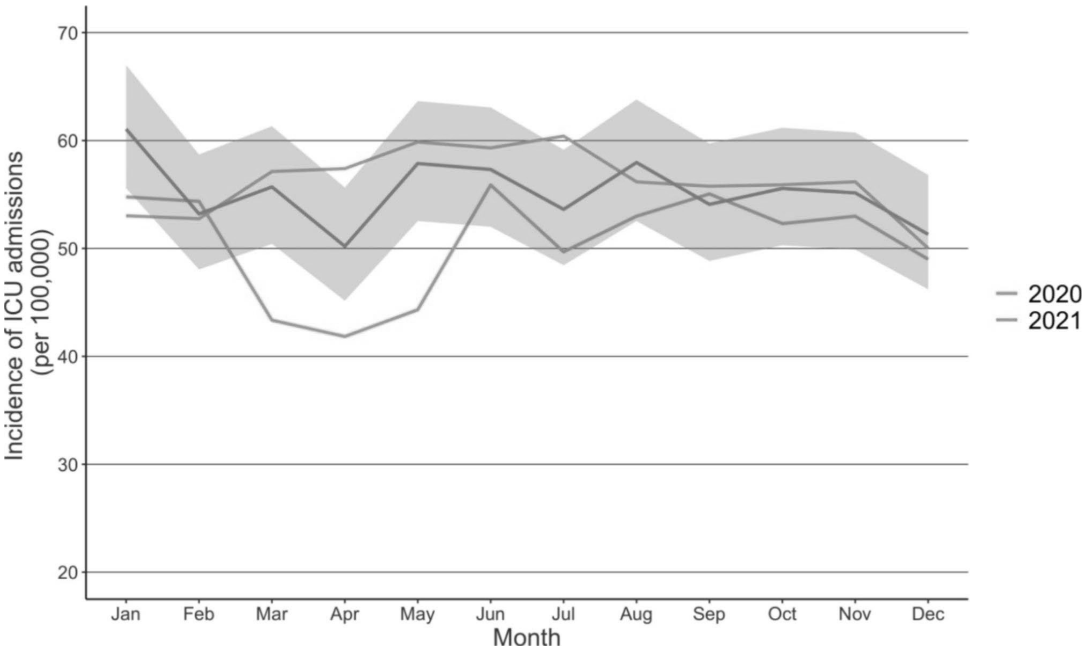

Fig. 2 Incidence of ICU admissions for any cause during the COVID-19 pandemic and the reference years (2017–2019). The darker line illustrates the mean of incidences in the reference years (2017–2019) with confidence intervals

incidence of all-cause ICU admissions remained at the same level when compared to the reference years.

When compared the all-cause ICU admissions in different participating hospitals, the most prominent change in March 2020 was seen in Mikkeli Central Hospital (IRR: 0.69, CI: 0.55–0.86) and in Tampere University Hospital (IRR: 0.78, CI: 0.61-1.00). In Central Finland Central hospital, the incidence of ICU admissions remained higher than in reference years during the year 2021, the IRR being 1.67 (CI: 1.25–2.23) in February 2021 and 1.41 (CI: 1.05–1.89) in September 2021. In Mikkeli Central Hospital, the incidence of ICU admissions was lower than in reference years during 2021. In February 2021, the IRR was 0.84 (CI: 0.68–1.04) and in August 2021, the IRR was 0.86 (CI: 0.70–1.05). In Tampere University Hospital, the incidence remained similar than in reference years during 2021.

The most prominent change occurred in the incidence of diseases of the nervous system (G), the incidence of diseases of the respiratory system (J), and the incidence of neoplasms (C and D) (Table 1). The incidence of the diseases of the nervous system decreased from 30.4 to 100 000 person-years in 2017–2019 to 26.7 per 100 000 person-years (IRR: 0.88 CI: 0.72 to 1.06) in 2020. Thereafter, the incidence increased to 48.1 per 100 000 person-years (IRR: 1.58, CI: 1.34 to 1.87) in 2021 when compared to the reference years. The incidence of diseases of the respiratory system decreased during the study period. The incidence of diseases of the respiratory system was 22.6 per 100 000 person-years during the reference years but decreased to 17.2 per 100 000 person-years (IRR 0.76, CI:0.60 to 0.96) in 2020. In 2021, the incidence was 15.9 per 100 000 person-years (IRR 0.70, CI: 0.55 to 0.89) when compared to the reference years. In the diseases of the blood and neoplasms, the incidence was 84.4 per 100 000 person-years during the reference years and then decreased, being the lowest (73.5) in 2020 (IRR: 0.87, CI: 0.78 to 0.98). The incidence increased slightly in 2021 to 75.8 per 100 000 person-years (IRR: 0.90, CI: 0.80 to 1.01).

The incidence of ICU admissions due to trauma (S) remained stable during the years 2020 and 2021 in comparison to the reference years (Fig. 3). During the lockdown in April 2020, the IRR was 1.21 (CI: 0.59 to 2.44). In October, the IRR was 0.81 (CI: 0.41 to 1.61). The incidence of ICU admissions due to trauma in 2021 remained similar to those in the reference years. The IRR was 0.92 (CI: 0.43 to 1.95) in April 2021 and 0.81 (0.41 to 1.60) in October 2021.

There were no changes in the length of ICU stay during 2020 and 2021 when compared to the reference years (Table 2).

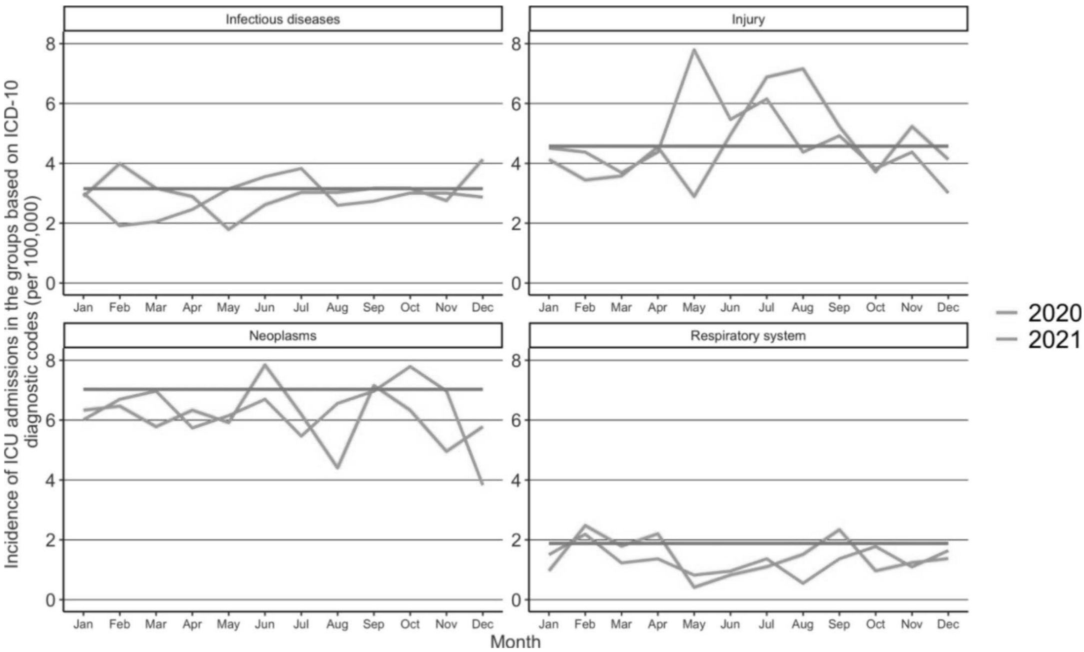

Fig. 3 Incidence of ICU admissions in the groups based on ICD-10 diagnostic codes during the COVID-19 pandemic and the reference years (2017–2019). The darker line illustrates the mean of incidences in the reference years (2017–2019)

Table 2 Mean and standard deviation for ICU stay duration in days during the COVID-19 pandemic and pre-pandemic period (2017–2019)

Month	Pre-pandemic 2017–2019		Pandemic 2020–2021	
	Mean	SD	Mean	SD
Jan	1,5	3,3	1,4	2,6
Feb	1,5	3,2	1,5	2,8
Mar	1,6	3,4	1,7	3,7
Apr	1,7	3,3	1,9	4,4
May	1,4	2,8	1,4	2,7
Jun	1,4	2,9	1,4	2,9
Jul	1,5	3,0	1,5	3,1
Aug	1,4	2,8	1,4	2,9
Sep	1,6	3,4	1,4	2,9
Oct	1,5	2,9	1,5	3,0
Nov	1,4	3,0	1,5	3,3
Dec	1,7	4,0	1,7	3,1

Discussion

The incidence of all-cause ICU admissions decreased after the lockdown was declared in 2020. At the same time, the number of COVID-positive patients in ICU units was highest in April 2020. The proportion of COVID-positive patients admitted to ICU was, however, only 3% in 2020 and 2021. In line with the findings of previous studies, the ongoing social distancing measures and restrictions reduced the spread of other respiratory infections, which are one of the most common reasons for ICU admission [10, 11]. In this study, the most prominent change in all-cause ICU admissions during the lockdown 2020 was seen in Mikkeli Central Hospital, which is a mid-size hospital. The incidence remained lower than in reference years during 2021 in Mikkeli Central Hospital, while an increase was seen in larger Central Finland Central Hospital. Based on the results of the present study, the incidence of severe diseases of the respiratory system in patients requiring ICU treatment decreased during the pandemic, which further supports the findings of previous studies. Moreover, after the announcement of a national lockdown in Finland in 2020, the overall number of emergency department visits and hospital inpatient admissions decreased, which may have also affected the number of ICU admissions [12, 13]. To our knowledge, the effect of the COVID-19 pandemic on the incidence of ICU admissions in Finland has not been previously published.

The number of patients requiring intensive care due to COVID-19 remained low during the pandemic in Finland [2]. This can be explained by the lower incidence of coronavirus in 2020 and 2021 in Finland, compared to many other countries, and the measures implemented, where necessary, during the pandemic.

During the study period, the most remarkable change in ICU admissions occurred in diseases of the nervous system, diseases of the respiratory system, and neoplasms. The incidence of diseases of the nervous system in patients requiring ICU treatment was lowest in 2020 but increased notably in 2021. However, the incidence of neoplasms in patients requiring ICU treatment first decreased in 2020 when compared to the reference years and then increased slightly in 2021. ICU admissions due to neoplasm include patients who have undergone oncological surgery due to malignant tumor. A previous study showed that when the lockdown started in Finland in April, the incidence of oncological surgery decreased slightly but remained at the level of previous years [14]. In addition, caring for COVID-positive patients requires more ICU capacity than patients who do not need isolation. Therefore, the total number of patients treated at the same time in ICUs may have been restricted.

According to previous studies, the number of ED visits due to acute coronary syndrome decreased during the first wave of the COVID-19 pandemic [15–17]. Fear of infection may have caused a decreased willingness to seek treatment and delayed medical intervention may have caused a worsening of the patients' cardiac disease. This may, therefore, be reflected in an increase in the number of ICU admissions during the second wave of the pandemic.

The incidence of ICU admissions due to trauma remained stable during the pandemic when compared to the reference years. According to a previous Finnish study, the total number of emergency department visits due to injury decreased by 16% during the lockdown period in 2020 [18]. Nevertheless, the incidence of severely injured trauma patients remained unchanged during the first wave of COVID-19 in Finland [19]. The social restrictions and recommendations to stay at home may have reduced the number of minor injuries because of the changes in peoples' behavior. However, our findings indicate that the rate of severe traumas and patients requiring ICU treatment because of live-threatening injury remained unchanged. According to the previous literature, the number of severe traumas globally decreased or remained stable during the pandemic [20–22].

The strengths of our study include the broad range of data from three large Finnish hospitals. Furthermore, many previous studies have only evaluated the impact of the COVID-19 pandemic in 2020. In this study, we were able to collect follow-up data from all patients during the first two years of the COVID-19 pandemic and to evaluate the impact of the changing restrictions. Our current study also has a limitation that should be addressed. We only analyzed treatment periods according to a patient's primary diagnosis, and therefore some of the patients may have had more than one diagnosis and reason for ICU stay.

Conclusions

In conclusion, the incidence of all-cause ICU admissions decreased during the lockdown due to the COVID-19 pandemic. The proportion of patients with COVID-19 requiring intensive care in Finland was only 3% in 2020 and 2021. Restrictions implemented during the pandemic reduced the spread of respiratory infections, which are one of the most common reasons for ICU admission. When the lockdown started in Finland, a slight decrease was seen in the incidence of oncological surgery and the incidence of ICU admissions due to neoplasm decreased. However, the incidence of ICU admissions due to trauma remained stable during the pandemic compared to the reference years.

Abbreviations

ICU Intensive Care Unit
CI Confidence Interval
IRR Incidence Rate Ratio
IQR Interquartile Range

Acknowledgements

Not applicable.

Author contributions

V.M., T.H. and V.P. conceived of the presented idea. S.J. and V.P. designed and performed the data analysis and analyzed the data. S.J. wrote the manuscript with input from all authors. All authors provided critical feedback, discussed the results, and helped shape the research and manuscript. V.M. and V.P. supervised the project.

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Data availability

Research data are not publicly available due to Finnish research legislation as the Law on the secondary use of routinely collected healthcare data prohibits to share data. Persons interest in gaining access to data must submit official application and study protocol to institutional review boards and after the evaluation of the protocol access to data may be granted, but it must be noted that the current legislation prohibits the delivery of original data out of Finland.
The data used in the current study available from the corresponding author on reasonable request.

Declarations

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

The ethical committee evaluation was waived by the Tampere University Hospital ethical committee. Tampere University Hospital is the tertiary academic unit of the Pirkanmaa hospital district. According to the Finnish research legislation ethical committee evaluation is not needed when routinely collected healthcare data is analyzed and the participants are not contacted. All methods were carried out in accordance with relevant guidelines and Finnish regulations (Law on the secondary use of routinely collected healthcare data and Law of medical research).

According to Finnish research law and the law on the secondary use of routinely collected healthcare data informed consent to participate is not required when instituitonal or national register data is analyzed retrospectively. Therefore, the need for informed consent was waived by the institutional review boards of the participating hospitals (Tampere University Hospital, Central Finland Hospital Nova and Mikkeli Central Hospital) and the ethical committee of the Tampere University Hospital.

Consent for publication
Not required due to the register-based study design.

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Competing interests.
The Authors declare that they have no competing interests.

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