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Incidence of post-COVID syndrome and associated symptoms in outpatient care in Bavaria, Germany: a retrospective cohort study using routinely collected claims data

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ABSTRACT

Objectives To estimate the treatment incidence of post-COVID syndrome (postinfectious sequelae present at least 12 weeks following infection) in the context of ambulatory care in Bavaria, Germany, and to establish whether related diagnoses occur more frequently than in patients with no known history of COVID-19.

Design Retrospective cohort analysis of routinely collected claims data.

Setting Ambulatory care in Bavaria, Germany, observed from January 2020 to March 2022 (data accessed May 2022).

Participants 391 990 patients with confirmed COVID-19 diagnosis, 62 659 patients with other respiratory infection and a control group of 659 579 patients with no confirmed or suspected diagnosis of COVID-19.

Primary and secondary outcome measures Primary outcome is diagnosis of post-COVID syndrome documented in ambulatory care. Secondary outcomes are: chronic fatigue syndrome, psychological disorder, fatigue, mild cognitive impairment, disturbances of taste and smell, dyspnoea, pulmonary embolism and myalgia.

Results Among all patients with confirmed COVID-19, 14.2% (95% CI 14.0% to 14.5%) received a diagnosis of a post-COVID syndrome, and 6.7% (95% CI 6.5% to 6.9%) received the diagnosis in at least two quarterly periods during a 2-year follow-up. Compared with patients with other respiratory infections and with controls, patients with COVID-19 more frequently received a variety of diagnoses including chronic fatigue syndrome (1.6% vs 0.6% and 0.3%, respectively), fatigue (13.3% vs 9.2% and 6.0%), dyspnoea (9.9% vs 5.1% and 3.2%) and disturbances of taste and smell (3.2% vs 1.2% and 0.5%). The treatment incidence of post-COVID syndrome was highest among adults aged 40–59 (19.0%) and lowest among children aged below 12 years (2.6%).

Conclusions Our results demonstrate a moderately high incidence of post-COVID syndrome 2 years after COVID-19 diagnosis. There is an urgent need to find efficient and effective solutions to help patients with dyspnoea, fatigue, cognitive impairment and loss of smell. Guidelines and treatment algorithms, including referral criteria, and occupational and physical therapy, require prompt and coherent implementation.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The data cover all statutory health insurance companies in Bavaria and have high generalisability to the general population.
⇒ By considering the proportion of patients with COVID-19 consulting a physician, our results are better able to differentiate between everyday complaints and medically significant illness than data from a self-reported questionnaire.
⇒ Follow-up of up to 2 years enables first assessment of the proportion requiring continuous care for a post-COVID syndrome.
⇒ The routinely collected data are not audited and contain little information regarding the severity of the symptoms.

INTRODUCTION

Approximately 15% of those with SARS-CoV-2 infection report symptoms that persist beyond the acute stage of the infection.[1] While some people report ongoing symptoms from the acute infection, such as breathlessness, loss of smell or taste and cough, a subgroup of people develop post-viral syndromes with diverse symptoms such as fatigue, pain and cognitive dysfunction. Such prolonged illnesses are termed collectively long COVID-19 (coronavirus disease) and, when persisting for more than 12 weeks, a diagnosis of post-COVID syndrome may be made.[2] As of March 2022, the prevalence of self-reported long COVID-19 in the UK population was estimated to be 2.7%, with 45% of those affected having COVID-19 more than 1 year previously, and 4% more than 2 years previously.[3]

The symptoms of those with post-COVID syndrome vary greatly in their nature and in severity. Data from the UK Corona Infection Survey show that 38.4% of people with self-reported long COVID-19 do not experience any restriction in their daily activities, with 18.1% reporting a severe restriction.[1] Consequently, the National Health Service England estimated that between 30% and 50% of people with long COVID-19 will need to consult a physician, that 18%–30% will require only a general practitioner (GP) consultation and that 20%–50% will require treatment from a specialist.[4]

Long COVID-19/post-COVID syndrome pose an as yet unquantified challenge to health services, both in the immediate term and prospectively for the continued care of patients with persisting symptoms. Diagnosis of a post-COVID syndrome requires a careful patient history under consideration of the frequency and severity of symptoms, relevant comorbidities and potential differential diagnoses.[5] According to several comprehensive reviews, the post-COVID syndrome is marked by the presence of fatigue, headache, cognitive dysfunction, postexertional malaise, orthostatic intolerance and dyspnoea.[2 6 7] Viral persistence, autoimmune reactions, chronic inflammatory processes and tissue destruction are postulated as underlying causes for the symptoms.[2 7] Numerous corresponding biomarkers have already been identified in this regard,[7] but these are usually inconspicuous in most patients.[2] Treatment focuses on the specific needs of individual patients, for example, by initiating a pulmonological rehabilitation or by providing appropriate psychological support.

In Germany, a number of initiatives aim to improve the quality of care for patients with post-COVID syndrome. A clinical guideline summarises the available evidence to provide specific recommendations in the context of the German health system.[2] Although a number of hospitals have established post-COVID clinics, most patients are expected to be treated within the context of the ambulatory sector, in which insured persons enjoy free access to GPs, specialists and psychotherapists without the need for referral.[8] For this reason, various networks have been formed to provide relevant continuing medical education courses, to facilitate referrals to physicians and psychotherapists with a special interest in the condition and improve the coordination of care. In Bavaria, the Bavarian Association of Statutory Health Insurance Physicians (German: *Kassenärztliche Vereinigung Bayerns*, KVB) established a Long COVID Network (KVB) to pursue these aims.

Objectives

The occurrence of post-COVID symptoms has been quantified in numerous population-based studies. However, the immediate and long-term burden on ambulatory healthcare services remains unclear. Whereas a number of patients report improvement over a course of several months, the experience of similar postinfectious syndromes such as chronic fatigue syndrome shows that a subgroup of patients with post-COVID syndrome will likely incur high treatment costs over many years.[9] The aim of the present study is therefore to estimate the treatment incidence of post-COVID syndrome in the context of ambulatory care in Bavaria, Germany. In order to provide information on the healthcare needs of the population, we set out to answer the following research questions:

1. What proportion of patients with a confirmed SARS-CoV-2 infection presents with a post-COVID syndrome up to 2 years later? What proportion requires treatment for a post-COVID syndrome over this extended period of time?
2. Do patients with a confirmed SARS-CoV-2 infection exhibit a higher incidence of diagnoses associated with post-COVID than patients with other respiratory infections, or patients without respiratory infection? What proportion requires treatment for these symptoms over the extended period of time?
3. How does the treatment incidence of post-COVID syndrome and associated symptoms vary by age?

METHODS

Study data

We analyse the Bavarian COVID-19 Cohort (BCC), a data set derived from anonymous claims data held by the Bavarian Association of Statutory Health Insurance Physicians. The BCC contains the claims data of all patients with a physician consultation related to COVID-19 (confirmed or suspected cases), together with a control group of 1 million patients without treatment related to COVID-19. The data cover approximately 85% of the population of Bavaria (2020: 11.2 million people with statutory health insurance) and are submitted by all physicians and psychotherapists in ambulatory care primarily for the purpose of remuneration. In Germany, GPs and specialists both work in licensed private practices in ambulatory care. The specialists comprise mainly dermatologists; ear, nose and throat specialists; gynaecologists; internists with and without specialisation (eg, cardiology, gastroenterology, pulmonology and oncology); neurologists; ophthalmologists; orthopaedics; psychiatrists; psychotherapists (both physician and non-physician); radiologists; surgeons; and urologists. Internists without specialisation can be licensed as GPs. Germany has a relatively weak primary care system with respect to the coordination of care. Therefore, patients can encounter specialists with or without referral.

All diagnoses relevant to the treatment episode are recorded on a quarterly basis using the German Modification of the International Classification of Diseases 10th Revision (ICD-10-GM) classification. This quarterly billing period therefore represents the unit of time for the study. The database allocates a unique and persistent pseudonym to each patient, removing all personally identifiable information (name, insurance number, exact date of birth, address, etc) to protect the identity of the

patients. The study data were updated in May 2022 to cover the period up to and including the first quarter of 2022. By using the data of a regional organisation, the delay in data availability is reduced and we are thus able to observe patient consultations until 31 March 2022, providing a follow-up of up to 2 years.

The study was conducted according to the relevant German guideline, the 'Good Practice of Secondary Data Analysis'.[10]

Cohort

By considering the diagnoses recorded by the physician, the BCC divides the patients with a physician contact due to COVID-19 into three categories. The first category consists of those with a record of confirmed COVID-19 (ICD-10: U07.1G). The second category consists of those for whom the physician recorded the exclusion of COVID-19 by PCR test (U07.1A), providing a pool of test-negative patients. Of these patients, only those with confirmed upper respiratory infection are included in the study. The third category contains those with no record of a confirmed or excluded COVID-19 diagnosis; these patients with unclear status are excluded from the study. Patients of the control group had no coronavirus-related contact over the entire period of observation, and no subsequent diagnosis of a post-COVID syndrome that would indicate a COVID-19 illness not observed in the study data.

The cohort for the present study thus represents a subset of the patients of the BCC and includes only those with index quarter up to Q2 2021. The three disjoint groups are defined as follows:

1. *COVID-19*. Patients with a PCR-confirmed diagnosis of COVID-19 (U07.1G) between January 2020 and June 2021 (ie, index quarter between Q1 2020 and Q2 2021).
2. *Other upper respiratory infection*. Patients with the diagnosis U07.1A (exclusion of COVID-19) between January 2020 and June 2021, for whom a confirmed upper respiratory infection (J00–J06) or influenza (J09–J11) was recorded in the same treatment episode. This group is thus a subset of all PCR test-negative patients, designed to facilitate a comparison between COVID-19 and other upper respiratory infections.
3. *Controls*. Patients without any physician contact relating to a confirmed, excluded or suspected COVID-19 infection or other respiratory infection. Patients were excluded if a diagnosis of a post-COVID syndrome was present during follow-up, suggesting that the patient had a preceding COVID-19 infection that was not observed in the context of ambulatory care in Bavaria (eg, diagnosis was made in a hospital setting).

The index quarter, representing the time of inclusion in the study and the start of the follow-up period, is defined for the COVID-19 group as the first quarter with confirmed COVID-19 diagnosis. For the other upper respiratory infection group, it is the first quarter with exclusion of COVID-19. Patients of the control group without physician contact related to COVID-19 were allocated an index quarter at random by drawing from the distribution of the COVID-19 group, ensuring a similar follow-up structure.

Outcomes

The primary outcome applicable to the COVID-19 group is treatment for a post-COVID syndrome. On 11 November 2020, the German Federal Institute for Drugs and Medical Devices introduced the emergency ICD-10-GM code U07.4 for the purpose of documenting a post-COVID-19 condition.[11] From January 2021, the code was changed to U09.9 to be consistent with the WHO version of the ICD-10. These codes record a physician-assessed diagnosis of post-COVID syndrome, with the COVID-19 infection as presumed trigger. As secondary keys, they should always be accompanied by a primary key that specifies the nature of the symptoms or disorder experienced.

In order to assess the specific complaints being treated, and to facilitate comparison with the control groups, we consider as secondary diagnoses a range of physician-confirmed diagnoses according to the ICD-10. These outcomes were predefined based on the symptoms listed in the German post-COVID guideline [2]. As significant pulmonological and airway complaints, we consider dyspnoea (ICD-10-GM code: U06.0), disturbances of smell and taste (R43) and pulmonary embolism (I26). General complaints of a postinfectious syndrome are identified via the diagnoses of chronic fatigue syndrome (G93.3), fatigue recorded as a symptom (R53), myalgia (M79.1) and mild cognitive impairment (F06.7). Finally, psychological disorder covers the diagnoses of anxiety (F41), affective disorders (F30–F39) and stress disorders (F41), which, in primary care, often exhibit a high degree of overlap. These outcomes are not intended as a comprehensive assessment of post-COVID symptoms, but aim instead to establish whether important known symptoms of post-COVID lead to above-average rates of consultation in ambulatory care.

Statistical analysis

The groups of the cohort were first compared with respect to the distribution of age and sex, as well as the prior record of outcome diagnoses. Differences in the distribution of age, sex and district of residence were corrected by weighting to standardise the control groups according to the distribution found in the COVID-19 group.

After summarising the groups at baseline, the cumulative incidence of each diagnosis was estimated using the Kaplan-Meier method to account for the right censoring due to different follow-up durations.[12] Patients with a record of an outcome diagnosis in the 2 years prior to the index quarter are excluded for that outcome, as the continuation of the diagnosis after inclusion cannot be viewed as a result of the infection. For all cohort groups, follow-up begins in the quarter after the index quarter, ensuring that postinfectious sequelae are not confused with the symptoms of acute infection. Outcomes will be

established primarily by considering the time until first diagnosis of the outcome. However, a secondary model considers the outcome to be present only when coded in a subsequent quarterly billing period, measuring the time until the second diagnosis. This additional perspective aims both to confirm the initial diagnosis and to indicate the proportion of patients requiring sustained medical treatment for the condition, thus reflecting a more persistent course of post-COVID. A similar approach is taken in the context of Germany's health insurance risk scheme.[13] Of primary interest is the proportion of patients in each group with a record of the respective outcomes by the end of the eight-quarter follow-up period, as estimated by the weighted Kaplan-Meier estimator. These models are applied to answer the first and second research questions.

The third research question regarding potential differences in the incidence of post-COVID by age will be answered by further stratifying the models into five age groups: children aged 0–11 years, youths aged 12–17 years, young adults aged 18–39 years, middle-aged adults aged 40–59 years and senior citizens aged 60 years and over. In order to provide an interpretable overview of age-specific differences, the result of the Kaplan-Meier estimators for each age group, cohort group and outcome will be compared.

Data were analysed using R (V.4.1) with the ICD10gm package for ICD-10 metadata processing and the survival package for Kaplan-Meier estimation.[14–16]

Patient and public involvement

None.

RESULTS

Figure 1 shows how the study cohort was selected from the underlying data of the BCC. Of the 690 251 patients with confirmed diagnosis of COVID-19, a total of 391 990 were diagnosed before Q2 2021 and were therefore included in the study. From the group of 188 337 patients with a record of a negative test result, 62 659 received a diagnosis of a different upper respiratory infection over the same period and therefore included in the 'Other respiratory infection' group. A further 2.5 million patients with suspected COVID-19 were excluded from the study because no record of a test result was available. Finally, of the 1 million patients of the pool without physician contact related to COVID-19, a control group of 659 579 had an index quarter between Q1 2020 and Q2 2021 and was therefore included in the study.

Figure 2 shows the age distribution of the three groups. Whereas the COVID-19 group is predominantly aged between 18 and 60 years, the group with other respiratory infection contains a large group of school-age children. These differences in age structure were largely removed after weighting (blue lines).

Table 1 summarises the three weighted groups of the cohort in the time before the index quarter. The average age of the patients in the COVID-19 group was 42.3 years, with 54% of patients being female. The most frequent of the outcome diagnoses present before inclusion were psychological disorders (28.2%) and fatigue (9.8%). After weighting, the three control groups are similar with respect to the distributions of age, sex and the prevalence of these diagnoses.

Figure 3 displays the Kaplan-Meier estimates for the treatment incidence during the eight quarters of follow-up. Table 2 summarises the estimated incidences at the end of this period, both for treatment in a single quarter and for treatment in multiple quarterly billing periods. Of those with confirmed COVID-19 diagnosis, the cumulative incidence of a post-COVID syndrome reaches 14.2% (95% CI 13.99% to 14.45%). Remarkably, 6.7% (95% CI 6.54% to 6.92%) of all patients with COVID-19 received this diagnosis in two or more quarters. Of the secondary outcomes, psychological disorders, fatigue and dyspnoea were the most frequent documented symptoms. Of particular note is a cumulative treatment incidence of 1.6% for chronic fatigue syndrome in the COVID-19 group, with 0.6% of all patients with COVID-19 receiving the diagnosis in multiple quarterly periods. Among patients with other respiratory infection and in controls without COVID-19-related contact, the proportions with a single diagnosis

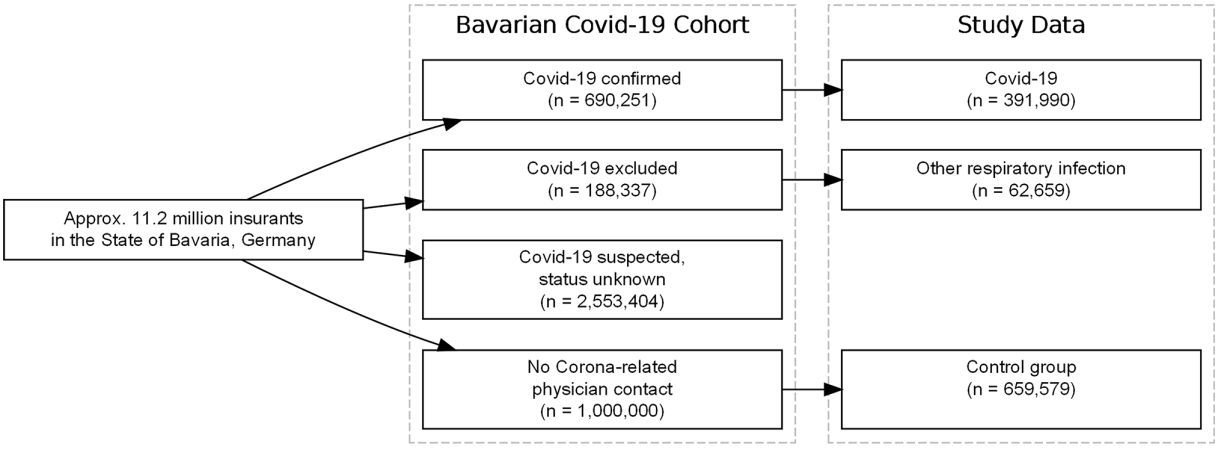

Figure 1 Flow chart.

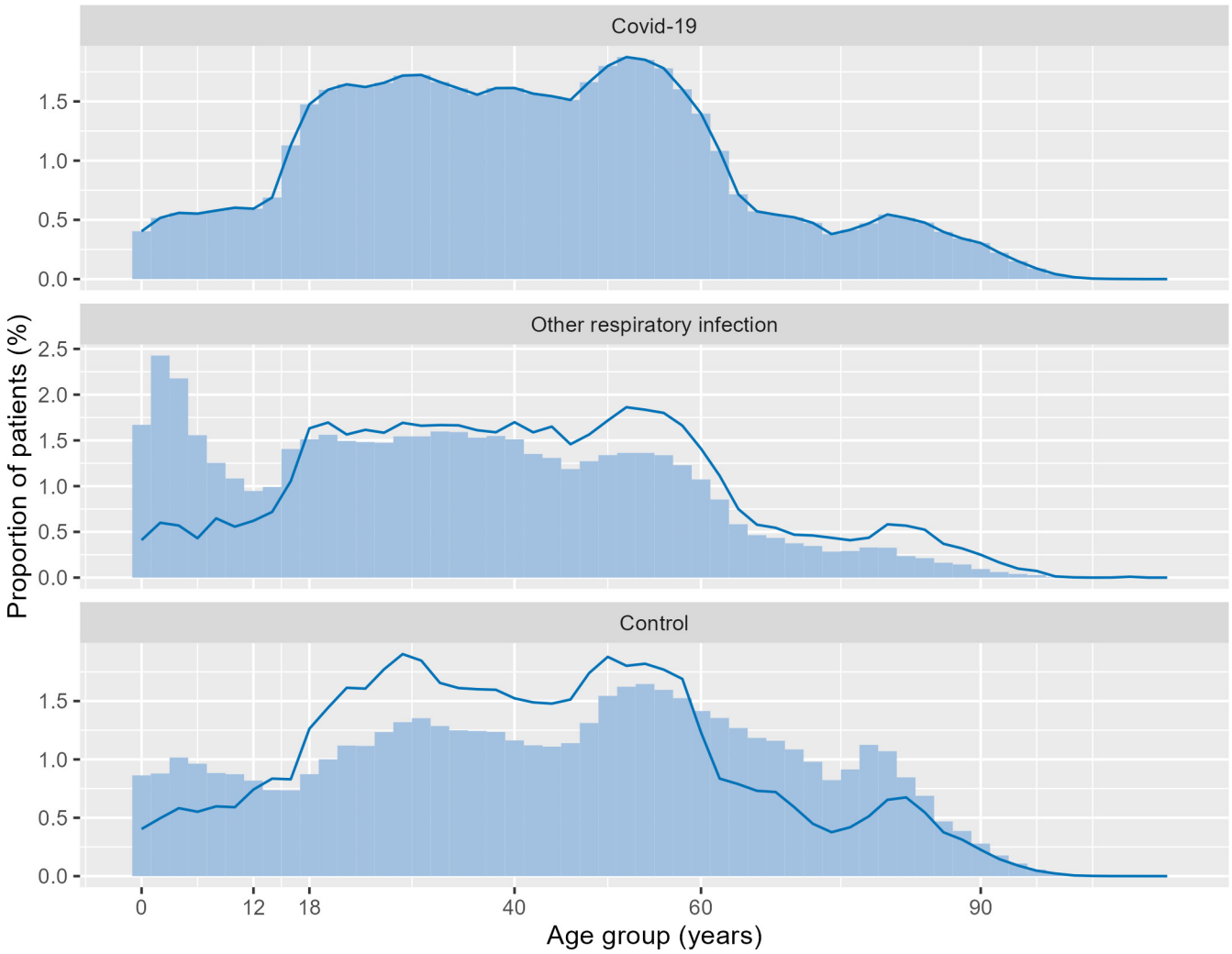

Figure 2 Age distribution of the three groups (blue line after matching procedure).

were 0.6% and 0.3%, respectively. Similarly, the treatment incidences of dyspnoea (9.9% with diagnosis in one or more quarters), disturbances of smell or taste (3.2%) and pulmonary embolism (0.4%) are increased substantially in the COVID-19 group. The incidence of mild cognitive impairment in patients with COVID-19 (0.39%) was lower than for the other symptoms, but higher compared with the other respiratory infection (0.18%) or control group (0.31%), which is more obvious by inspection of figure 3. In contrast, the treatment incidence for psychological disorders (14.8% vs 12.8%) and myalgia (3.9% vs 3.4%) is similar in the two infection groups, which each has a higher incidence than the control group of patients unrelated to COVID-19 (9.4% for psychological disorder, 2.3% for myalgia).

Figure 4 shows the estimated treatment incidence after eight quarters by age group. All outcome diagnoses demonstrate a clear association with age, with the form of the association varying by outcome. In particular, the treatment incidence of post-COVID syndrome ranges from 2.6% (95% CI 2.1% to 3.1%) in children up to the age of 11 to 19.0% (95% CI 18.6% to 19.5%) in the age group 40–59. Similarly, chronic fatigue syndrome is diagnosed in only 0.1% (95% CI 0.0% to 0.2%) of children in the COVID-19 group, compared with 2.3% (95% CI 2.1% to 2.5%) in the age group 40–59. Among the 12–17 year-olds, persistent disturbances of taste and smell occur in 3.4% (95% CI 2.9% to 4.9%) of patients with COVID-19, which is comparable to young and middle-aged adults. Persistent dyspnoea, pulmonary embolism and mild cognitive impairment are all more common among older patients. Detailed results of the Kaplan-Meier estimation are provided as online supplemental information.

DISCUSSION

The primary contribution of the present study is to quantify the treatment incidence of post-COVID syndrome and related diagnoses in the context of German ambulatory care. Among all patients receiving a confirmed diagnosis of COVID-19 in an outpatient setting, the recorded incidence of a post-COVID syndrome was 14.2% (95% CI 13.9% to 14.5%) over the 2-year follow-up. The proportion with physician-documented post-COVID syndrome varied substantially by age group, with the highest incidence being

Table 1 Standardised characteristics of the cohort groups prior to the index quarter

Characteristic	COVID-19 n=391 990	Other respiratory infection n=62 659	Control n=659 579
Sex (%)			
M	45.9	45.9	45.9
W	54.1	54.1	54.1
Age			
Mean (SD)	42.3 (21.0)	42.0 (20.8)	42.3 (20.9)
Age group (%)			
(0, 11)	6.4	6.4	6.4
(11, 17)	4.8	4.8	4.8
(17, 39)	35.8	36.0	35.8
(39, 59)	33.6	33.7	33.4
(59, 110)	19.4	19.2	19.5
Chronic fatigue syndrome (%)	0.5	0.6	0.4
Psychological disorder (%)	28.2	32.7	24.4
Fatigue (%)	9.8	11.4	7.2
Mild cognitive impairment (%)	0.6	0.5	0.5
Sense of taste/ smell (%)	0.3	0.5	0.2
Dyspnoea (%)	4.6	5.6	3.4
Pulmonary embolism (%)	0.4	0.5	0.4
Myalgia (%)	4.2	4.6	3.2

19.0% (95% CI 18.6% to 19.5%) in adults aged between 40 and 59 years and lowest being 2.6% (95% CI 2.1% to 3.1%) among children aged 0–11 years. The greatest differences between the COVID-19 and control group are seen in fatigue, dyspnoea, disturbance of smell and taste and cognitive impairment.

Through comparison with two carefully selected control groups, we demonstrate that diagnoses associated with post-COVID syndrome are more frequent in patients with confirmed COVID-19. This holds both for diagnoses such as dyspnoea, disturbances of smell and taste and pulmonary embolism, as well as for general symptoms such as fatigue, and chronic fatigue syndrome. However, although psychological disorders such as anxiety, depression and stress disorders are strong predictors for the development of post-infectious syndromes,[17] we observe only a small increase in such diagnoses following confirmed COVID-19.

Estimates of the prevalence of post-COVID syndrome vary greatly depending on factors such as context and study design. Whereas the population-based UK Corona Infection Survey yielded a self-reported prevalence of 14% [1], a recent review reported a pooled post-COVID incidence of 53%.[18] Smaller studies from Germany report that 34% or 46% of non-hospitalised patients have persisting symptoms.[19 20] Such extreme variation in incidence estimates is common with, for example, functional somatic syndromes such as chronic fatigue or irritable bowel syndrome. In general, studies that screen the population proactively for symptoms often find a high prevalence, whereas those counting patients who consult a physician for their symptoms yield a considerably lower prevalence. The consultation of a physician is therefore an important consideration to differentiate between commonly experienced complaints of a transitory nature and medically significant illness.[21] Our primary result that 14.2% of patients with a confirmed outpatient diagnosis of COVID-19 later received the diagnosis of a post-COVID syndrome from a physician therefore seems plausible and adds important context to these population-based figures.

It is thought that a proportion of those with a post-COVID syndrome experience considerable improvement in their symptoms over a period of months, while others may decide to tolerate mild symptoms and choose not to consult a physician on a regular basis. For this reason, we consider the repeated presentation for post-COVID syndrome to be a key indicator of disease burden. We find that 6.7% (95% CI 6.5% to 6.9%) of all patients with confirmed COVID-19 received a post-COVID diagnosis in at least two different quarterly billing periods during the 2-year follow-up. This represents approximately 47% of those receiving a single post-COVID diagnosis and indicates chronification of the condition in this subgroup with long-term implications for health services.

A recent review on post-COVID in children found conflicting evidence regarding the potential increased risk of experiencing postinfectious symptoms.[22] Our study is however consistent with, for example, the UK coronavirus survey in finding a lower incidence of post-COVID among children and young people.[1] With respect to the outcomes measured, we find that children with COVID-19 under the age of 12 years differ only marginally from those with other respiratory infections. Nevertheless, a proportion of 2.6% with diagnosis of a post-COVID syndrome demonstrates that a substantial subgroup of children do experience persisting symptoms that cause them to consult a physician.

The control group of patients without corona-related physician contact exhibits lower treatment incidences than both the COVID-19 group and the group of patients with other respiratory infections, even after adjusting for the demographic structure of the patients. There are a number of possible reasons for this. First, respiratory infections may themselves lead to postinfectious syndromes. Taquet *et al* used electronic patient records to compare a group of patients with COVID-19 with a matched group of patients with influenza, finding that outcomes such as fatigue, pain and breathing difficulties were present in both groups, but more common among patients with COVID-19.[23] Second, there may be unobserved structural differences between those consulting a GP or other outpatient physician for a suspected COVID-19 infection

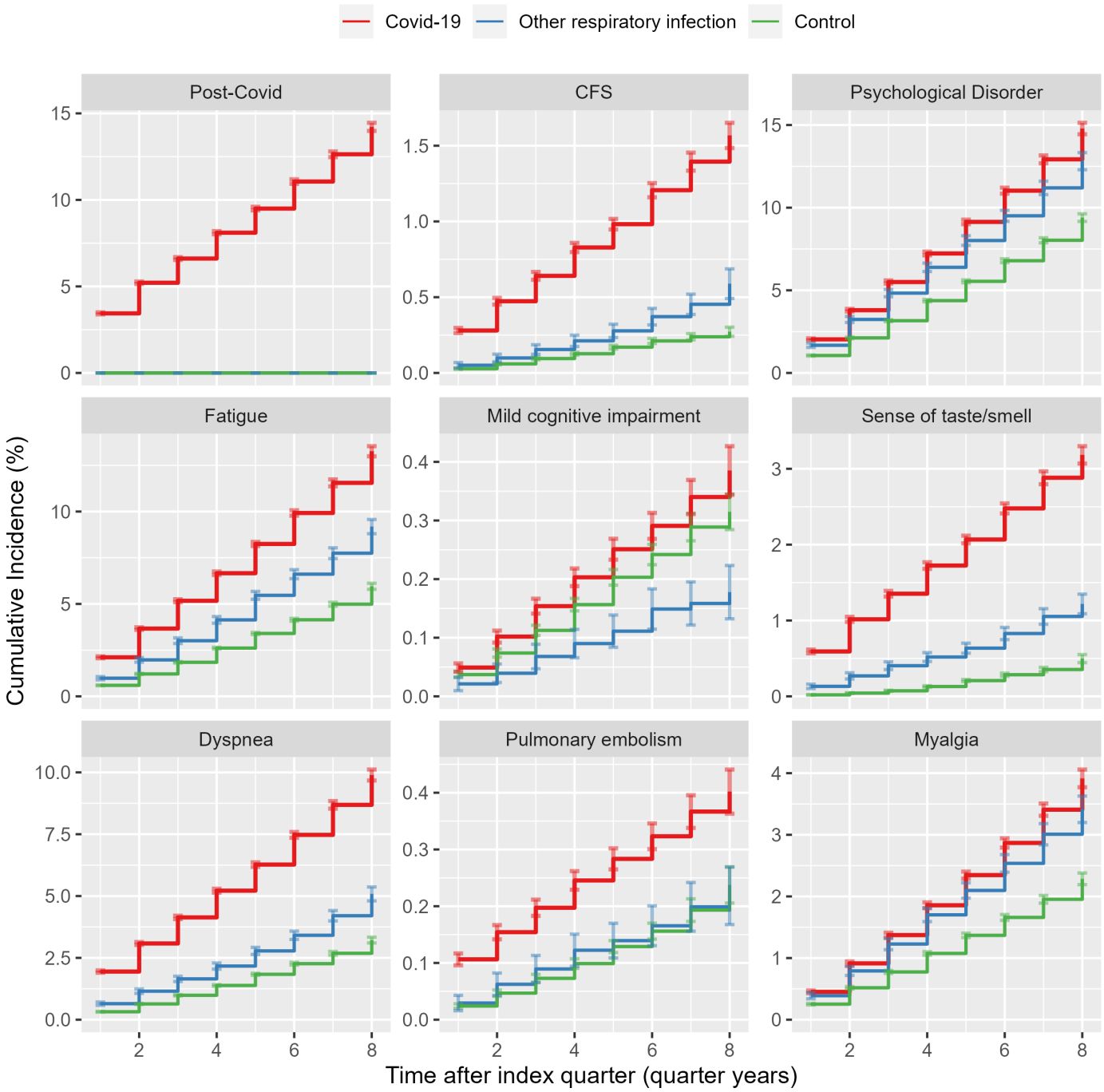

Figure 3 Kaplan-Meier estimates for treatment incidence. CFS, Chronic Fatigue Syndrome.

and those not presenting, or presenting at a dedicated testing centre or in a hospital setting. In particular, age, existing comorbidities and socioeconomic factors are likely to influence the setting in which a person presents with COVID-19-type symptoms. For these reasons, it is informative to incorporate both a 'test-negative' group of patients with other respiratory infection and a control group that comprised patients with no known treatment related to COVID-19.

A previous study pooling the claims data of major health insurance companies in Germany calculated the incidence rate ratios for 96 predefined outcomes, finding that patients with confirmed COVID-19 were significantly more likely to be diagnosed with these outcomes than a control group matched on age, sex and prevalent medical conditions.[24] However, the data covered a smaller, potentially selective proportion of the population for the period until the end of the year 2020. Furthermore, the study was not able to report the absolute proportion of patients estimated to experience the outcomes, or the proportion with diagnosis repeated in a subsequent quarter. Our study is therefore complementary to this previous work, providing incidence estimates with extended follow-up.

Psychological disorders, fatigue, dyspnoea and disturbance of smell and taste were the most frequent documented ICD-10 codes. It is noticeable, however, that

Table 2 Kaplan-Meier estimates for the proportion of patients in each group diagnosed with each outcome in at least one quarter during the eight-quarter follow-up, and in at least two quarters

	COVID-19		Other respiratory infection		Control	
	Incidence	95% CI	Incidence	95% CI	Incidence	95% CI
Post-COVID						
One quarter or more	14.22	13.99 to 14.45	0.00	0.00 to 0.00	0.00	0.00 to 0.00
Two quarters or more	6.73	6.54 to 6.92	0.00	0.00 to 0.00	0.00	0.00 to 0.00
Chronic fatigue syndrome						
One quarter or more	1.57	1.48 to 1.65	0.59	0.49 to 0.69	0.27	0.24 to 0.30
Two quarters or more	0.61	0.55 to 0.67	0.13	0.09 to 0.17	0.07	0.06 to 0.09
Fatigue						
One quarter or more	13.26	12.99 to 13.54	9.19	8.80 to 9.57	5.96	5.79 to 6.12
Two quarters or more	3.20	3.02 to 3.37	1.74	1.54 to 1.93	0.96	0.88 to 1.04
Dyspnoea						
One quarter or more	9.89	9.67 to 10.11	5.09	4.80 to 5.37	3.22	3.10 to 3.34
Two quarters or more	2.70	2.55 to 2.84	0.99	0.86 to 1.12	0.59	0.54 to 0.64
Pulmonary embolism						
One quarter or more	0.40	0.36 to 0.44	0.22	0.17 to 0.27	0.24	0.21 to 0.27
Two quarters or more	0.22	0.19 to 0.26	0.11	0.07 to 0.15	0.11	0.09 to 0.13
Psychological disorder						
One quarter or more	14.79	14.44 to 15.13	12.81	12.29 to 13.33	9.40	9.17 to 9.63
Two quarters or more	6.87	6.59 to 7.16	6.39	5.95 to 6.83	4.03	3.86 to 4.21
Sense of taste/smell						
One quarter or more	3.18	3.07 to 3.30	1.22	1.09 to 1.35	0.50	0.44 to 0.55
Two quarters or more	0.60	0.55 to 0.66	0.16	0.11 to 0.21	0.04	0.03 to 0.06
Mild cognitive impairment						
One quarter or more	0.39	0.34 to 0.43	0.18	0.13 to 0.22	0.31	0.28 to 0.35
Two quarters or more	0.16	0.14 to 0.18	0.08	0.05 to 0.12	0.19	0.16 to 0.22
Myalgia						
One quarter or more	3.92	3.77 to 4.06	3.41	3.20 to 3.63	2.29	2.19 to 2.38
Two quarters or more	0.91	0.83 to 0.99	0.74	0.63 to 0.85	0.46	0.42 to 0.51

the frequency of psychological disorders is equally high in the respiratory group. It could be hypothesised that patients with increased health anxiety or somatisation tendencies are more likely to seek out doctors for therapy or sick leave, and that this applies to both the COVID-19 group and other respiratory infections group. The ICD-10 code 'mild cognitive impairment' was not documented as frequently, but was more prevalent in the COVID-19 group, as were myalgias and pulmonary embolism. The differences were even more pronounced for fatigue, dyspnoea and disturbance of smell and taste. These results also fit well with the studies that have shown that it is particularly the cardiovascular[25] and pulmonary systems[26] as well as the brain[27] that are affected by COVID-19. Therefore, our results highlight the need to develop efficient and effective healthcare solutions to meet the needs of patients with post-COVID syndrome in outpatient care, particularly with respect to the most frequently reported symptoms. Concepts for inpatient rehabilitation have already been proposed to treat somatic and psychological disorders[28]; and there are already first hints that rehabilitation measures could be successful to improve fatigue, dyspnoea and cognition.[29–31] Physical fitness, psychological outcomes and capacity to work might also be improved.[32] Olfactory training is recommended for loss of smell and taste,[2] although studies on this are still inconclusive.[33] Therefore, the effectiveness of all these approaches would still need to be investigated in further, larger studies, ideally together with implementation studies in outpatient care.

The use of secondary claims data brings both strengths and limitations that must be considered when interpreting our results. A major strength is the coverage of 85% of the Bavarian population, allowing the formation of a large and representative cohort with comparable control groups over a period of up to 2 years following infection. However, the data are collected for billing purposes and are not subject to systematic audit. They are influenced by the treatment

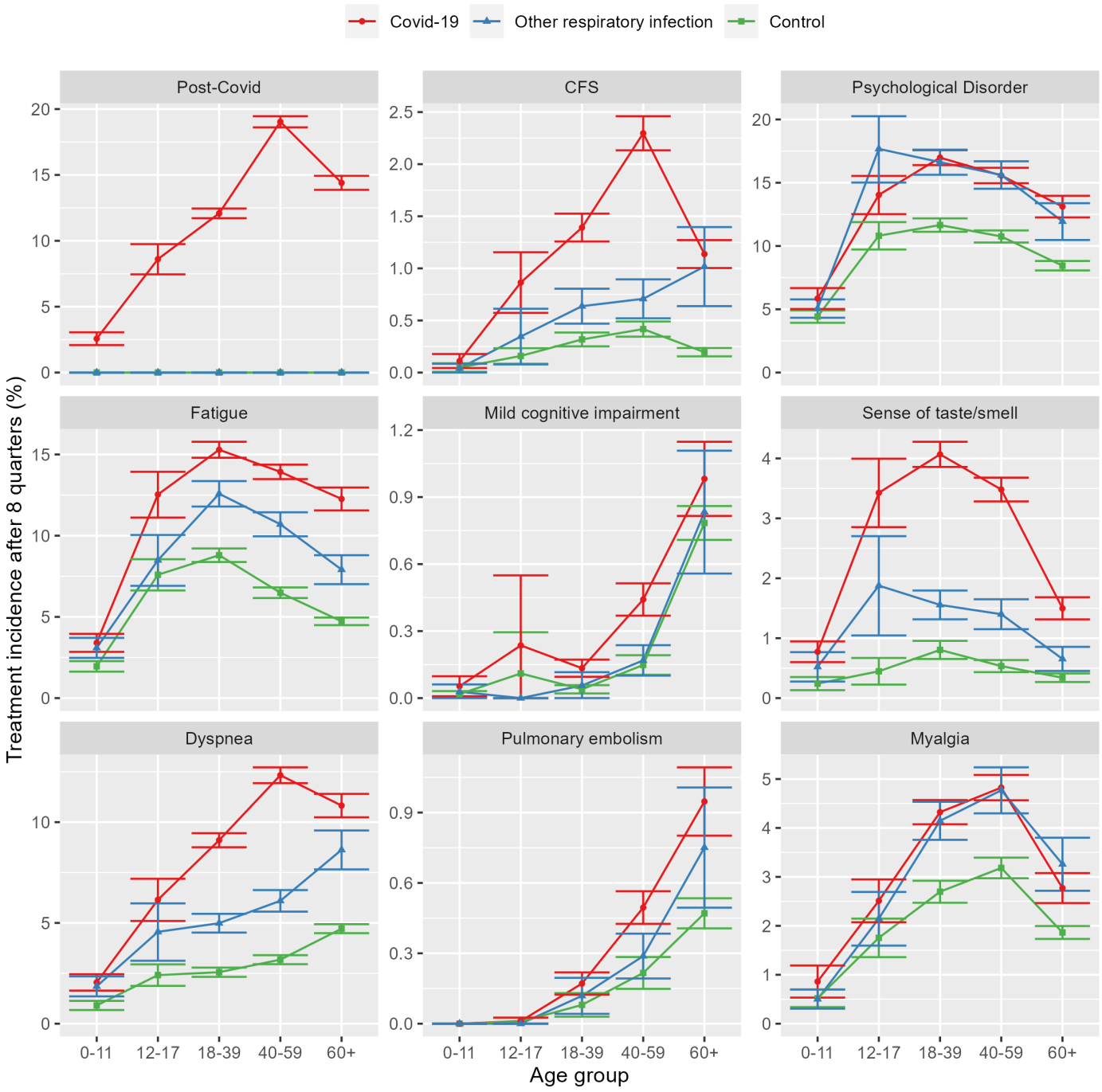

Figure 4 Estimated treatment incidence after eight quarters by age group. CFS, Chronic Fatigue Syndrome.

provided and the coding practices of the physician. A large proportion of patients with physician contact-related COVID-19 have no record of a test result, and it is possible that those with confirmation of the test result had more severe symptoms during the acute infection that required treatment. This impacts somewhat on the generalisability of the results. Our results show, however, that the newly introduced code for post-COVID syndrome has been used extensively by the physicians in ambulatory care, with incidence in the expected range. In contrast, a study by the OpenSAFELY group found that the corresponding SNOMED-CT codes were used rarely by GPs in England.[34]

A further strength of the use of routinely collected data is the ability to differentiate between pre-existing and new-onset conditions. This is especially important because some symptoms of post-COVID syndrome are common in the general population and may be mistaken for a postinfectious sequela of COVID-19. However, the deterioration of a previously existing condition may also be viewed as a post-COVID syndrome.[2] For example, a pre-existing asthma or chronic fatigue syndrome may be exacerbated by COVID-19. We are unable to consider this as post-COVID because insufficient data are available on symptom severity. Future work could

however assess whether the healthcare usage of patients with pre-existing conditions increased following infection.

Finally, we note that the vaccination campaign in Germany did not start until early 2021, so our COVID-19 cohort is a collective of largely unvaccinated patients, infected predominantly with the wild-type and alpha variants of the SARS-CoV-2 virus. The generalisability of the results to a population with high vaccine coverage under later variants is unclear and should be the subject of further research.

CONCLUSION

Our results demonstrate a moderately high incidence of post-COVID syndrome following infection with SARS-CoV-2. There is an urgent need to find efficient and effective solutions to help patients with dyspnoea, fatigue, cognitive impairment, loss of smell and mental disorders. Guidelines and treatment algorithms, including referral criteria, and occupational and physical therapy, require prompt and coherent implementation. Further research is required both to find new therapeutic options and to assess the implications of post-COVID syndrome for health services.

Contributors ED, MT, RG and AS had the study idea. ED and AH analysed the data. ED wrote the first draft of the manuscript. KL, AG and AS helped with writing. AS is acting as guarantor.

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Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval It was stated by the Medical Ethics Committee of the Medical Faculty of the Technical University Munich that ethical oversight is waived, because the data are anonymised and analysed by the KVB to support its statutory duties (reference number: 2022-292-W-SR).

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