



# Healthcare resource use and costs under pandemic circumstances in The Netherlands: Results from the lifelines COVID-19 cohort

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## ABSTRACT

**Objectives:** This study aims to estimate healthcare resource use (HCRU) and direct healthcare costs of COVID-19 and post-COVID-19 condition (PCC) in the Netherlands.

**Methods:** This study is based on a sub-cohort of the Lifelines general population cohort that repeatedly completed questionnaires during the COVID-19 pandemic. PCC was defined based on increased post-COVID-19 symptom scores compared to individuals' pre-infection symptom scores. Three groups were identified in the cohort: COVID-19 positive participants with PCC (PCC group), COVID-19 positive participants without PCC (COVID-19 group), and COVID-19 negative participants (control group). HCRU in the past three months was assessed in four waves of questionnaires (from June 2021 to June 2022). Self-reported frequencies of resource use in primary, secondary, and emergency care as well as hours of homecare and informal care received were calculated as an annual per person rate. Associated costs were calculated per person, using standard unit prices in 2022 Euros.

**Results:** HCRU was highest in the PCC group for almost all types of healthcare. Relative differences between PCC and control participants were highest for the hours of nursing care at home received, occupational and speech therapist consultations, day treatments at a rehabilitation center, and occupational physician visits. Total average annual healthcare costs per person were estimated at €1136, €616, and €678 for the PCC, COVID-19 and control group, respectively.

**Conclusion:** PCC is associated with a substantial increase in HCRU and associated costs in healthcare and society as a whole. The results may guide health authorities in planning for public health emergency preparedness.

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## Introduction

The unprecedented influx of COVID-19 patients during the pandemic has confronted health authorities across multiple countries with severe capacity limits in physical infrastructure and healthcare workers. In the acute phase of the pandemic, elective care for non-COVID-19 patients was downscaled by delaying or can-

celling procedures to increase capacity for COVID-19 patients [1]. Meanwhile, in-person contacts with general practitioners (GPs) decreased, due to cancelled or postponed care [2].

Since the acute phase of the pandemic has ceased, a substantial part of COVID-19 survivors still uses healthcare resources due to post-COVID-19 condition (PCC) [3]. A Dutch longitudinal cohort study reported a PCC prevalence of 12.7%, based on measurements from March 2020 until August 2021 [4]. PCC, also referred to as "long COVID," is defined as "the continuation or development of new symptoms 3 months after the initial SARS-CoV-2 infection, with these symptoms lasting for at least 2 months with no other

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explanation" [5,6]. Symptoms of PCC are highly heterogeneous, but include fatigue, shortness of breath and cognitive symptoms. PCC symptoms may persist, fluctuate or relapse over time [7].

Healthcare decisionmakers can be helped with a detailed description of healthcare expenses of both COVID-19 and PCC across different healthcare domains (e.g., emergency, outpatient, inpatient, and long-term care) to evaluate healthcare resource use (HCRU) and associated costs during the past pandemic as well as to plan for pandemic preparedness. Prior studies have investigated HCRU and direct medical costs of PCC, reporting substantial increases up to 2 years following COVID-19 diagnosis [8–10]. However, many of these studies were single-arm, and the ones including a control group often pertained to individuals without a COVID-19 diagnosis. The observation period was less than 1 year in the majority of studies with a pre-defined duration, and some studies provided long-term follow-up data of the post-acute COVID-19 phase and left aside a definition of PCC. Few studies have investigated the costs of outpatient visits: a study in Israel with a follow-up of 12 months reported a substantial increase in the utilization of healthcare services and direct healthcare cost for PCC, and a study in the United Kingdom (UK) reported a 44% increase in primary care consultation costs for PCC patients compared to patients with a history of COVID-19 but without PCC [11,12]. Thus far, there is a paucity of evidence regarding the direct healthcare costs associated with outpatient visits and other healthcare resources related to PCC in the Netherlands.

The current study aims to estimate HCRU and associated costs of PCC in the Netherlands. The results may deepen the understanding of the scale and urgency of PCC to the healthcare system and society as a whole and guide future resource allocation.

## Methods

### Study sample

This study is based on data collected within the Lifelines COVID-19 cohort study ( $n = 76,503$ ), an add-on study to the multidisciplinary, prospective, population-based, observational Dutch Lifelines cohort study examining the health and health-related behaviors of approximately 170,000 people in the north of the Netherlands [13,14]. The studies within the framework of the Lifelines study are granted permission by the Medical Ethical Committee of the University Medical Centre Groningen (2007/152) and all participants provided written informed consent. The current study will use data from four measurement waves (from June 2021 to June 2022) that assessed healthcare use and was completed by 34,384 adult participants.

### Symptom assessment and PCC definition

The Lifelines COVID-19 cohort is a general population sample aimed to measure the health and societal impact of COVID-19. COVID-19 in participants was based on a positive PCR/antigen test or a physician's diagnosis. Self-tests performed at home were not included. We categorized participants into three groups: COVID-19 positive participants with PCC, COVID-19 positive participants without PCC, and COVID-19 negative participants, which are hereafter referred to as "PCC group," "COVID-19 group," and "control group," respectively. The PCC group was determined by comparing the means of post SARS-CoV-2 infection symptom scores between 90 and 150 days after infection with the means of pre-infection symptom scores at least 7 days before infection. Symptoms were assessed using a five-point ordinal Likert scale, which measured the degree to which participants were bothered by each respective symptom (1 = not at all, 5 = extremely) in the past 14 days. Participants were classified as having PCC if at least one symptom

had substantially increased (at least one point) to at least moderate severity (a score of three points) at 90 to 150 days after COVID-19 compared to the mean pre-COVID-19 value. Since an international consensus on symptoms associated with PCC is lacking, the classification of PCC was based on all symptoms available, i.e., headache, chest pain, back pain, painful muscles, dizziness, difficulties with breathing, nausea, feeling hot and cold alternately, lump in the throat, tingling extremities, general tiredness, heavy arms or legs, runny nose, pain when breathing, sore throat, ageusia or anosmia, fever, diarrhea, dry cough, wet cough, sneezing, stomach pain, and itchy eyes [4,15]. The COVID-19 group included participants who did not match the criteria to be classified as having PCC. The no-COVID-19 group included participants who did not have a confirmed infection with SARS-CoV-2 and served as a control group.

### Healthcare resource use

HCRU was measured with the Medical Consumption Questionnaire (iMCQ) [16]. The iMCQ measures non-disease specific medical consumption and is recommended by the Dutch healthcare institute [17]. HCRU was calculated by counting self-reported frequencies of consultations (both physical and via phone call) with a healthcare provider in primary care and frequencies of visits of a specialist in secondary care in the past 3 months.

In the Netherlands, primary care is directly accessible for patients, whereas secondary care is only accessible after a referral by a primary care provider, such as the general practitioner (GP). Other types of healthcare resources were hospitalizations and emergency room visits (with or without ambulance transport) as well as the hours received in housekeeping, nursing, and informal care and occupational healthcare. Furthermore, the number of day treatments in the hospital, a rehabilitation center or other healthcare facility were measured. A list of all types of healthcare resources is provided in the Supplementary materials (Table S1).

Participants were excluded from the current analysis if they reported at least once 65 or more consultations, visits, or days, which was deemed an unrealistically high value considering a period of 3 months with approximately 65 working days. Also, participants reporting more than 2184 hours of care received were excluded, based on a conservative assumption of 24 hours per day over 13 full weeks. To prevent participant identification, inpatient days in healthcare facilities other than the hospital were merged because of frequencies less than 10.

### Costs

Standard unit prices were derived from the Dutch guideline for economic evaluation in healthcare, providing reference prices in Euros at the price level of 2022. The guideline includes prices for all types of healthcare resources, except for the occupational physician [17,18]. Frequencies of occurrence for each type of healthcare resource were subsequently multiplied by standard unit costs to calculate annual healthcare costs per participant. Costs were accumulated to estimate per person healthcare costs for the three study groups and were expressed per 12 months, as HCRU was derived from data reported over four consecutive year quarters. The base case analysis was conducted from a healthcare perspective, which implied the exclusion of costs of informal care, such as care provided by family, friends, or neighbors, and costs of the occupational physician.

### Scenario analyses

To estimate the effect of the addition of costs of informal care and occupational healthcare to the total costs, two scenar-

**Table 1**

Population characteristics of the subsample of adult participants in the Lifelines prospective general population cohort that responded to the COVID-19 specific questionnaires distributed between June 2021 and June 2022.

|                          | PCC (n = 1003) | COVID-19 (n = 2467) | Control (n = 24,354) |
|--------------------------|----------------|---------------------|----------------------|
| Sex, % female            | 74.0%          | 60.5%               | 60.2%                |
| Age, mean (SD)           | 54 (12)        | 57 (11)             | 60 (12)              |
| BMI, mean (SD)           | 26.7 (4.7)     | 26.0 (4.1)          | 26.0 (4.2)           |
| Educational level, n (%) |                |                     |                      |
| High                     | 360 (35.9)     | 832 (33.7)          | 8520 (35.0)          |
| Medium                   | 427 (42.6)     | 950 (38.5)          | 8622 (35.4)          |
| Low                      | 190 (18.9)     | 619 (25.1)          | 6649 (27.3)          |
| Unknown                  | 26 (2.6)       | 66 (2.7)            | 563 (2.3)            |
| Chronic disease (%)      |                |                     |                      |
| Cardiovascular disease   | 12.1%          | 9.5%                | 12.4%                |
| Lung disease             | 11.8%          | 8.8%                | 9.1%                 |
| High blood pressure      | 9.3%           | 7.0%                | 9.1%                 |
| Auto-immune disease      | 5.7%           | 3.8%                | 4.9%                 |
| Diabetes                 | 3.8%           | 2.2%                | 3.4%                 |
| Coronary disease         | 2.9%           | 2.5%                | 3.3%                 |
| Psychological illness    | 2.8%           | 1.8%                | 2.7%                 |
| Chronic muscle disease   | 2.5%           | 0.8%                | 1.3%                 |
| Other                    | 20.5%          | 14.3%               | 18.1%                |

Abbreviations: BMI = body mass index; PCC = post-COVID-19 condition; SD = standard deviation. The "Other" category under Chronic disease included, but is not limited to, cancer, kidney disease, stroke, liver disease, heart attack, narrowing arteries in legs, neurological disease, and problems with spleen.

ios were explored in addition to the base case. The first scenario included costs of informal care by valuing the hours of care provided by family, friends, or neighbors, as reported by the participants. A second scenario included the costs of the occupational physician, which were estimated from publicly available tariffs of a Dutch provider of occupational physician services [19,20].

Further, the PCC group was based on the definition of the symptoms to classify PCC as described earlier. A third scenario applied an alternative, stricter, definition of PCC using 10 instead of 23 symptoms. These 10 symptoms (chest pain, difficulties with breathing, pain when breathing, painful muscles, ageusia or anosmia, tingling extremities, lump in throat, feeling hot and cold alternately, heavy arms or legs, and general tiredness) were previously defined as core symptoms for PCC in the Lifelines COVID-19 cohort [4].

## Results

### Population characteristics

A participant selection flow-chart is given in Figure 1 of the Supplementary Materials. 24,354 participants were included in the control group, 2467 participants in the COVID-19 group, and 1003 participants in the PCC group. A total of 143 participants were excluded due to unrealistically high values. Another 6417 participants with a COVID-19 diagnosis were excluded from the analysis because of insufficient data on symptom scores before or after their COVID-19 diagnosis. General characteristics of the study groups are displayed in Table 1. The majority of patients was female in all three groups, especially for the PCC group. Types of chronic diseases were rather similar between the PCC and control group, whereas chronic diseases were less often reported in the COVID-19 group.

### Healthcare resource use

The average annual number of primary care consultations was highest in the PCC group for all types of healthcare providers (Figure 1A). PCC patients most often consulted a physical therapist: six times in 1 year. A GP and a general practice mental health

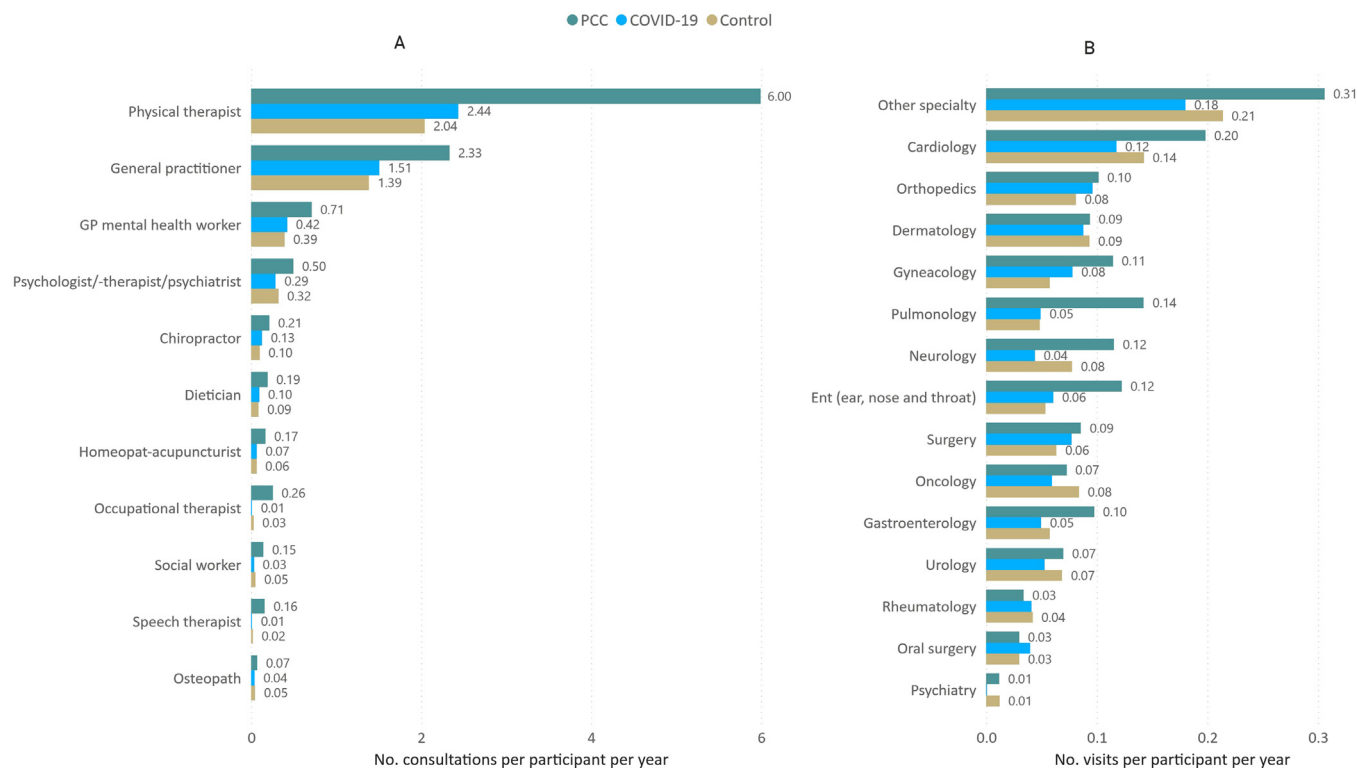
worker were consulted more than twice and less than once a year, respectively. In terms of relative differences between groups, the largest difference was observed for the occupational therapist (PCC to control: 8.7 times; PCC to COVID-19: 20.3 times) and the speech therapist (PCC to control: 8.0 times; PCC to COVID-19: 14.2 times). Other healthcare providers were at least 1.5 times more often consulted by individuals in the PCC group, compared to the other groups.

Regarding secondary care visits, the PCC group had the highest annual number of visits in 9 out of fifteen specialties, compared to the other two groups (Figure 1B). The highest absolute difference between PCC and COVID-19 was in the "unspecified specialty" category (0.13 visits), followed by the pulmonology specialty (0.09 visits). In relative terms, participants with PCC visited a pulmonologist 2.9 times more often than participants in the other two groups. The relative difference in Ear, Nose, and Throat specialty visits was 2.3 between PCC and control and 2.0 between PCC and COVID-19. The relative difference was highest between PCC and COVID-19 for psychiatry, which was due to an average number of approximately zero visits in the COVID-19 group.

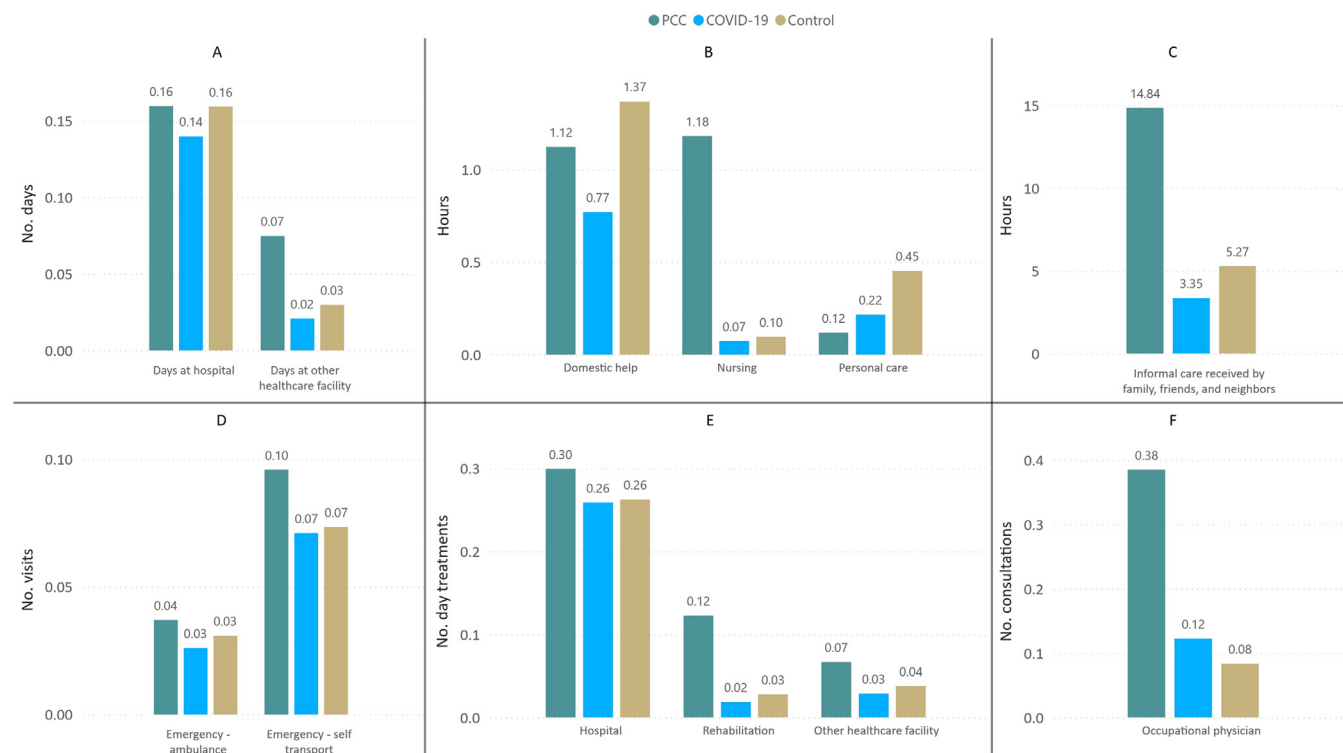
HCRU in different healthcare domains other than primary care consultations and secondary care visits is presented in Figure 2. Remarkably, within home care, more hours of nursing were received in the PCC group, whereas the difference was less pronounced and even in the opposite direction for domestic help and personal care (Figure 2B). Furthermore, number of hours received for informal care was substantially higher in the PCC group than in the other groups (Figure 2C). The number of visits at the Emergency Department were higher for the PCC group as well (Figure 2D). Participants with PCC also reported substantially more visits for rehabilitation: 6.6 and 4.4 times higher in PCC versus COVID-19 and control, respectively (Figure 2E). See figures in the Appendix for boxplots of the HCRU data per group.

### Costs

Total average annual healthcare costs per participant amounted to EUR 1136 for the PCC group, EUR 616 for the COVID-19 group,



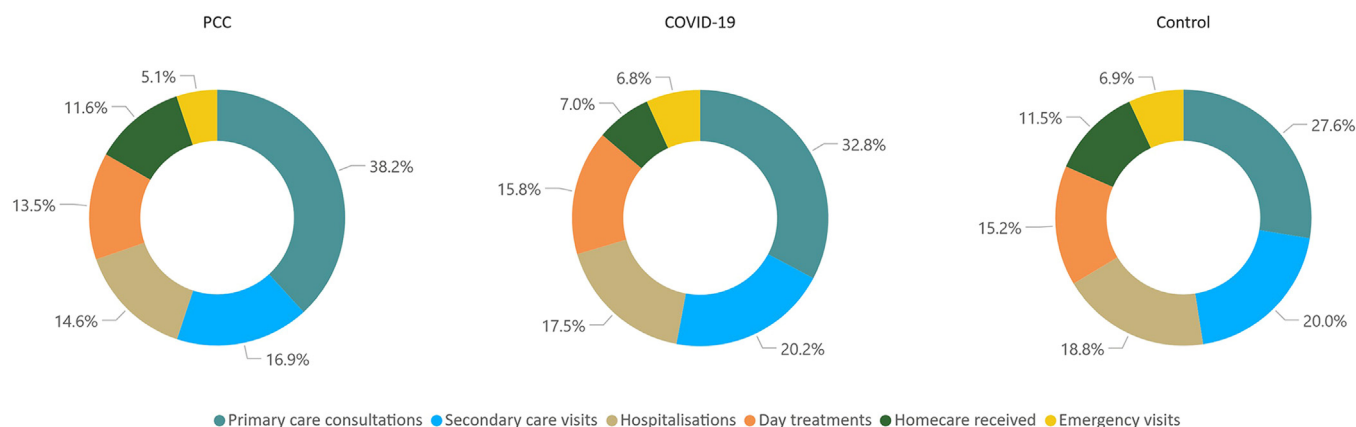
**Figure 1.** Healthcare resource use in primary and secondary care of COVID-19 positive study participants with Post-COVID-19 Condition (PCC), COVID-19 positive study participants without Post-COVID-19 Condition (COVID-19), and COVID-19 negative study participants (Control). A) number of consultations per participant by specialty in primary care; B) number of visits per participant by specialty in secondary care. Abbreviations: GP = general practice.



**Figure 2.** Healthcare resource use of COVID-19 positive study participants with Post-COVID-19 Condition (PCC), COVID-19 positive study participants without Post-COVID-19 Condition (COVID-19), and COVID-19 negative study participants (Control). All values are expressed per participant per year. A) Hospitalization at the hospital or other healthcare facility in number of days; B) Hours of homecare received; C) Hours of informal care received by family, friends, and neighbors; D) Number of visits at the Emergency Department; E) Number of day treatment at the hospital, rehabilitation facility, or other healthcare facility; F) Number of consultations at the occupational physician.



**Figure 3.** Annual average healthcare costs (EUR 2022) per COVID-19 positive study participant with Post-COVID-19 Condition (PCC), COVID-19 positive study participant without Post-COVID-19 Condition (COVID-19), and COVID-19 negative study participant (Control) by group of healthcare resources.



**Figure 4.** Distribution of costs per group of healthcare resources as a proportion of the annual average healthcare costs for COVID-19 positive study participants with Post-COVID-19 Condition (PCC), COVID-19 positive study participants without Post-COVID-19 Condition (COVID-19), and COVID-19 negative study participants (Control).

and EUR 678 for the control group. Except for hospitalizations, costs of the PCC group were substantially higher than costs of the COVID-19 group. Compared to the other two groups, average annual costs per participant in the PCC group were more than twice as high for primary care consultations (PCC: € 434; COVID-19: € 202; Control: € 187). Costs of the control group were higher for all groups of healthcare resources compared to the COVID-19 group, except for primary care consultations. Average annual costs per participant are shown per group of healthcare resources in Figure 3.

In each of the three study groups, primary care consultations accounted for the largest proportion of the annual average healthcare costs. The proportion of costs for each healthcare resource component per study group are displayed in Figure 4.

#### Scenario analyses

Hours of informal care provided by family, friends, or neighbors amounted to 14.8 hours per week per PCC participant, against 3.4 and 5.3 hours in the COVID-19 and control group, respectively (Figure 2F). Compared to the base case, total annual costs per participant in the first scenario where informal care was included increased by 24.6% (€ 1415 vs € 1136) for the PCC group, 10.2% (€

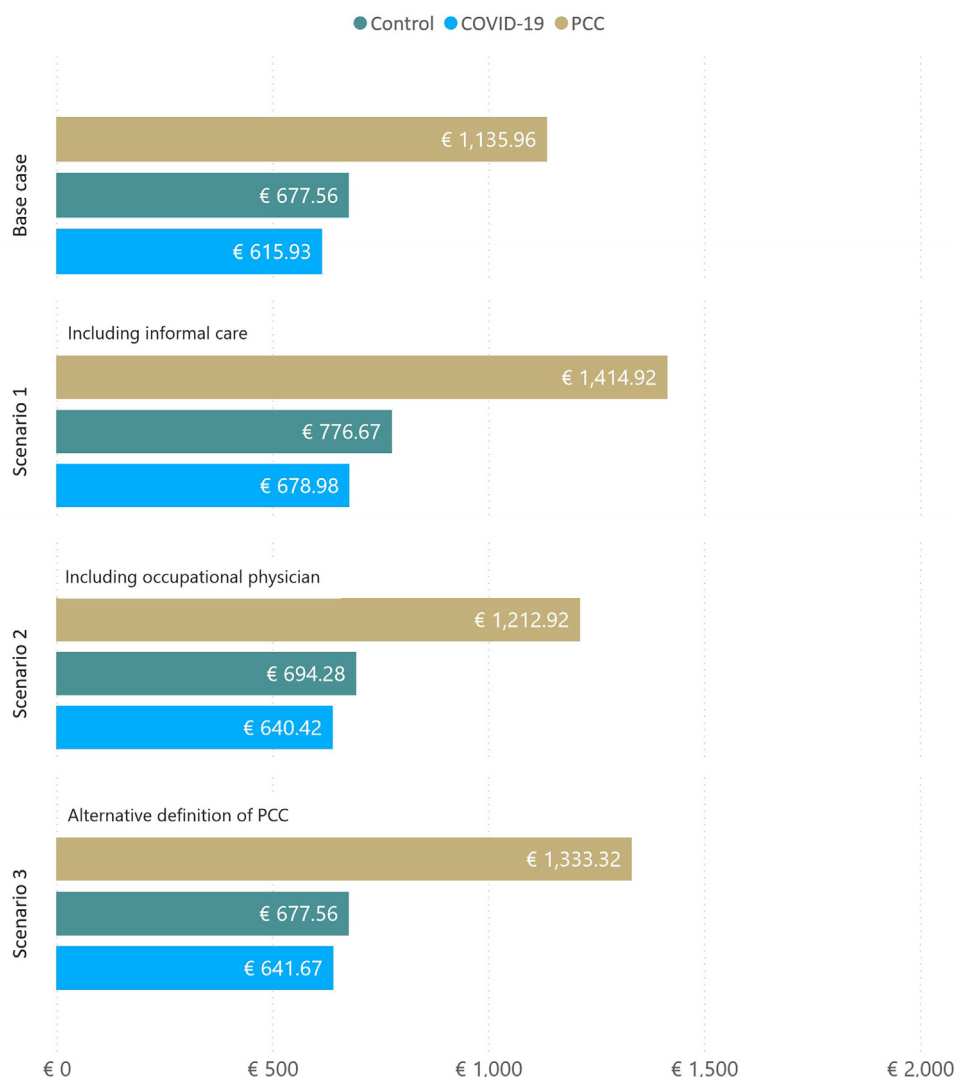
679 vs € 616) for the COVID-19 group, and 14.6% (€ 777 vs € 678) for the control group (Figure 5). The inclusion of cost of the occupational physician in the second scenario was based on 0.385, 0.122, and 0.084 visits per year, resulting in a cost increase of 6.8% (€ 1213 vs € 1136), 4.0% (€ 640 vs € 616), and 2.5% (€ 694 vs € 678) for the PCC group, the COVID-19 group, and the control group, respectively.

The alternative definition of PCC using only 10 symptoms led to a different distribution of participants between the COVID-19 group and the PCC group: 378 participants with PCC under the base case definition were now classified as COVID-19 participants. The third scenario resulted in a cost increase of 17.4% (€ 1333 vs € 1136) for the PCC group and 4.2% (€ 642 vs € 616) for the COVID-19 group, compared to the base case. Costs per group are presented per scenario in Figure 5.

#### Discussion

##### Main findings

The current study provides relevant estimates of HCRU and healthcare costs during the pandemic across three subgroups. On average, HCRU across different healthcare domains was higher



**Figure 5.** Scenario analyses in addition to the base case. Costs are given as an average annual costs (EUR 2022) per COVID-19 positive study participant with Post-COVID-19 Condition (PCC), COVID-19 positive study participant without Post-COVID-19 Condition (COVID-19), and COVID-19 negative study participant (Control). In the first scenario, costs of informal care were included, based on the hours of care provided by family, friends, and neighbors, as reported by the participant. In the second scenario, the costs of the occupational physician were included. In the third scenario, an alternative definition of PCC was applied, based on 10 instead of 23 symptoms.

among those with PCC compared to the COVID-19 group and the control group. Among primary care consultations, the largest difference in absolute terms was observed in the physical therapist consultations. Relative differences in HCRU between the PCC group and the control group were most pronounced in the number of consultations at the speech and occupational therapist, as well as in the number of day treatments at a rehabilitation center, the hours of nursing received, and the number of visits at the occupational physician. Average annual healthcare costs of participants with PCC were €1136 per person, compared to €616 for participants who recovered from COVID-19 and €678 for participants without COVID-19.

### Interpretation

The relatively high number of GP consultations in the PCC group can likely be explained by the persistence of a wide diversity of symptoms as well as the absence of an effective care pathway [15]. Considering several physical symptoms associated with PCC, such as chest pain, back pain, painful muscles, it was not surprising that participants in the PCC group reported a relatively high

number of physical therapist consultations, occupational therapist visits, and day treatments at a rehabilitation center. Moreover, despite the fact that the mean age in the PCC group was lower compared to the other groups, the hours of nursing care could also be explained by physical disabilities and complaints due to PCC.

At the time of writing, the emergency phase of the pandemic has ceased and the number of new COVID-19 cases worldwide has decreased. Nonetheless, a substantial proportion of PCC patients experience persistent symptoms and daily life limitations at 24 months after infection. A study in Switzerland found that approximately one out of five COVID-19 infected people still reported COVID-19 related symptoms by 2 years after infection [3]. Another study from China among patients discharged from the hospital found that people with PCC symptoms had lower health-related quality of life, decreased exercise capacity, more mental health issues, and increased healthcare use at 24 months postinfection [21]. These numbers reveal the longitudinal impact of PCC on patients, their families, and society, and address the need for dedicated care to this particular group of patients. It should be noted though that the risk of PCC development may differ by the SARS-CoV-2 variant of infection. The risk of PCC seems to be lower with *Omicron* in-

fections (versus *Delta* infections) and was inversely associated with the number of COVID-19 vaccine doses received [22–24]. Notably, the two studies mentioned above enrolled individuals in the first year of the pandemic (2020) [3,21].

The cost estimates presented here allow for calculation of costs attributable to PCC. Attributable costs could serve as a valuable input to health economic evaluations regarding COVID-19 care. The incorporation of costs of long-term sequelae would increase accuracy of cost-effectiveness estimates in the context of COVID-19, a point that was also raised in a literature review on economic evaluations of acute COVID-19 drug treatments [25]. The current study narrows the knowledge gap by providing COVID-19 and PCC cost estimates based on a comprehensive measurement of HCRU.

The per participant cost may vary from person to person. Between July 18, 2020 and January 1, 2025, paramedic recovery care for PCC patients was reimbursed in the Netherlands [26,27]. However, the costs per patient depends on the amount and types of healthcare resources used, as a maximum number of treatments applies for some types of care. For instance, physiotherapy or remedial therapy is reimbursed for up to 50 treatments in 6 months, occupational therapy for up to 10 hours in 6 months, dietician consultations for up to 7 hours in 6 months, whereas no maximum applies for speech therapy [28]. Additionally, the choices made regarding health insurance (e.g., the height of the deductible) can play a significant role in healthcare expenses as well [29].

Besides healthcare related costs, the inclusion of costs of informal care, as analyzed in the first scenario, showed a substantial increase in the costs per person for PCC patients. The inclusion of cost of the occupational physician in the second scenario revealed the significance of direct non-medical cost in the calculation of overall cost estimates as well. The scenario using 10 symptoms instead of 23 looked into an alternative classification of PCC. A lower number of symptoms to qualify PCC shifts part of the patients from the PCC group to the COVID-19 group. This shift resulted in costs for both groups being higher than in the base case. This can likely be explained by a higher proportion of severe patients in the PCC group as well as in the COVID-19 group, compared to the base case, resulting in higher costs per cost component for PCC. The use of all symptoms available (=23) in the definition of PCC in the base case instead of 10 symptoms was deemed relevant because of the lack of an international consensus on symptoms associated with PCC. Both definitions may lead to a misclassification of PCC, since individuals in the base case may have been considered as having PCC based on one or more symptoms that are afterwards not associated with PCC, or vice versa for the scenario analysis. The impact of the scenario using 10 symptoms emphasizes the relevance of a clear definition of the disease to properly interpret healthcare costs of COVID-19 and PCC.

Similar to the present study, costs of GP, nurse and physiotherapist consultations were found to be significantly higher in PCC patients in a study performed in the UK [11]. The outcome of the study is consistent with the outcome presented here in the sense that the number of consultations with the GP, general practice mental health worker and physiotherapist were high compared to the other types of consultations. Furthermore, a German study reported direct healthcare costs attributable to PCC and estimated a mean cost of €4583 per case, based on hospitalizations, ICU treatments and hospital procedures [30]. The costs of secondary care in the German study were based on hospital procedures, which enables a more specific cost calculation than using the reference price of a general outpatient visit as was done in the current study. It is arduous though to estimate the direction of differences in costs between both studies.

PCC may substantially impact healthcare systems and economies, requiring further investigation of optimal care and policies to mitigate the effects [31]. The HCRU and associated

costs for PCC patients as reported here should be interpreted in comparison to the other groups, rather than as an overview of national HCRU and budgeting. This is because the resource use questionnaire in the Lifelines cohort and the methods used to convert resource use into costs mostly apply to economic evaluation analysis in healthcare. These methods are not aligned with how national healthcare spending is generally reported. Furthermore, the Lifelines COVID-19 sub-cohort is not a valid representation of the total Dutch population [13]. The PCC costs as reported in the present study should therefore not be compared with average healthcare spending per capita in the Netherlands to draw conclusions about absolute magnitude of the resource use or costs. Therefore, we can only say that *relative to other people in the Lifelines cohort*, PCC patients have more HCRU and consequently higher costs.

### Strengths and limitations

The strength of the current study lies in the large sample size derived from a Dutch general population cohort. As the study participants reported on their symptoms at multiple time points, we could classify three study groups, representing populations with and without COVID-19 and PCC, based on 23 identified symptoms that were repeatedly assessed during the COVID-19 pandemic. HCRU could comprehensively be included, based on a standardized instrument for measuring medical consumption [16].

The study is also subject to a few limitations. First, the external validity of the results may be limited and healthcare costs as estimated here should be carefully compared to similar evidence presented elsewhere. This is because age, sex, body mass index and smoking history of participants of the COVID-19 Lifelines cohort were slightly different from the total Lifelines cohort, which has shown to be representative of the regional population [13,32]. Moreover, geographical variation in prevalence of PCC in the Netherlands may impact the differences in HCRU and costs between groups as presented here.

Next, while the control and COVID-19 groups served as references to contextualize and interpret the findings for the PCC group, the cost estimates provided here should not be interpreted as costs directly attributable to PCC. Implementing a difference-in-difference approach would be challenging, since COVID-19 infection (as the exposure) varied over time. Moreover, the study aimed to estimate HCRU and associated costs of PCC, rather than to identify or explain factors underlying differences in HCRU and costs between PCC and control groups over time.

Further, within the secondary care visits, the “Other” category had the highest proportions for all three study groups. Although 14 distinct hospital sub-specialties had been included in a multiple-choice question to the number of secondary care visits, one rather important specialty (i.e., internal medicine) appeared to be not included in the response options. Visits reported in the “Other” category may represent the internal medicine outpatients clinic.

Finally, the study overlooked medication use and associated costs. Considering that medication may substantially contribute to the direct healthcare costs of PCC, the absence of medication in the cost calculation may be perceived as a limitation.

### Implications for future research

Follow-up research looking into the factors contributing to high healthcare consumption is needed. Determining the relation between existing conditions or population characteristics may help towards the efficient allocation and organization of healthcare resources. Besides HCRU, medication use and associated costs need to be investigated. Moreover, the inclusion of non-medical cost elements, such as productivity loss, probably contributes substantially

to the societal impact of PCC and may enhance the comparison across the groups of the current analysis. Data regarding working hours or days lost due to the disease were however not measured as part of the Medical Consumption Questionnaire (iMCQ).

This study addresses the scale and urgency of HCRU of PCC patients to the Dutch healthcare system. Although numerous symptomatic and supportive clinical approaches are being explored, no broadly effective treatment or care pathway for PCC is available yet [33]. The need to identify the types of healthcare used by PCC patients as well as the need for access to specialist PCC services have been addressed earlier [34,35]. In 2024, the Dutch government has decided to fund the establishment of post COVID-19 clinics, of which the first ones are in use at the time of writing [36,37]. Having observed a higher HCRU across multiple healthcare providers and medical specialties, and considering the extensively reported complexity of symptoms of PCC patients, the setup of dedicated clinics may be an opportunity to improve access to hospital care and effectively search for root causes of certain symptom profiles in PCC patients. However, there are still many knowledge gaps regarding the condition of interest. Evidence concerning the epidemiology, biological mechanisms, clinical manifestations, but also the wider societal impact of PCC is still immature. Prevalence studies of PCC are needed to gain insight into the magnitude of PCC and the specification by patient characteristics. Based on the outcome of such studies, a stratification of PCC into homogeneous subgroups may support the optimization of care pathways.

The outcome of the present study implies a substantial economic impact of PCC on the healthcare system. The study findings can be of use in policies regarding pandemic preparedness, which should go beyond the acute phase of the pandemic and include coordination of and clinical capacity for the prevention and treatment of long-term consequences. This urges early identification of long-term effects of infectious diseases as part of pandemic preparedness.

Health-related quality of life is another important aspect of further research in PCC. Utilities, or health state preference values, facilitate the calculation of quality-adjusted life years (QALYs), which is a standard measure in health economic evaluation. Although a few studies explored health-related quality of life, expressed as utility values in COVID-19 survivors with long-term sequelae, heterogeneity between individuals' health profiles is substantial [38,39]. Moreover, country-specific utility estimates would enhance cost-effectiveness analyses of healthcare interventions in the area of PCC.

## Conclusions

PCC is associated with a substantial increase in HCRU and associated costs in healthcare and the society as a whole. The results of the present study reveal what types of healthcare are mainly used by PCC patients, which may support policymakers in structuring efficient care pathways for PCC. Given that healthcare resources, such as budgets and personnel in both primary and secondary care, are generally growing scarcer, it is important to monitor resource use to identify bottlenecks throughout the care pathway.

## Availability of data and material

The data underlying this article were provided by Lifelines. Lifelines is a facility that is open for all researchers. Information on application and data access procedure is summarized on [www.lifelines.nl](http://www.lifelines.nl).

## Declaration of competing interest

The authors have no competing interests to declare.

## CRediT authorship contribution statement

**Clazinus Veijer:** Data curation, Formal analysis, Visualization, Writing – original draft. **Antoinette Dorothea Isabelle van Asselt:** Conceptualization, Supervision, Writing – review & editing. **Sander Kurt Riemer van Zon:** Conceptualization, Data curation, Writing – review & editing. **Judith Gerarda Maria Rosmalen:** Conceptualization, Funding acquisition, Writing – review & editing. **Sandra Brouwer:** Writing – review & editing. **Tanja Fens:** Data curation, Supervision, Writing – review & editing.

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## Ethics approval

The Lifelines cohort study and its add-on studies were approved by the Medical Ethical Committee of University Medical Center Groningen (2007/152) and participants provided written informed consent to take part.

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## Supplementary materials

Supplementary material associated with this article can be found in the online version, at [doi:10.1016/j.ijid.2026.108854](https://doi.org/10.1016/j.ijid.2026.108854).

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