**Title:** Trajectories of functional limitations, health-related quality of life and societal costs in individuals with Long COVID: a population based longitudinal cohort study

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**ABSTRACT**

**Objectives**

To examine trajectories of functional limitations, fatigue, health-related quality of life (HRQL) and societal costs of patients referred to long COVID clinics.

**Design**

Longitudinal single-arm service evaluation utilising real-time user data.

**Setting**

35 Long COVID clinics in the UK.

**Participants**

4087 adults diagnosed with long COVID in primary or secondary care deemed suitable for rehabilitation, and registered in the Living With Covid Recovery (LWCR) programme between 4 August 2020 and 5 August 2022.

**Main Outcome Measures**

Generalised linear mixed models were fitted to estimate trajectories of functional limitations, using the Work and Social Adjustment Scale (WSAS); scores of ≥20 indicate moderately severe limitations. Secondary outcomes included fatigue using the Functional Assessment of Chronic Illness Therapy – Fatigue (FACIT-F) reversed score (scores of ≥22 indicate impairment), HRQL using the EQ-5D-5L, and long COVID-related societal costs, encompassing healthcare costs and productivity losses.

**Results**

The mean WSAS score at 6 months after registration in the LWCR was 19.1 (95% confidence interval (CI) 18.6, 19.6), with 46% of the participants (95% CI 40.3%, 52.4%) reporting a WSAS score above 20 (moderately severe or worse impairment). The mean change in the WSAS score over the 6-month period was -0.86 (95% CI -1.32, -0.41). The mean reversed FACIT-F score at 6 months was 29.1 (95% CI 22.7, 35.5) compared to 32.0 (95% CI 31.7, 32.3) at baseline. The mean EQ-5D-5L score remained relatively constant between baseline (0.63, 95% CI 0.62, 0.64) and 6 months (0.64, 95% CI 0.59, 0.69). The monthly societal cost per patient related to long COVID at 6 months was £931, mostly driven by the costs associated with working days lost.

**Conclusions**

Individuals referred to long COVID clinics in the UK reported small improvements in functional limitations, fatigue, HRQL and ability to work within 6 months of registering in the LWCR programme.

**Strengths and limitations of the study**

* Prospective, longitudinal follow-up of a large population of individuals with a confirmed long COVID diagnosis and real-time outcome data collection.
* Sample includes individuals referred to 35 long COVID clinics, geographically spread across the UK, enhancing the generalisability of the results.
* The use of generic, validated measures facilitates the interpretation of the long COVID burden compared with other diseases.
* All analyses were based on complete cases; we acknowledge that individual dropout may have introduced bias.
* Separate trajectory models for individuals with different follow up periods were conducted to minimise biases due to dropout.

**INTRODUCTION**

Long COVID, as defined by the National Institute of Health and Care Excellence (NICE), refers to the persistence of symptoms lasting for at least 12 weeks following COVID-19 infection 1. It has been suggested that at least 1 in 10 patients who had COVID-19 experience long COVID symptoms 2. By March 2024 (latest figures made available by the Office for National Statistics), an estimated 2 million people in the UK (3.3% of the population), reported experiencing symptoms consistent with long COVID 3. These symptoms have a particularly significant impact on the working-age population, leading to both absenteeism (productivity loss due to time off work) and presenteeism (lower productivity due to illness while working) 4. It has been estimated that these productivity losses amounted to £5.7 billion in the UK between 2022 and 2023 5.

The manifestations of long COVID are diverse and vary significantly among individuals. Common symptoms include fatigue, cognitive impairment, breathlessness, anxiety and depression 6. These symptoms impair individuals’ daily functioning, including their ability to work, manage home responsibilities, engage in social and leisure activities, and maintain personal relationships. The high prevalence of long COVID, the diversity of the symptoms and rehabilitation pathways have added to the complexity of providing adequate care for long COVID patients in the UK NHS 3.

To help address these challenges, a bespoke digital health intervention, Living With Covid Recovery (LWCR), was developed and implemented across 35 long COVID clinics in the UK 7. The LWCR intervention was designed to facilitate remote rehabilitation and to support the recovery of people living with long COVID. The LWCR collected patient-reported outcome measures, encompassing the aspects of breathlessness, fatigue, anxiety, cognition and depression, enabling clinicians to monitor and adjust the care provided to each patient 8.

In a recent cross-sectional study 7, we described the characteristics and self-reported symptoms of a cohort of patients referred to long COVID clinics in England. We found that over half of this care-seeking population reported moderately severe or worse functional limitation within the first month (baseline) of registering in the LWCR programme. Fatigue seemed to be the dominant symptom explaining the variation in functional limitations, with a substantial impact on the individual’s ability to work and activities of daily living.

A recent umbrella review suggested that long COVID is likely to have an impact on family life, social functioning and mental health, but highlighted that the existing evidence is premature and insufficient to inform health care decision making 9. They emphasised that representative, prospective studies are vital to improve current understanding of the impact of long COVID on functional impairment, health outcomes and costs over time.

This paper reports on the trajectories of functional limitations, fatigue, HRQL and societal costs within the first 6 months after registration in the LWCR. In addition, we investigate whether these trajectories differ according to patient characteristics or the extent of the individuals’ participation in the LWCR programme.

**METHODS**

**Design and setting**

This is a population-based, longitudinal cohort study of patients with long COVID, who were referred to 35 specialised long COVID clinics in the UK and participated in the LWCR programme.

**Intervention**

The LWCR was a digital health intervention designed to support the recovery of individuals living with long COVID symptoms. The LWCR programme was developed collaboratively by a multidisciplinary team including clinicians, patient and public involvement representatives, academics and an industry partner, and encompasses three key components: 1) a mobile app for patients, which collects their symptoms and uses that information to deliver tailored, personalised advice; 2) a dashboard that allows clinicians to review patient’s progress and communicate with them; and 3) a clinical pathway that specifies how patients can safely receive this remote supported care. Patient information collected through the LWCR app enables the long COVID clinics to manage the high volume of patients and provide remote supported care. Further details about the development of the LWCR intervention are reported elsewhere 7 8.

**Population**

In 2020 the UK NHS has established specialist clinics to provide multidisciplinary services for individuals with a diagnosis of long COVID referred from primary and secondary care. Eligible participants were identified by the long COVID clinic as being suitable for the LWCR programme if they were aged 18 or over, had access to a smartphone, were considered likely to benefit from the digital intervention, were working, fit for rehabilitation and able to read English. This study included individuals with long COVID registered in the LWCR programme between 4 August 2020 and 5 August 2022, who completed the baseline questionnaires for the outcomes of interest within one month of registration (defined as ‘baseline’ in this study). Individuals could complete the questionnaires independently or supported by a health professional in the long COVID clinic. We also those individuals who are either retired or have chosen not to work for reasons unrelated to long COVID. The paper reported the results for those individuals who have not ticked this box.

**Primary outcome**

The primary outcome was the trajectory of Work and Social Adjustment Scale (WSAS) between baseline and 6 months after registration in the LWCR. WSAS is a self-reported measurement of functional limitations, evaluating how a specific condition affects a patient’s ability to carry out activities across five dimensions: 1) work, 2) home management, 3) social leisure activities, 4) private leisure activities and 5) close relationships 10. Each domain is rated between 0 (not at all) and 8 (very severely), resulting in a total score ranging from 0 to 40, with higher scores indicating greater functional impairment. A WSAS score of 20 or more has been considered to indicate moderately severe or worse functional impairment 10 11.

**Secondary outcomes**

Secondary outcomes for this study included trajectories of fatigue, HRQL and long COVID-related societal costs.

FACIT-F

The Functional Assessment of Chronic Illness Therapy–Fatigue (FACIT-F) measures self-reported fatigue and its impact on daily activities and function. This measure consists of 13 items, with each item rated between 0 (very much fatigue) and 4 (not at all). The summary score ranges from 0 to 52, with lower scores indicating more severe levels of fatigue. A threshold value of 30 was chosen to indicate impairment, in line with fatigue reported in a cancer population 12. In this study, we reversed the FACIT-F score (calculated as 52 minus the reported score) to align the direction of the score with that of the primary outcome. We refer to this as Reversed FACIT-F Scale; higher values of the reversed scale represent greater fatigue, with scores equal or above 22 indicating impairment.

EQ-5D-5L

The EQ-5D-5L is a self-reported HRQL measure consisting of five domains: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Each domain is rated on a 5-level scale. Take mobility for example, patients can choose from five options, ranging from “no problems in walking about” to “unable to walk about”. Responses to these questions are then combined with health-related preference weights from the UK population to construct an index EQ-5D-5L score 13. This score is anchored at 0 (death) and 1 (full health), allowing for negative values indicating health states worse than death.

Costs

The cost analysis took the societal perspective and included healthcare costs across primary and secondary care settings, as well as costs associated with working days lost (productivity losses) due to long COVID. The health service use questionnaire in the LWCR app recorded the number of GP visits, psychotherapy and physiotherapy sessions, hospital inpatient stays, and outpatient appointments in the past four weeks (month). To calculate healthcare costs, we combined the resource use with unit costs from the Unit costs of Health and Social Care 14 and NHS national tariffs 15. The health service use questionnaire also asked patients to report the number of days off work due to long COVID in the past four weeks. To calculate the total cost associated with working days lost, we costed the number of days off work using the average national minimum wage hourly rate (£13.57) and the average working hours per week (33.9 hours) estimated by the Office for National Statistics 16.

Patient demographics

The LWCR also included a Patient Demographic questionnaire, which collected socio-demographic data from patients, including age, gender, ethnicity and highest educational level. The Index of Multiple Deprivation (IMD) is derived from the individual’s postcode.

**Patient and public involvement**

This study had substantial patient and public involvement (PPI) with co-investigator (KB), the steering group, individual work package management groups and an overall PPI Advisory Group. The feedback from PPI was essential at an early stage in determining the PROMs chosen in the study and the primary outcome measure of the WSAS, and at a later stage in interpreting the findings of study and implications for practice.

**Statistical analysis**

The WSAS, fatigue and EQ-5D-5L scores were summarised as means for each month following registration in the LWCR over the 6-month follow-up. Trajectories were reported by fitting linear mixed models of the monthly means on the month following registration in the LWCR, assuming a quadratic relationship between the outcome and time. Socio-demographic variables, including age, gender, ethnicity, highest educational level, and IMD were also included in the models as control variables. The mean change from baseline to 6 months in the WSAS score was modelled using an analysis of covariance (ANCOVA).

We reported monthly mean costs up to 6 months following registration, based on the resource use reported on a monthly basis. Linear mixed effects models were also used to estimate the cost trajectories, adjusting for the same socio-demographic and time variables included in the outcome trajectory models. In addition, we also investigated whether the probability of reporting any working days lost at 6 months was associated with individual characteristics and time off work at baseline.

All our analyses were based on complete cases assuming that the drop out was at random conditional on the case mix. The frequency with which each questionnaire (one for each endpoint) was completed differed according to endpoint, and hence the sets of complete cases varied across endpoints. We reported differences in socio-demographic factors between individuals with different follow up times. To address potential biases arising from these differences, we reported separate trajectories for three types of participants: 1) those who completed the questionnaires only within the first month of registration (baseline), 2) those who completed the questionnaire at baseline and follow up between 2 and 5 months after registration in the LWCR, and 3) those who completed the questionnaire at baseline and follow up until at least 6 months after registration in the LWCR.

**RESULTS**

**Patient demographics**

The study included 4,087 individuals with long COVID, who completed the baseline Patient Demographic Questionnaire within the first month of registration in the LWCR (Table 1). There were missing data on education (n=272, 6.7%), ethnicity (n=990, 24%) and IMD (n=316, 7.7%). The participants had a mean age of 47.3 (12.2) years, 3,859 (94%) of whom were in the working age bracket (18-65). The participants were 71% (n=2,920) female, 89% (n=3,365) of white ethnicity, and about half (n=2,001, 52%) had a degree or postgraduate degree. 10% (n=385) were from the most deprived quintile and 24% (n=919) from the least deprived. Similar patient characteristics were seen in those who completed the baseline WSAS, EQ-5D-5L and resource use questionnaires (online supplemental material table S1).

Table 1 contrasted the characteristics of the participants in the whole sample (n=4,087) with those with different completion status of the WSAS questionnaire. Amongst individuals who completed the baseline WSAS (n=3,518) within the first month of registration, 63% (n = 2,228) completed the questionnaire only at baseline, 27% (n = 949) completed it at baseline and follow-up between 2 and 5 months after registration, and 10% (n = 341) completed it at baseline and follow up until at least 6 months after registration.

Table 1: Baseline socio-demographic characteristics of the study participants for the whole sample, and according to completion status of the primary outcome.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Patient characteristics n(%), unless stated otherwise | Study population  n(%)\* (n = 4087) | WSAS completed within the first month of registration (baseline) only n(%)\*  (n=2228) | WSAS completed at baseline and follow-up between 2 and 5 months after registration n(%)\*  (n=949) | WSAS completed at baseline and follow-up until at least 6 months after registration n(%)\* (n = 341) |
| Age (years), mean (SD) | 47.3 (12.2) | 46.3 (12.3) | 48.5 (11.9) | 49.7 (12.0) |
| Age category (years) | | | | |
| 18 – 30 | 429 (10.5) | 262 (11.8) | 83 (8.7) | 26 (7.6) |
| 30 – 50 | 1960 (48.0) | 1118 (50.2) | 431 (45.4) | 142 (41.6) |
| 50 – 65 | 1470 (36.0) | 738 (33.1) | 383 (40.4) | 146 (42.8) |
| 65 and over | 228 (5.6) | 110 (4.9) | 52 (5.5) | 27 (7.9) |
| Gender | | | | |
| Female | 2920 (71.4) | 1584 (71.1) | 692 (72.9) | 239 (70.1) |
| Male | 1155 (28.3) | 638 (28.6) | 253 (26.7) | 101 (29.6) |
| Non-binary | 12 (0.2) | 5 (0.2) | 4 (0.4) | 1 (0.3) |
| Highest educational level | | | | |
| No education | 151 (4.0) | 90 (4.2) | 35 (3.7) | 14 (4.1) |
| School leaver (NVQ 1-2) | 847 (22.2) | 479 (22.1) | 213 (22.5) | 85 (25.1) |
| A-level (NVQ-3) | 816 (21.4) | 480 (22.1) | 179 (18.9) | 82 (24.2) |
| Degree (NVQ-4) | 771 (20.2) | 414 (19.1) | 206 (21.8) | 62 (18.3) |
| Postgraduate degree (NVQ-5) | 1230 (32.2) | 701 (32.4) | 313 (33.1) | 96 (28.3) |
| Missing | 272 | 64 | 3 | 2 |
| Ethnicity | | | | |
| White | 3365 (88.8) | 1898 (88.4) | 846 (89.7) | 313 (92.9) |
| Non-white | 426 (11.2) | 249 (11.6) | 97 (10.3) | 24 (7.1) |
| Missing | 990 | 81 | 6 | 4 |
| IMD quintile | | | | |
| 1 to 2 (20% most deprived) | 385 (10.2) | 210 (9.8) | 114 (12.2) | 33 (9.9) |
| 3 to 4 | 748 (19.8) | 425 (19.9) | 181 (19.4) | 67 (20.1) |
| 5 to 6 | 875 (23.2) | 488 (22.9) | 206 (22.0) | 90 (27.0) |
| 7 to 8 | 844 (22.4) | 489 (22.9) | 199 (21.3) | 75 (22.5) |
| 9 to 10 (20% least deprived) | 919 (24.4) | 523 (24.5) | 235 (25.1) | 68 (20.4) |
| Missing | 316 | 93 | 14 | 8 |

\* Percentages are based on the complete cases within each variable. WSAS: Work and social adjustment scale. SD: standard deviation. NVQ: National Vocational Qualification. IMD: Index of multiple deprivation

Participants who completed WSAS questionnaire at baseline and follow-up between 2 and 5 months after registration, were on average older (48.5 vs 46.3), more likely to have a degree (54.9% vs 51.5%) and more likely to be female (72.9% vs 71.1%) compared to those who completed the WSAS questionnaire at baseline only. Participants with follow up until at least 6 months (versus those who completed the WSAS questionnaire at baseline only) were on average older (49.7 vs 46.3), less likely to have a degree (46.6% vs 51.5%), more likely to be white (92.9% vs 88.4%) and less likely to be in the least deprived quintile (20.4% vs 24.5%).

**Functional limitations**

Figure 1 reports the trajectories of the functional limitations for all respondents, and according to the completion status of the WSAS questionnaire. The estimated mean WSAS score at 6 months after registration based on the complete case analysis (N=3,518; Figure 1, Panel A) was 19.1 (95% confidence interval (CI) 18.6, 19.6), with nearly half of the respondents (46.3%, 95% CI 40.3%, 52.4%) expected to have a WSAS score above 20 (moderately severe or worse impairment). This compares to a mean WSAS score of 20.5 (95% CI 20.2, 20.9) at baseline, at which point 54.9% (95% CI 51.7%, 58.0%) of the participants had a WSAS score above 20. The mean change in the WSAS score over the 6-month period was -0.86 (95% confidence interval -1.32, -0.41). Similar trajectories were observed for each individual component of the WSAS (online supplemental material, Figure S2). In particular, functional impairment in the individual’s ability to work and enjoy social leisure activities remains moderately severe or worse over the 6-month follow up.

The mean WSAS score over time was somewhat higher (greater impairment) for those participants who completed WSAS at baseline and follow-up until at least six months after registration, compared to those with shorter follow up (Figure 1, panel B). The observed mean (standard deviation-SD) baseline WSAS score for the participants who reported WSAS at baseline only was 19.8 (SD 10.1; n=2,228). This compared with a mean baseline WSAS score of 21.3 (SD=9.1; n=949) and 23.3 (SD=9.1; n=341) for those who reported WSAS at follow up between 2 and 5 months and at least 6 months after registration, respectively. The slope of the trajectories over time was relatively similar between individuals with follow up less than 6 months and those with at least 6 months follow up. Of the participants who completed WSAS at baseline and follow-up until at least six months (n=341), 203 (59.5%) reported functional limitations in the moderately severe or worse category (WSAS scores above 20).

Table 2 reports associations between WSAS trajectories over the 6-month follow up and baseline socio-demographic characteristics. Individuals aged 50 and above reported lower functional impairment over time compared to younger adults. For example, patients aged 65 or above were associated with lower (-4.48, 95% CI -6.18, -2.78) average WSAS score compared to individuals aged 18 to 29. Men were also associated with a lower average WSAS score (-1.63, 95% CI -2.32, -0.93) over time compared to women. Individuals in the most deprived quintile were associated with a higher (1.41, 95% CI 0.40, 2.43) functional impairment compared to those in quintile 2 or above.

<< Figure 1 here >>

**Fatigue**

The trajectories of fatigue for all respondents, and according to the completion status of the FACIT-F questionnaire are reported in online supplemental material (Figure S1). Similar to the primary outcome, mean reversed FACIT-F scores slightly decreased (less impairment) over time; the estimated mean reversed FACIT-F score at 6 months was 29.1 (95% CI 22.7, 35.5) compared to 32.0 (95% CI 31.7, 32.3) at baseline. However, there were little differences in fatigue trajectories between individuals with different completion status of the FACIT-F questionnaire.

Table 2: Associations between the Work and Social Adjustment Scale (WSAS) score trajectories over the 6-month follow up and baseline socio-demographic characteristics

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Patient characteristic | N (%) | Estimate (SE) | 95% CI | p-value |
| Age (years) |  |  |  |  |
| 18-29 | 426 (10.5%) | Reference |  |  |
| 30-49 | 1,945 (47.9%) | -0.73 (0.56) | (-1.82, 0.37) | 0.192 |
| 50-64 | 1,461 (36.0%) | -2.38 (0.57) | (-3.50, -1.25) | <0.001 |
| 65+ | 227 (5.6%) | -4.48 (0.87) | (-6.18, -2.78) | <0.001 |
| Gender |  |  |  |  |
| Female | 2,900 (71.7%) | Reference |  |  |
| Male | 1,147 (28.3%) | -1.63 (0.35) | (-2.32, -0.93) | <0.001 |
| IMD |  |  |  |  |
| Quintiles 2+ | 3,369 (89.8%) | Reference |  |  |
| Quintile 1  (most deprived) | 383 (10.2%) | 1.41 (0.52) | (0.40, 2.43) | 0.006 |
| Months since baseline |  | -0.34 (0.17) | (-0.67, -0.01) | 0.041 |
| Age\*Months since baseline |  |  |  |  |
| 18-29 |  | Reference |  |  |
| 30-49 |  | 0.14 (0.18) | (-0.21, 0.50) | 0.429 |
| 50-64 |  | -0.13 (0.18) | (-0.49, 0.22) | 0.461 |
| 65+ |  | -0.32 (0.25) | (-0.80, 0.17) | 0.200 |

IMD: Index of multiple deprivation

**Health-related quality of life**

Figure 2 reports the trajectories of the EQ-5D-5L for all respondents, and according to the completion status of the EQ-5D-5L questionnaire. The estimated mean EQ-5D-5L based on the complete case analysis (n=3,523) was 0.63 (95% CI 0.62, 0.64) at baseline and 0.64 (95% CI 0.59, 0.69) at 6 months after registration (Figure 2, Panel A). The differences in the trajectories of EQ-5D-5L between individuals with follow-up less than 6 months and those with follow up until at least 6 months were small (Figure 2, Panel B).

**Costs**

Of the individuals who completed the baseline resource use questionnaire (n=3,422) within the first month of registration, 53% (n = 1,816) completed the questionnaire only at baseline, 39.4% (n = 1,347) completed it at baseline and follow-up between 2 and 5 months after registration, and 7.6% (n = 259) completed it at baseline and follow up until at least 6 months after registration (Online supplemental material, Table S2). Participants with follow up until at least 6 months (versus those who completed the resource use questionnaire at baseline only) were on average older (50.5 vs 45.8), less likely to have a degree (44.0% vs 52.7%), more likely to be white (93.4% vs 87.6%) and less likely to be in the least deprived quintile (19.5% vs 24.9%).

<< Figure 2 here >>

Table 3 reports resource use and costs according to the completion status of the resource use questionnaire. Full results based on the complete case analysis over the 6-month period is reported in online supplemental material (Table S3). The health care costs associated with hospital and primary care visits were small and remained relatively constant over time (online supplemental material, Table S3), and did not differ according to the completion status of the resource use questionnaire (Table 3).

The participants who completed the questionnaire at baseline only (n = 1,816), reported on average 6.2 (SD 9.9) days off work due to long COVID within the first month of registration, corresponding to a mean (SD) productivity loss of £570 (908). Almost half of these participants (n = 834, 46%) reported at least one day off work (per month), and 18% (n = 324) reported 20 (or more) days off work at baseline. Individuals who completed the resource at both baseline and any follow up reported somewhat higher mean working days lost and associated costs. For example, participants who completed the resource use questionnaire at baseline and follow-up until six months (n=259), reported 7.7 (11.1) days off work six months after registration, which corresponded to a mean (SD) monthly productivity loss at 6 months of £712 (1,017). About half of these individuals (n = 131, 51%) reported at least one day off work, and 23% (n = 60) reported 20 or more working days lost at 6 months.

Table 3. Mean monthly resource use and cost according to completion status of the resource use questionnaire: 1) resource use completed within the first month of registration (baseline) only; 2) resource use completed at baseline and follow-up between 2 and 5 months after registration c) resource use completed at baseline and follow-up until at least 6 months after registration.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Resource use completed within the first month of registration (baseline) only (n = 1,816) | | | Resource use completed at baseline and follow-up between 2 and 5 months after registration (n = 1,347)\* | | Resource use completed at baseline and follow-up until at least 6 months after registration (n = 259) | |
|  | Resource use Mean (SD) | Cost (£) Mean (SD) | Resource use Mean (SD) | | Cost (£) Mean (SD) | Resource use Mean (SD) | Cost (£) Mean (SD) |
| GP visits | 1.1 (1.4) | 42.5 (55.5) | 1.0 (1.3) | | 39.6 (49.5) | 0.9 (1.1) | 35.9 (42.2) |
| Outpatient visits | 1.0 (1.7) | 141.9 (227.3) | 0.8 (1.3) | | 116.0 (182.0) | 0.8 (1.4) | 113.2 (186.7) |
| Physiotherapy sessions | 0.3 (0.8) | 21.2 (53.7) | 0.3 (0.7) | | 20.7 (51.1) | 0.4 (1.0) | 27.1 (67.1) |
| Psychotherapy sessions | 0.3 (1.0) | 9.8 (31.2) | 0.3 (0.8) | | 8.6 (26.6) | 0.3 (0.9) | 10.9 (29.6) |
| Inpatient stay (days) | 0.0 (0.5) | 23.7 (240.1) | 0.0 (0.5) | | 16.8 (240.4) | 0.1 (0.5) | 31.7 (251.4) |
| Working day lost | 6.2 (9.9) | 569.6 (908.2) | 6.8 (10.2) | | 629.3 (937.8) | 7.7 (11.1) | 712.2 (1016.9) |
| Total societal cost |  | 808.7 (1053.3) |  | | 831.0 (1034.4) |  | 931.1 (1121.8) |

\*Results reported in this column correspond to a weighted average of the monthly mean resource use and costs across months 2 to 5. SD: standard deviation. GP: general practitioner.

Of those individuals (n = 141) who reported at least one day off work (per month) at baseline and had follow up until at least 6 months, 102 (72%) continued to report at least one day off work at 6 months, and 51 (36%) reported 20 or more working days lost (unable to work at all). The latter group was particularly worse off at 6 months compared to baseline (online supplemental material table S4). Associations between the probability of reporting at least one day off work due to long COVID at 6 months and baseline socio-demographic variables are reported in online supplemental material (Table S5).

**Discussion**

**Main findings**

This study provides new evidence on the recovery trajectory of care-seeking patients with long COVID and its impact on function, health outcomes and costs. Individuals referred to long COVID clinics in the UK reported little improvements in functional limitations, fatigue and HRQL over the first 6 months after registration in the LWCR programme. Our analysis suggested that almost half of long COVID patients were expected to have moderately severe or worse functional impairment at 6 months, emphasising ongoing challenges in long COVID recovery. Individuals under the age of 50, female and those more deprived appeared to report smaller improvements over time.

Separate analysis according to level of engagement of the individuals in the LWCR programme suggested that individuals with 6 months or longer follow up reported somewhat higher functional impairment compared to participants with less than 6 months follow up. However, we found that both groups reported similar, modest improvements over time.

While long COVID-related health care utilisation remained relatively constant over the 6-month period, the average number of working days lost increased slightly over time. Almost three quarters of the participants who reported loss of working days at baseline, and remained engaged in the LWCR programme, continued to report working days lost at 6 months, and over a third of these were unable to work at all. Societal costs were primarily driven by productivity losses and averaged £931 per individual per month at 6 months after registration.

**Comparisons with previous studies**

A previous umbrella review9 found that long COVID is likely to have an impact on activities of daily living, social functioning and employment. However, the study concluded that the existing literature provides a patchy, heterogeneous, and thus inconclusive picture of the health, social and economic burden of long COVID.

This longitudinal study adds to our recent cross-sectional paper7 by showing a persisting functional impairment over the 6-month period after registration in the LWCR. The mean WSAS score was 19.1 (95% CI 18.6, 19.6) at 6 months, suggesting that care-seeking long COVID patients have, on average worse functional impairment than individuals who had a stroke (mean WSAS score of 16)17. We found that there was a small improvement in function over time (mean change in WSAS score was -0.86, 95% CI -1.32, -0.41), but this is unlikely to be clinically relevant. A previous study18 suggested that a minimal clinically important difference was expected to be 8 points on the 0-40 WSAS scale. In addition, we found that nearly 60% of the participants who remained engaged in the LWCR programme still reported moderately severe or worse impairment at 6 months.

This paper found that the trajectories of the WSAS and FACIT-F scores were remarkably similar over time. This corroborates previous evidence from the cross-sectional study7, which suggested that fatigue was the major driver of the variation in functional limitations. By looking at a much larger sample, this longitudinal analysis finds that HRQL of long COVID patients in the LWCR programme remained persistently low over the 6-month follow up. The mean EQ-5D-5L at 6 months was 0.64, which is on par with the HRQL observed for patients with advanced cancers19 20.

A recent observational study conducted in Switzerland showed that 23% and 17% of patients infected with COVID-19 did not fully recovery by 6 and 24 months, respectively21. This contrasts with our findings, which suggested that about 46% of participants still had moderately severe or worse functional impairment at 6 months. The reasons for this difference are varied and related to differences in the study design and target population. Firstly, the Swiss study included a comparator group (with no COVID infection), which may have helped minimise selection biases. Secondly, the primary outcome in that study was the EQ-VAS, which tends to have low sensitivity to small changes in health status and be prone to ceiling effects. Thirdly, the Swiss study included individuals living in a single canton (Zurich) in Switzerland and only those with the wild-type COVID-19 alpha variant, who may be less likely to have prolonged effects over time22.

Our findings about more modest levels of improvement over time align well with other European studies reporting on the recovery of long COVID patients23-25. A cohort study conducted in the Catalan region followed long COVID patients for a median of 23 months and found that only 8% (26 out of 341) recovered during follow up23. Another study conducted in Southern Germany also found that about 29% (3289 out of 11 536) of long COVID patients reported impaired general health and working capacity between 6 to 12 months after COVID-19 infection24.

Most treatment-seeking long COVID patients in our study sample were under the age of 65 (94%), consistent with existing findings that the prevalence of long COVID was highest among the working-age population26 27. Previous studies indicate between 13% and 43% of COVID-19 affected individuals do not return to work six months after infection26 28. Our study shows an average of 7.7 days off work (per month) at 6 months, equivalent to a third of working days lost. Our study also finds that almost three quarters of individuals who reported working days lost at baseline continued to report absenteeism at 6 months due to long COVID. This is likely related to symptoms such as fatigue, dyspnoea, cognition and mental health symptoms, as reported elsewhere28-30. It is worth noting that we were not able to distinguish between individuals in different types of job arrangements (part-time, full-time, self-employed), but our PPI work suggested that our sample includes a mix of employment types and hence, it is likely to be representative of the working-age population.

An Australian study suggested that, even for those who returned to work at 6 months, 34% of patients had new problems with mobility, 34% with pain and 43% with usual activities31. This is in line with the findings of a survey conducted by Living With 32, which collected feedback from 1,874 LWCR participants between March 2023 and March 2024. This survey found that over half (1100 out of 1874) of the individuals who returned to work have struggled at the workplace, and over a third (650 out of 1874) required adjustment at work. This highlights the prolonged impact of long COVID on the individual’s working ability 28, suggesting challenges in job performance even for those returning to work. As a result, our estimated cost associated with working days lost might be an underestimate of the productivity losses due to long COVID as it excludes costs associated with reduced productivity at work (presenteeism).

**Strengths and limitations**

One strength of this study lies in the prospective, longitudinal follow-up of a large population of individuals with a confirmed long COVID diagnosis and the real-time data collection on functional impairment, symptoms, HRQL and resource use. The sample includes individuals referred to 35 long COVID clinics in the UK, which have a good geographical representation across the country. In addition, the use of generic, validated measures, such as WSAS and EQ-5D-5L, facilitates the interpretation of the long COVID burden compared with other diseases.

A limitation of our study was the loss to follow-up. We observed that a high proportion of patients disengaged with the LWCR app. As patients had full control over the utilisation of the app, dropout could be attributed to many reasons. A potential concern is that disengagement with the app could be strongly associated with patient’s recovery, in which case, our results would be an overestimate of the overall long COVID burden as they speak to those still needing help. However, the Living With survey 32 found that only 5% (110 out of 1874) of the respondents reported having stopped using the app because they ‘got better’. In fact, many individuals (nearly 20%) reported that they disengaged with the LWCR app because ‘their symptoms were not improving’. Moreover, this study conducted separate trajectory models for individuals with different follow up periods and did not find meaningful differences in the trajectories between them.

A related limitation is the potential bias introduced by missing data in the socio-demographic variables. Nevertheless, complete case analysis has been recommended as the primary analysis when low levels of missing data in the explanatory variables were observed compared to dependent variables 33.

Despite the large and geographically representative sample, individuals recruited to this study were referred by long COVID clinics and needed to meet specific criteria to be eligible to register in the LWCR app. In particular, our sample included individuals who were considered likely to benefit from the LWCR intervention and were fit for rehabilitation. Consequently, our estimates may be somewhat conservative as we potentially excluded individuals less fit and less (digitally) educated than the ‘average’ long COVID patient. In addition, some clinical information, such as the date and severity of the index COVID infection, vaccination status and virus variant, were not available in our study, and hence we were unable to evaluate the extent to which these factors have had an impact on long COVID recovery.

**Conclusion**

Individuals referred to long COVID clinics in the UK reported little improvement in functional limitations, fatigue and HRQL over the first 6 months after registration in the LWCR, irrespective of the period that participants remained engaged in the programme. This persistent functional impairment and poor quality of life over time significantly affects the individual’s ability to work and presents a significant economic burden to the individuals themselves as well as to the economy. Addressing ongoing challenges related to fatigue and its impact on work absenteeism should be a priority for future health care interventions aimed at supporting recovery of individuals with long COVID. Important dimensions of health inequality, such as gender and deprivation should be considered when devising health policy recommendations for the treatment and management of long COVID.

**Contributors**: HG, WH and MG conceived and designed the study. JW, SW and WH analysed the data. JW and MG drafted the first draft of paper. JW, HG, SW, AB, PF, JH, DS, KB, CR, WH and MG provided critical comments and approved the submitted manuscript. HG is guarantor for the overall content.

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**Ethics approval**: This study involves human participants and was approved by the East Midlands–Derby Research Ethics Committee (reference 288199). Data were routinely collected in the Living With Digital Health Interface as part of clinical care. Patient consent was not required.

**Data availability statement:** Data are available upon reasonable request. To request access to the underlying research data, please contact Dr Henry Goodfellow: henry.goodfellow@nhs.net.

**FIGURES**

**Figure 1:** (A) Estimated trajectories of the Work and Social Adjustment Scale (WSAS) over the 6-month follow up (FU). (B) Observed trajectories according to completion status of the WSAS questionnaire: 1) WSAS completed within the first month of registration (baseline) only; 2) WSAS completed at baseline and follow-up between 2 and 5 months after registration 3) WSAS completed at baseline and follow-up until at least 6 months after registration. A WSAS score of 20 (dashed line) or more is considered to indicate moderately severe or worse functional impairment.

**Figure 2:** (A) Estimated trajectories of the EQ-5D-5L over the 6-month follow up (FU). (B) Observed trajectories according to completion status of the EQ-5D-5L questionnaire: 1) EQ-5D-5L completed within the first month of registration (baseline) only; 2) EQ-5D-5L completed at baseline and follow-up between 2 and 5 months after registration 3) EQ-5D-5L completed at baseline and follow-up until at least 6 months after registration

**REFERENCES**

1. National Institute for Health and Care Excellence. COVID-19 rapid guideline: managing the long-term effects of COVID-19 2024 [Available from: <https://www.nice.org.uk/guidance/ng188>.

2. Rajan S, Khunti K, Alwan N, et al. In the wake of the pandemic. *Preparing for Long COVID Policy Brief* 2021;39

3. Office for National Statistics. Prevalence of ongoing symptoms following coronavirus (COVID-19) infection in the UK: 30 March 2023 2023 [Available from: <https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/conditionsanddiseases/bulletins/prevalenceofongoingsymptomsfollowingcoronaviruscovid19infectionintheuk/30march2023>.

4. Davis HE, Assaf GS, McCorkell L, et al. Characterizing long COVID in an international cohort: 7 months of symptoms and their impact. *EClinicalMedicine* 2021;38

5. Kwon J, Milne R, Rayner C, et al. Impact of Long COVID on productivity and informal caregiving. *The European Journal of Health Economics* 2023

6. Crook H, Raza S, Nowell J, et al. Long covid—mechanisms, risk factors, and management. *bmj* 2021;374

7. Walker S, Goodfellow H, Pookarnjanamorakot P, et al. Impact of fatigue as the primary determinant of functional limitations among patients with post-COVID-19 syndrome: a cross-sectional observational study. *BMJ open* 2023;13(6):e069217.

8. Murray E, Goodfellow H, Bindman J, et al. Development, deployment and evaluation of digitally enabled, remote, supported rehabilitation for people with long COVID-19 (Living With COVID-19 Recovery): protocol for a mixed-methods study. *BMJ open* 2022;12(2):e057408.

9. Nittas V, Gao M, West EA, et al. Long COVID through a public health lens: an umbrella review. *Public health reviews* 2022;43:1604501.

10. Mundt JC, Marks IM, Shear MK, et al. The Work and Social Adjustment Scale: a simple measure of impairment in functioning. *The British Journal of Psychiatry* 2002;180(5):461-64.

11. Cozza SJ, Shear MK, Reynolds CF, et al. Optimizing the clinical utility of four proposed criteria for a persistent and impairing grief disorder by emphasizing core, rather than associated symptoms. *Psychological Medicine* 2020;50(3):438-45.

12. Piper BF, Cella D. Cancer-related fatigue: definitions and clinical subtypes. *Journal of the National Comprehensive Cancer Network* 2010;8(8):958-66.

13. Devlin NJ, Shah KK, Feng Y, et al. Valuing health‐related quality of life: An EQ‐5 D‐5 L value set for E ngland. *Health economics* 2018;27(1):7-22.

14. Lesley A. Curtis AB. Unit Costs of Health and Social Care 2020. Personal Social Services Research Unit, University of Kent, Canterbury2021.

15. National Health Service. National Tariff 2020 [Available from: <https://www.england.nhs.uk/pay-syst/national-tariff/>.

16. Office for National Statistics. Average hourly pay 2021 [Available from: <https://www.ethnicity-facts-figures.service.gov.uk/work-pay-and-benefits/pay-and-income/average-hourly-pay/latest>.

17. Hommel M, Trabucco-Miguel S, Joray S, et al. Social dysfunctioning after mild to moderate first-ever stroke at vocational age. *Journal of Neurology, Neurosurgery & Psychiatry* 2009;80(4):371-75.

18. Zahra D, Qureshi A, Henley W, et al. The work and social adjustment scale: reliability, sensitivity and value. *International journal of psychiatry in clinical practice* 2014;18(2):131-38.

19. Paracha N, Abdulla A, MacGilchrist KS. Systematic review of health state utility values in metastatic non-small cell lung cancer with a focus on previously treated patients. *Health and quality of life outcomes* 2018;16:1-30.

20. Pourrahmat M-M, Kim A, Kansal AR, et al. Health state utility values by cancer stage: a systematic literature review. *The European Journal of Health Economics* 2021;22(8):1275-88.

21. Ballouz T, Menges D, Anagnostopoulos A, et al. Recovery and symptom trajectories up to two years after SARS-CoV-2 infection: population based, longitudinal cohort study. *bmj* 2023;381

22. Canas LS, Molteni E, Deng J, et al. Profiling post-COVID-19 condition across different variants of SARS-CoV-2: a prospective longitudinal study in unvaccinated wild-type, unvaccinated alpha-variant, and vaccinated delta-variant populations. *The Lancet Digital Health* 2023;5(7):e421-e34.

23. Mateu L, Tebe C, Loste C, et al. Determinants of the onset and prognosis of the post-COVID-19 condition: a 2-year prospective observational cohort study. *The Lancet Regional Health–Europe* 2023;33

24. Peter RS, Nieters A, Kräusslich H-G, et al. Post-acute sequelae of covid-19 six to 12 months after infection: population based study. *Bmj* 2022;379

25. Tran V-T, Porcher R, Pane I, et al. Course of post COVID-19 disease symptoms over time in the ComPaRe long COVID prospective e-cohort. *Nature communications* 2022;13(1):1812.

26. Gualano MR, Rossi MF, Borrelli I, et al. Returning to work and the impact of post COVID-19 condition: A systematic review. *Work* 2022;73(2):405-13.

27. Thompson EJ, Williams DM, Walker AJ, et al. Long COVID burden and risk factors in 10 UK longitudinal studies and electronic health records. *Nature communications* 2022;13(1):3528.

28. Kerksieck P, Ballouz T, Haile SR, et al. Post COVID-19 condition, work ability and occupational changes in a population-based cohort. *The Lancet Regional Health–Europe* 2023;31

29. Awan I, Balouch AH, Juseja AK, et al. Long Term Impact of COVID-19 Infection on Sleep and Mental Health. *Pakistan Journal of Medical & Health Sciences* 2022;16(04):102-02.

30. Chaumont H, Meppiel E, Roze E, et al. Long-term outcomes after NeuroCOVID: A 6-month follow-up study on 60 patients. *Revue Neurologique* 2022;178(1-2):137-43.

31. Hodgson CL, Higgins AM, Bailey MJ, et al. The impact of COVID-19 critical illness on new disability, functional outcomes and return to work at 6 months: a prospective cohort study. *Critical Care* 2021;25:1-12.

32. Robson C. WJ. Living With Covid Recovery Survey [Conference presentation]. NHS England Long COVID Meeting. London, UK, 2023.

33. Jakobsen JC, Gluud C, Wetterslev J, et al. When and how should multiple imputation be used for handling missing data in randomised clinical trials–a practical guide with flowcharts. *BMC medical research methodology* 2017;17:1-10.